The Cryosphere Discussions

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Comment on tc-2022-12

Jack Hutchings (Referee)

Referee comment on "Molecular biomarkers in Batagay megaslump permafrost deposits reveal clear differences in organic matter preservation between glacial and interglacial periods" by Loeka L. Jongejans et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-12-RC1, 2022

Reviewer Comments

Jongejans et al. present a study that uses bulk and organic geochemical measurements to investigate the organic matter stored in the ~55 m headwall of the Batagay slump. This is quite intriguing as this slump is a unique insight into a long history of permafrost accumulation (and degradation) that may be useful for both understanding the evolution of permafrost landscapes as well as predicting future impacts of carbon stored in permafrost sediments as the environment is transformed by anthropogenic climate change. Overall, I find their manuscript to be well-written and quite detailed, but not overly long. I deeply appreciate the technical detail presented in the biomarker work (Table 2 is a delight) that is sometimes overlooked or omitted by organic geochemists.

I have relatively few questions and comments as this paper seems to fit nicely into the recent series of papers involving the ongoing investigation of the Batagay slump. Here are a few worth considering:

- The authors note that the interglacial units appear to have “decreased OM quality” whereas the glacial periods have “variable but overall higher OM quality”. This makes sense when thinking about relative temperature and rates of cycling and, perhaps, the different residence time of OM within the active layer where OM degradation occurs. However, the OM stock sizes between the interglacial and glacial periods must be quite different. Therefore, we might consider the differing consequences of releasing a relatively small amount of “fresh” glacial-era OM compared to relatively large amounts of “degraded” interglacial-era OM. Additionally, regardless of the characteristics of sediment-bound particulate OM, the Woody Layer contains, of course, wood and other plant detritus that will be readily remineralized upon thaw.
- Related to the above, I think a worthwhile and interesting calculation would be to estimate (even roughly) the relative sizes of C stocks within each of the types of units.

If we could estimate the average C stock (i.e., organic C density per unit area) of these units, could we then also estimate (again, roughly) the amount of C mobilized by the Batagay slump since its formation?

- Combined with stock estimates, the authors could incorporate some of the biomarker-based degradation insights to categorize the pools of carbon mobilized as either "pre-processed" or "fresh" to perhaps get some insight into if we expect the mobilized material to be quickly remineralized or simply redeposited downstream. Combining this with knowledge of other thaw slumps could be useful for developing some insights into the consequences of this type of extreme thaw into local (nutrient loading), regional (source of deltaic organic matter), and even global (atmospheric) carbon cycles.
- This may be more appropriate for a different article (perhaps one with a stronger focus on cryostratigraphy and geomorphology), but, is the size/scale of Batagay a unique feature? Retrogressive thaw slumps are well-studied and widely documented, but the scale of Batagay is quite impressive. While we can expect that as we warm the Arctic, we will have more thaw-related features, will we expect more Batagay-scale slumps? And, do we think there is anything unique in terms of biogeochemical cycling and/or consequences for local/downstream ecosystems of a single Batagay-scale slump versus multiple, smaller slumps whose total volume of mobilized permafrost might be similar to Batagay?
- The authors note that an unconformity exists between the Lower Sand Unit and the Woody Layer and that the Woody Layer occupies erosional gullies that formed during the last interglacial. While I realize precise dating of accumulation rates is difficult, I would be curious to see an estimate of the amount of carbon mobilized from the Lower Sand Unit due to the warming-induced erosional processes during the last interglacial.