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Title: Substrate potential of last interglacial to Holocene permafrost organic matter for future microbial greenhouse gas production

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Comments to Reviewer 1:

The structure of the introduction has improved and is much clearer now. Also many of the grammatical errors have been corrected, although a few new ones have emerged in the revised parts of the manuscript. I still have a few comments that should be addressed prior to publication in BGS:

P1, L12: …,which form…. – Changed as suggested. Line 12.

P1, L17: …pyrolysis experiments on the… – Changed as suggested. Line 17.

P2, L49: These deposits provide…. – Changed as suggested. Line 49.

P3, L73: replace 'applied' by 'performed'. Or even better, adjust the whole sentence to: In addition, microbial biomarkers such as….are analyzed to examine… – Second option is considered. Line 73.

P4L107: add the IR-OSL age. – Age data added. Line 108.

P4:125: This line confused me earlier. I don't think soils freeze over. Lakes do, but soils/sediments just freeze. Delete 'over' (but check with a native speaker if you can). – "over " is removed. Line 126.

L201-205: Can you add how PLFAs were identified? In particular the position of branches/unsaturations/presence of rings (rather than unsaturation). – PLFAs were identified by means of mass spectrum interpretation and comparison with a standard mix comprising saturated, unsaturated, branched and cyclo-propyl-fatty acid methyl esters. Lines 173-175.

L205: 'The sum of all brGDGTs (…) varies between xx and xx, while concentrations of the….' – Changed as suggested. Line 208.

L234: …but reach their maximum at a different depth. – Changed as suggested. Lines 237-238.

L298-305: This paragraph should go to the introduction. – Elements of this paragraph are already part of the introduction. Thus, we would like to keep this paragraph at this position as a starter for the following discussion. Lines 302-309.

L312: add the TOC concentration between brackets. I have no idea what a 'typical concentration' is for a Yedoma deposit… – It was simply meant, that the TOC values are in the same range as observed in other studies investigating Yedoma deposits. This sentence was rewritten and we added "up to 4.9% TOC". Lines 315-317.

L316: Since you do not present any results that directly support the thermokarst environment during the Holocene and Eemian, add a reference after the statement that Holocene and Eemian sediments are deposited in a thermokarst environment. This seems quite important given your sub-conclusion in the last paragraph of this section. – We added a reference to this sentence. Line 320.

L316: The BIT index is not properly introduced, nor are BIT index values presented in the results section. At least mention brGDGTs as soil end-member and crenarchaeol (currently not introduced at all) as marine end-member, being produced by marine algae. Consequently, soils are characterized by high BIT index values, and marine sediments by low BIT index values.

As for your specific setting: BIT index values in lake sediments are not well understood (see e.g. Blaga et al 2009 J. Paleolimn. or Blaga et al 2011 GCA), and can easily reach values op to 1 as well, as the BIT index can be influenced by Thaumarchaea and (unknown) aquatic brGDGT-producers (e.g. Tierney et al., 2010 GCA, Weber et al., 2015 GCA). Hence, the BIT index is not a very reliable tool to differentiate between soils and thermokarst/lake material. The only statement I would be comfortable making is that BIT index values in your permafrost material are high, and thus have a terrestrial origin (as opposed to marine). – The BIT Index was only used to underline the terrestrial character or origin of the OM. However, the pyrolysis data also can stand alone. Thus, the BIT data are not really important in this context and the reviewer is right that they do not bring additional information into the story. Thus, we removed these data from the manuscript, but keep them in the supplement table for readers which might be interested in those data. Removed from Lines 320 ff.

L320ff: Try to avoid using samples, but instead mention the type of sediment. In this case active layer material. This makes it easier to follow what deposit is being discussed. – We do not agree here, since samples are defined as "TOC-rich samples from active layer and LP (MIS 3 and 4)" in line 321 and then we refer to this definition by writing "these samples". Every time the samples set is changed samples are clearly described/defined again for instance "LP glacial period sample with lower TOC (line 334)" or "Eemian samples" (line 337). In our opinion adding always sample descriptions would create many repetitions and make the text only longer and less simple to read.

L338: replace dryer by drier. – Changed as suggested. Line 340.

L349: Peterse et al 2014?? – Changed as suggested. Line 352.

L365: replace 'as to' by 'on'. – Changed as suggested. Line 367.

L380: decreased compared to what? Other layers? Or over time? – We added "compared to the active layer. Line 382.

I don't understand the next sentence. Life marker signals represent living community… – It is meant that the permafrost preserves the past microbial community from time of deposition. We added "in the permafrost section" in line 383" and "Thus, the permafrost preserved the microbial community of the past." in line 384-385.

L410: 'warmer conditions' or 'higher temperatures'. – We removed "temperature". Line 413.

L413: Stapel et al 2017 is not listed in the references. – Changed to 2016. Line 416.

L417: …suggest lower soil-moisture content in the active… – Changed as suggested. Line 420.

L418: An explanation for the lower soil-moisture content is that all cores… – Changed as suggested. Line 421.

L424-425: this is exactly the reason why I asked earlier to normalize biomarker data to TOC, as this makes a fairer comparison than comparing g biomarker/g sediment. It would make sense to use the TOC-normalized brGDGT concentrations here too. – We added br-GDGT/gTOC data. Lines 426-428.

Also, these last few lines seem a bit out of place here, and should better fit with the discussion on the sources of OC in the different permafrost layers. – These lines are related to the microbial biomarker abundances in our and the Kolyma study by Peterse et al. (2014), thus we would like to keep them at the current position in the chapter where we discuss the microbial biomarker signals.

L470: As a consequence, or consequently. – Changed as suggested. Line 474.

L482: Thus, in contrast to simply using the… – Changed as suggested. Line 486.

L490: these – Changed as suggested. Line 494.

Comments to Reviewer 2

General comments

I find the manuscript much improved. Except for a few typos, I have no further objections.

Technical corrections

Line 43: "can lead to enhanced microbial production" – Changed as suggested! Line 43.

Line 49: "these deposits provide" – Changed as suggested! Line 49.

Line 55: "thermo-erosional" (I also had to fight with auto-correct here.) – Changed as suggested! Line 55.

Line 99: "thermo-erosion" – Changed as suggested! Line 99.

Line 331: Replace "its" with "their" – Changed as suggested! Line 333.

Line 490: "These deposits" – Changed as suggested! Line 494.

Additionally we revised Tables 1 and 2. In Table 1 the column order was changed starting now from left to right with the cores followed by the age assignment. In Table 2 the column "OM quality" was removed as an artefact of a previous version. Also the table captions were revised.

Table and Figure assignment in the text was checked and revised.

Supplement Fig. S1 was revised now including also PLFAs in µg/gTOC. Supplement Tables were revised.