Author responses to reviewer comments, and edits to manuscript *"Mineral-bound organic carbon exposed by hillslope thermokarst terrain: case study in Cape Bounty, Canadian High Arctic" (Paper submitted to 'SOIL' | egusphere-2025-3428)*

2nd round of reviews

We would like to thank the reviewer for the comments on our manuscript # egusphere-2025-3428. We have paid close attention to the suggested edits and made the requested changes as detailed below, with reviewer's comments in regular font, directly followed by our responses in italic (*blue font*). All additional references and changes not requested by the reviewer are editorial in nature and do not significantly alter the content of the manuscript.

Report #1
Anonymous referee #3 | Submitted on 01 Apr 2026

General Comments

This manuscript presents a valuable case study from Cape Bounty in the Canadian High Arctic, focusing on the fate of mineral-bound organic carbon (MAOC) exposed by hillslope thermokarst. By analyzing mineralogy, elemental concentrations, and organo-mineral interactions in both disturbed and undisturbed profiles, the authors provide nuanced insights into carbon stability in permafrost regions. The finding that a significant fraction of OC is stabilized by organo-metallic complexes and poorly crystalline iron oxides (13% and 6%, respectively) is both novel and insightful. The conclusion that deep thaw features may expose more degradable OC despite certain mineral protections is well-supported. Overall, this is a well-executed study that contributes significantly to our understanding of cryoturbated carbon dynamics.

We would like to warmly thank the reviewer for their positive evaluation of our work.

Specific Comments

1. Abstract (Line 23): For the sake of clarity and context regarding the "deep thaw" mentioned later, please specify the exact depth of the deepest samples retrieved in this study

We have changed the sentence to now read: "[…] the proportion of organo-metallic complexes drops from ~18% in surface samples (2 – 22 cm) to ~1 % in the deepest samples (50 – 70 cm)" (L23).

2. Hypothesis Development (Lines 96-98): While the application of this hypothesis to the Cape Bounty site is valuable, the framing suggests it is a entirely new concept in the broader field of soil carbon sequestration. I suggest rephrasing this to acknowledge that while the mechanism is established in temperate or other soil systems, its specific behavior and magnitude in Arctic thermokarst terrains remain an important area of investigation.

We thank the reviewer for their comment. We now specified that this hypothesis holds for frozen sediments at depth: "We hypothesize that organo-mineral interactions may be more prominent in surface layers that are subject to recurrent positive temperatures, but that it may be limited at depth if buried and frozen sediments have not experienced pedological development" (L99). We further acknowledge this when referring to the nature, quantities and environmental factors controlling the different organo-mineral interactions (LL87-89): "While extensively studied in unfrozen terrestrial ecosystems (e.g., Kleber et al., 2015 and references therein), the nature, quantities and environmental factors controlling the different organo-mineral interactions are still poorly understood in sediments exposed by hillslope thermokarst features (Opfergelt, 2020)."

3. Calcium-OC Interactions (Line 105): The discussion on Calcium (Ca) focuses heavily on Ca-bridging. However, recent research suggests that Calcium may be more intricately associated with specific SOC decomposition products beyond simple bridging. I recommend the authors consult and incorporate the findings of Rowley et al. (2025) (Calcium is associated with specific soil organic carbon decomposition products, SOIL, 11, 381–388). Addressing these specific carbon groups would significantly strengthen the mechanistic interpretation of your results. As you state, selective extractions omit large biopolymers and physically occluded OC, so the conclusion that 20% of TOC is chemically stabilized may be an underestimate. The wording could be tweaked to acknowledge this, since it's a central conclusion.

Thank you for this reference. We do not discuss calcium in great detail in the article, as the methods used in this study do not enable to measure its influence on OC preservation. We have, however, included your suggestion in the results section (LL270-271): "Yet, calcium can sometimes play an important role in OC stabilization (e.g., Rowley et al., 2018), by forming cationic cation bridges or beyond, by associating with specific soil OC decomposition products (Rowley et al., 2025 and references therein)" and in the discussion (LL485-486): "[…] therefore account for a relatively small proportion of the TOC (20 ± 4%) but likely support residence times spanning hundreds to thousands of years with no drastic environmental changes (e.g., pH, redox, organic matter inputs, etc...). This proportion may be underestimated, as it does not take into account associations with calcium (Rowley et al., 2025). In contrast, […]"

References

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