Downstream persistence of particulate organic carbon released from thaw slumps on the Peel Plateau (NT, Canada)

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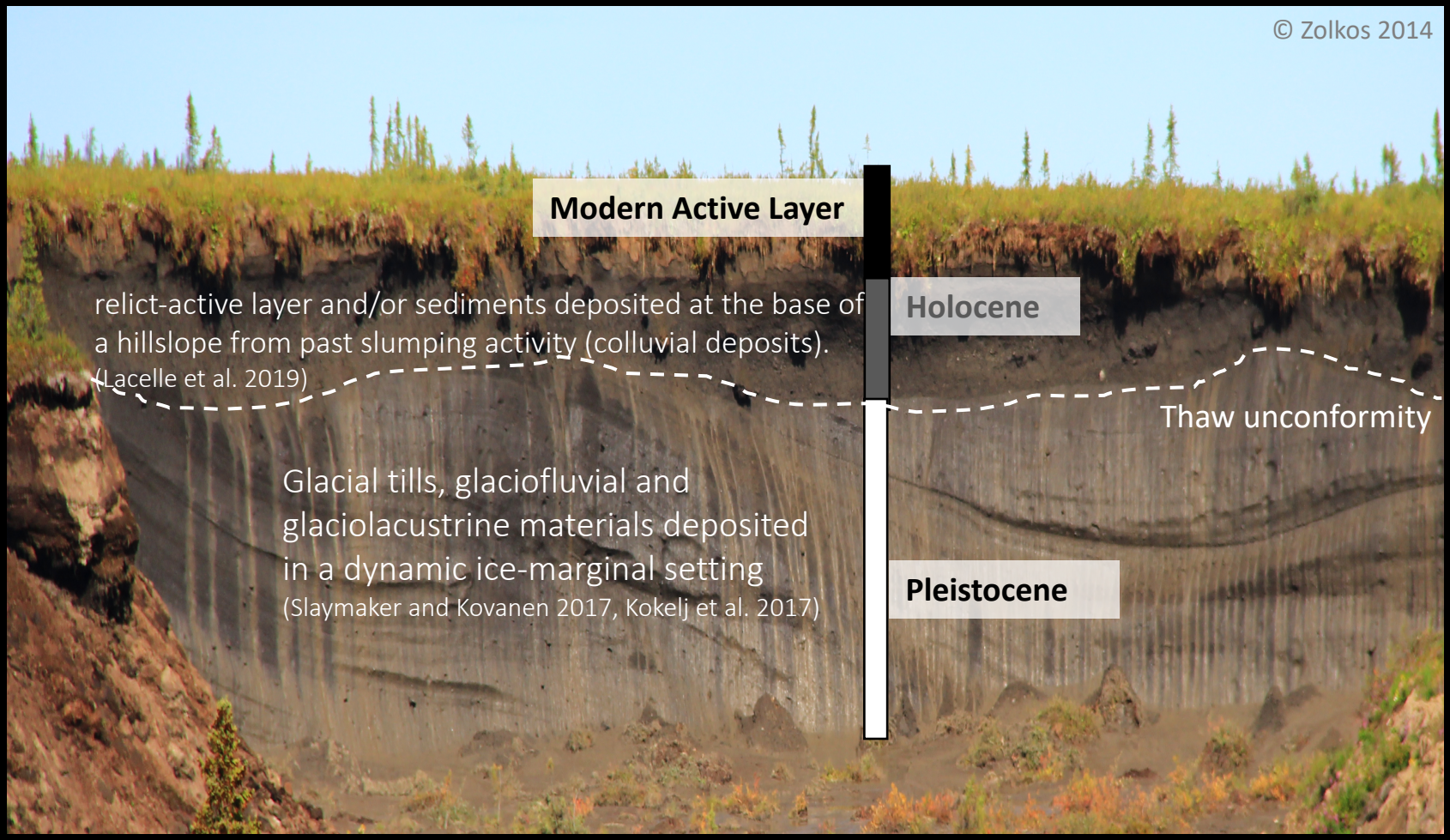
Hillslope thermokarst can rapidly transport terrestrial organic carbon to aquatic systems

In a former ice-marginal landscape, the Peel Plateau has a relatively high proportion of thaw slumps and shares similarities with other permafrost preserved glaciated landscapes distributed across northwestern Canada, Alaska, and Siberia

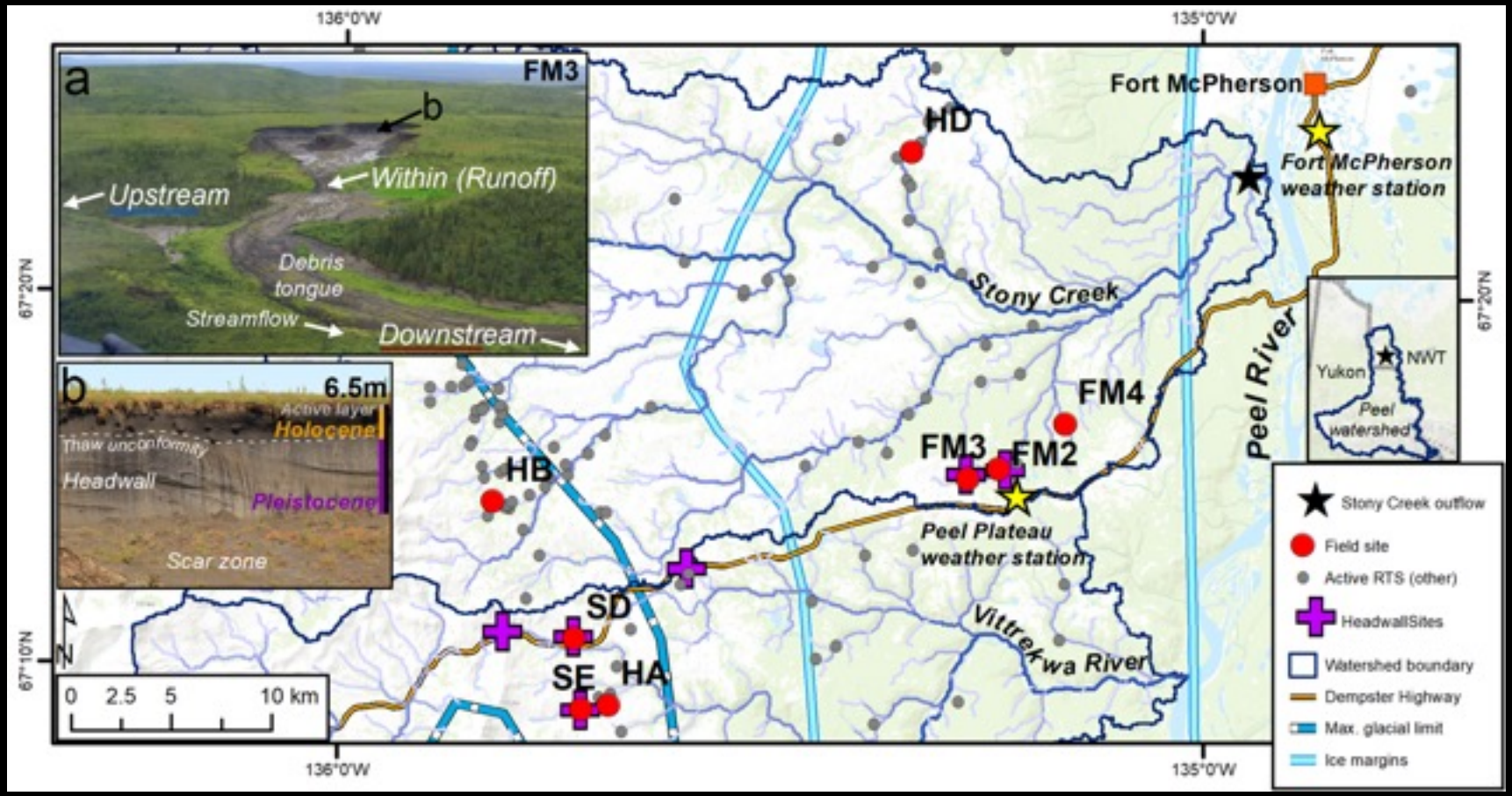
(Kokelj et al. 2017)

Terrestrial Material exposed in slump headwalls on the Peel Plateau



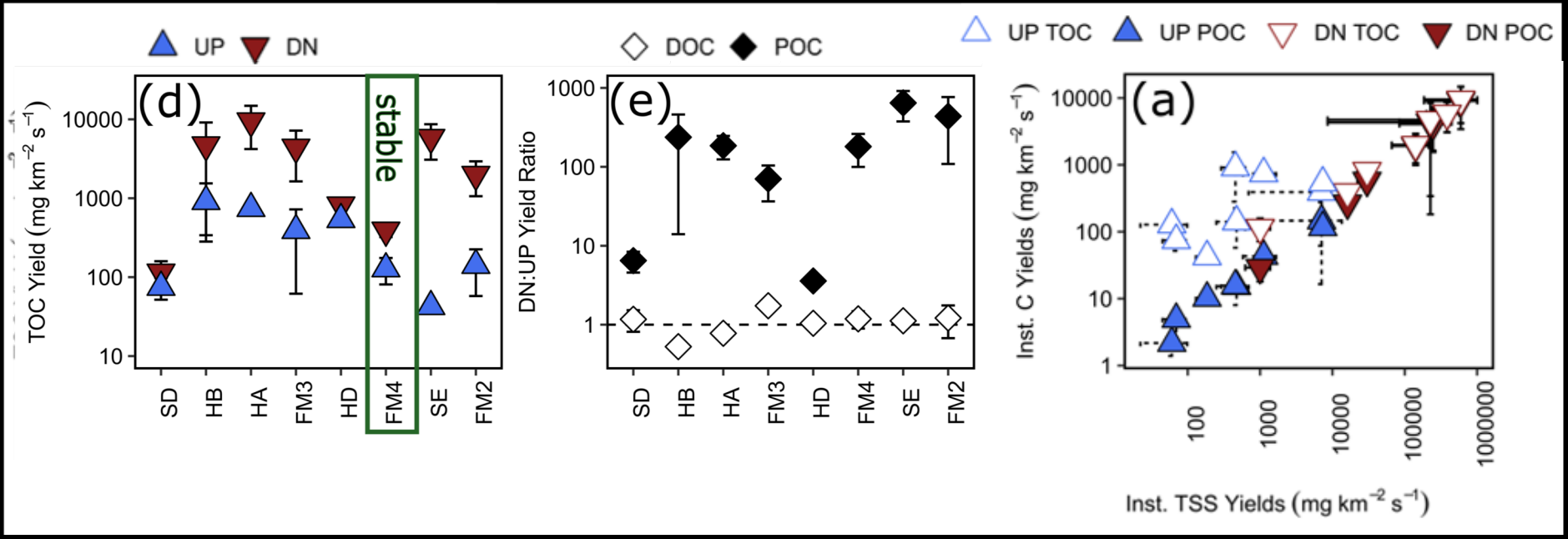
Upstream-downstream comparisons on the Peel Plateau

Adapted from Zolkos et al. 2018



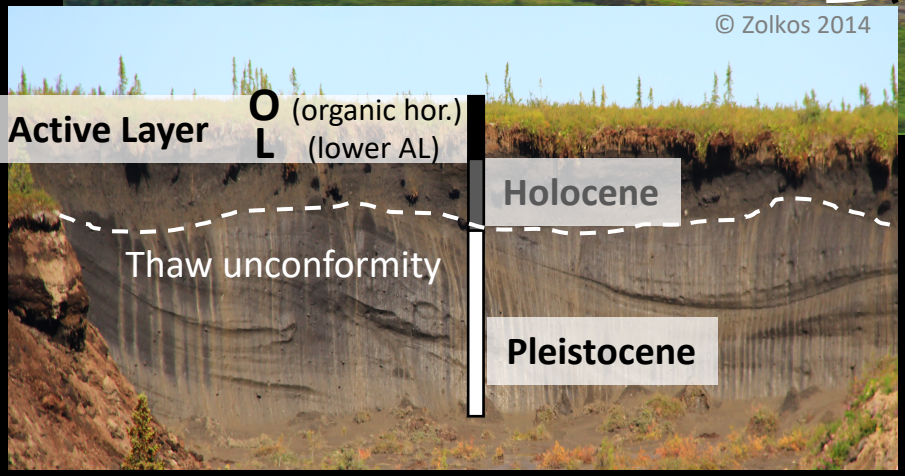
We began this project by looking at immediate impacts on low-order streams using an upstream-downstream study design at 8 slumps across the Stony Creek and Vittrekwa River watersheds on the Peel Plateau. We additionally sampled potential organic matter sources, including “slump” headwalls.

Sediment-associated POC increases organic carbon yields by orders of magnitude

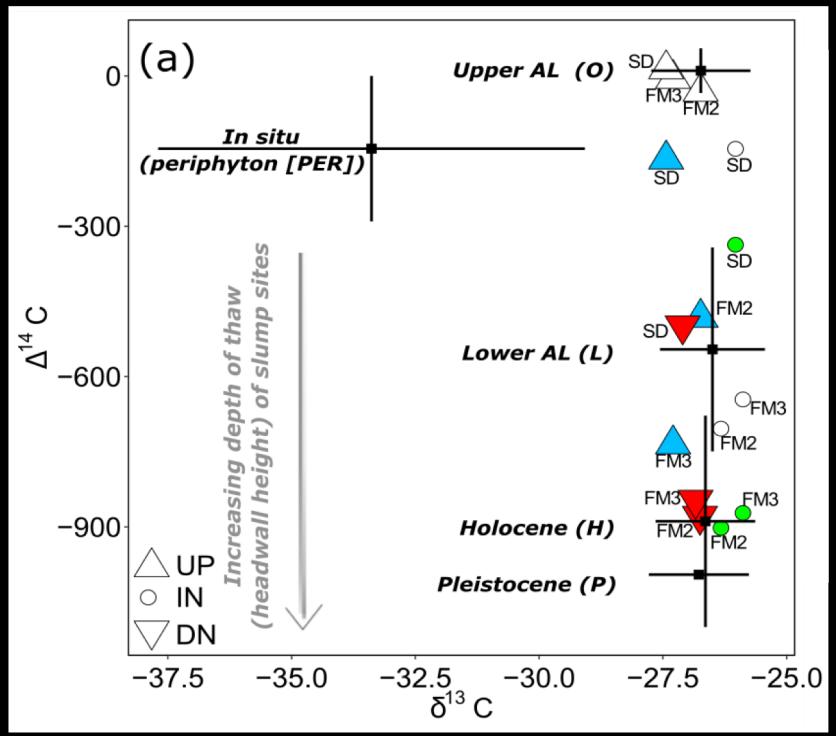


Shakil et al. in prep

Material is older and relatively more ‘reworked’



Here hollowed shapes are dissolved organic carbon, filled shapes are particulate organic carbon. Note distinct differences in ages between two phases.



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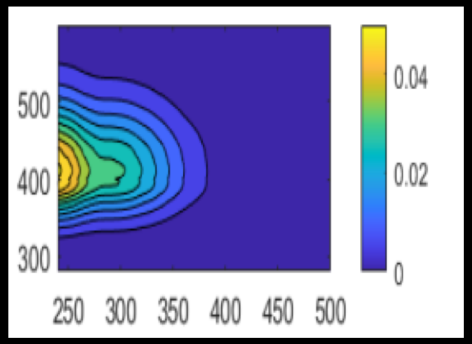
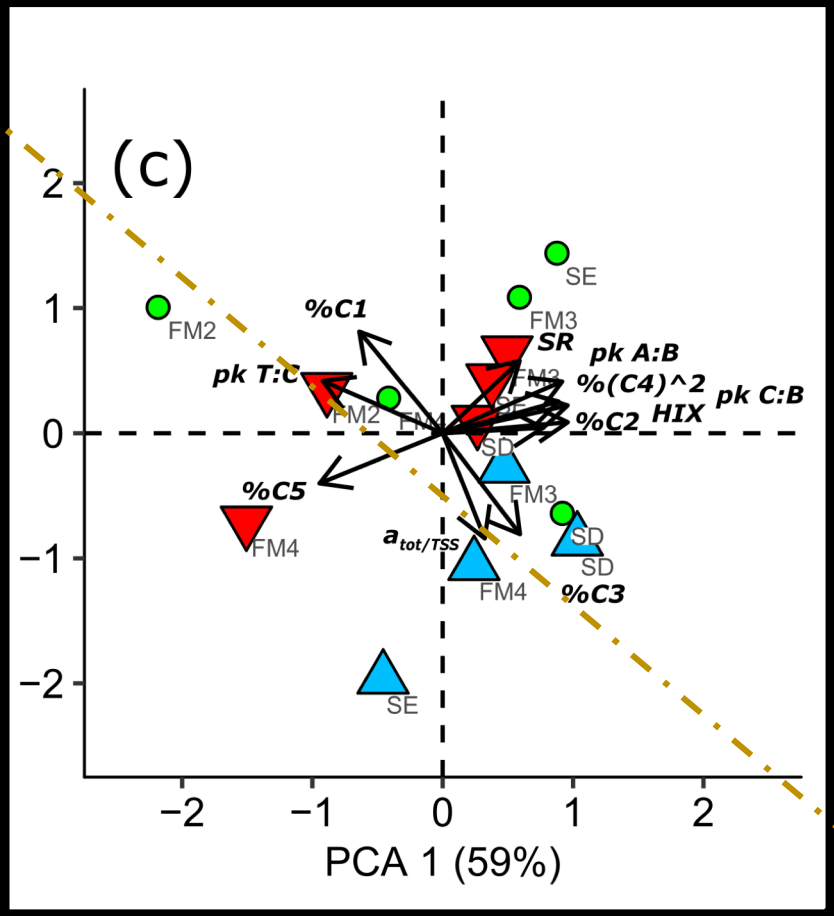
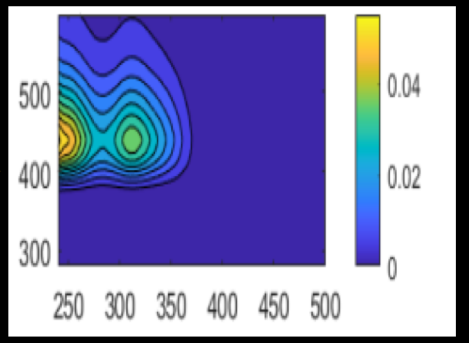


Slump-impacted

Greater contribution to fluorescence from component 1 of a PARAFAC model of base-extracted particulate organic matter fluorescence (BEPOM)

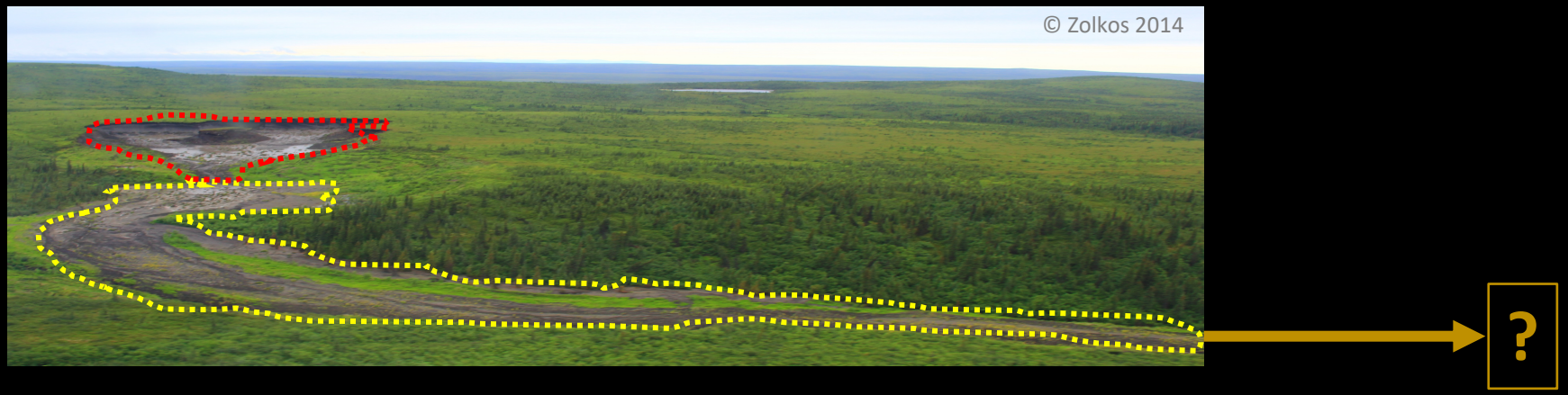
C1 described as terrestrial material with greater reworking since production





Un-impacted

Downstream persistence

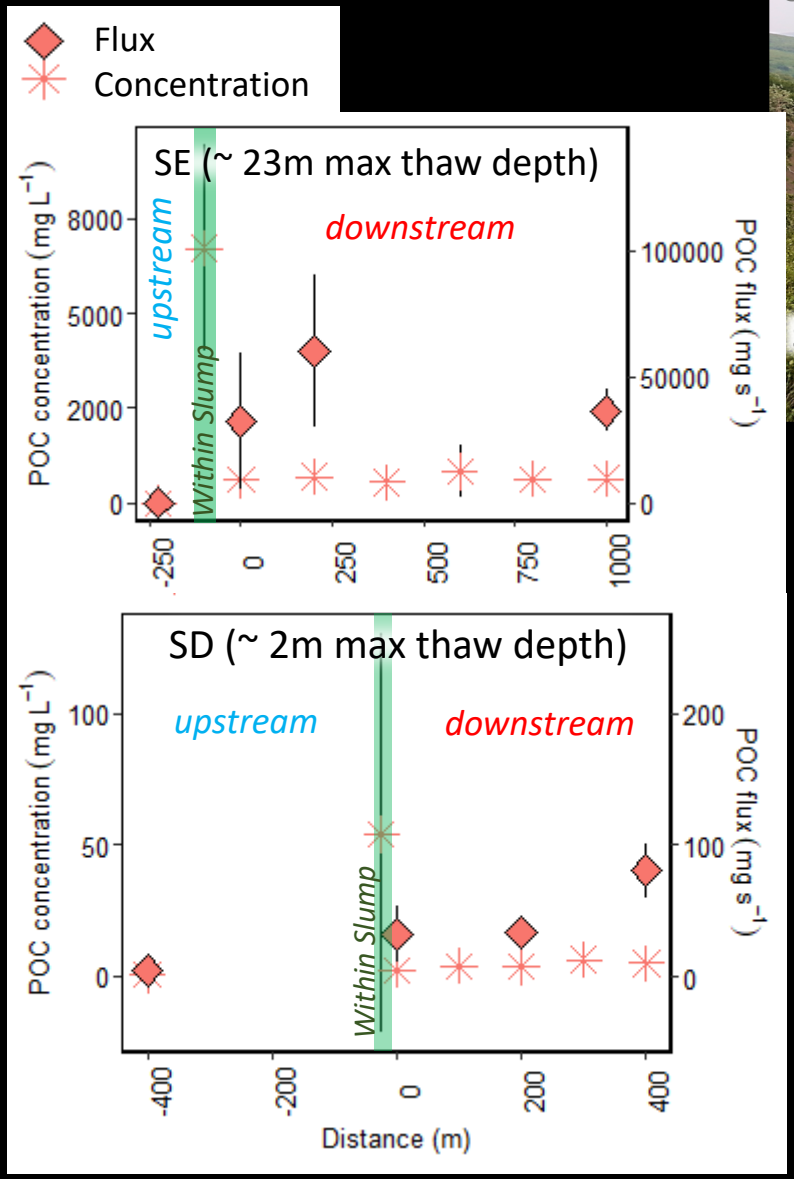


>80% of the material excavated from the landscapes…

…Is likely contained within debris tongues that extend several km into the valleys away from site of thaw (van der Sluijs et al. 2018)
Which are limited by the stream's ability to erode it, likely taking centuries to millennia to be transported (Shakil et al. in prep)

Some material is making it's way to larger watershed scales (Kokelj et al. 2013)
So to what extent are the effects we see here propagating downstream and how important are they for the larger Peel River watershed (…and beyond to the Ocean)

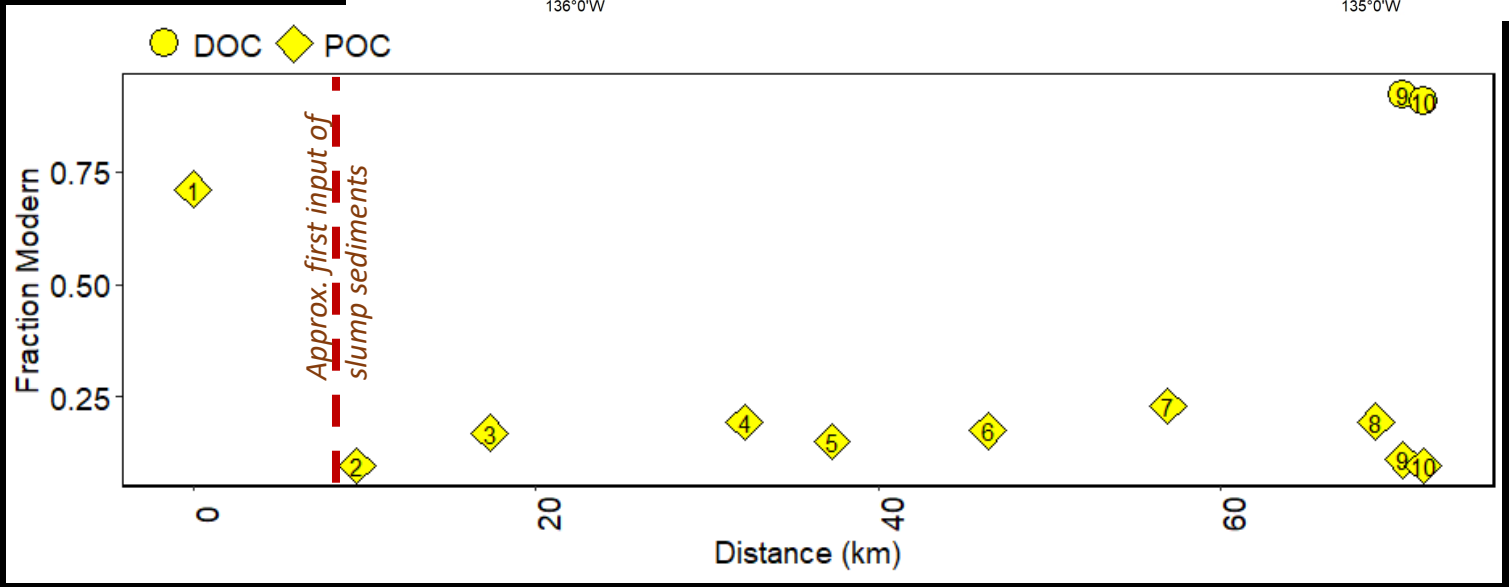
No evidence of decrease in flux downstream



Note sediment saturated systems in valley, readily available for transport

Persistence of aged material via POC

The Fraction Modern of POC decreased to less than 0.25 (^{14}C age increased by thousands of years) with the introduction of slump inputs and remained similarly depleted in ^{14}C at the watershed outlet, in contrast to substantially more modern DOC.



Ongoing work

- We will use compositional measurements (%POC, C:N, fluorescence, $\Delta^{14}C$) and flux of DOC and POC obtained from tributary streams representing different vegetative, slump-density, and geological units in the Stony Creek watershed to assess slump signals the importance of slump-mobilized POC at the Stony Creek outlet

- Using historical suspended sediment, POC, and discharge data for the 75,000 km^2 Peel River drainage basin containing the Stony Creek watershed, we will examine whether there have been increases in instantaneous sediment and POC fluxes during the thaw season to track the trends of intensifying slump activity that have been documented on the Peel Plateau

- Constraining the downstream effect of these abrupt, localized disturbances may improve detection and prediction of change that will likely cascade through the region over the coming decades.

STAY TUNED FOR PAPERS SOON TO BE OUT! Questions? FEEL FREE TO CONTACT ME!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References

1. Kokelj S V, Lantz T C, Tunnicliffe J, Segal R and Lacelle D 2017 Climate-driven thaw of permafrost preserved glacial landscapes, northwestern Canada Geology 45 371–4

2. Lacelle D, Fontaine M, Pellerin A, Kokelj S V and Clark I D 2019 Legacy of Holocene Landscape Changes on Soil Biogeochemistry: A Perspective From Paleo-Active Layers in Northwestern Canada Journal of Geophysical Research: Biogeosciences 124 2662–79

3. van der Sluijs J, Kokelj S V, Fraser R H, Tunnicliffe J and Lacelle D 2018 Permafrost Terrain Dynamics and Infrastructure Impacts Revealed by UAV Photogrammetry and Thermal Imaging *Remote Sensing* **10** 1734

4. Slaymaker O and Kovanen D J 2017 Pleistocene Landscapes of Western Canada *Landscapes and Landforms of Western Canada* World Geomorphological Landscapes ed O Slaymaker (Cham: Springer International Publishing) pp 27–48 Online: https://doi.org/10.1007/978-3-319-44595-3_2

5. Zolkos S, Tank S E and Kokelj S V 2018 Mineral Weathering and the Permafrost Carbon-Climate Feedback *Geophysical Research Letters* **0** Online: https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018GL078748

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