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Discussions

Interactive comment on "Organic matter composition and stabilization in a polygonal tundra soil of the Lena-Delta" *by* S. Höfle et al.

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Response to Review #2

Major comments:

"My first concern addresses the representativeness of samples. In studies working in sedimentary systems it is very normal to study just one core, but often with dozens of individual depth increments. Also spatial variability in lake or marine sediments quite often is not very large. In contrast, spatial variability is one of the very basic characteristic of soils. This holds particularly true for permafrost soils.. . .."

- The analytical methods used are time consuming and also expensive (NMR, 14C). We thus were not able to measure replicates to account for spatial and analytical vari-

ability. However, further analyses are in progress, which investigate spatial variability (different polygons wet/dry and polygon structures in different parent material) but will also be less detailed than it is normally performed in soil science for standard soil analytical methods. The study had the aim to test if the methods mentioned above provide additional/more specific information than bulk parameters. We added a comment in section 2.1 (lines 128-133): 'Because of the complex analyses performed, only one soil profile with four soil horizons has been sampled and no replicates were analysed. However, large amounts of soil per horizon were sampled and mixed to obtain a representative sample at least for the soil pits (ca. 1x1 m). Thus spatial heterogeneity of organic matter in the active layer soils (e.g. Jones et al., 2010) is not represented by this sample set.'

"My second query concerns the occluded organic matter fractions. It has to be highly appreciated that the authors transported the samples in a frozen stage, thus preventing formation of artefacts concerning aggregation by drying. However, does the soil really show an aggregated structure? . . .."

- Aggregation of Arctic soils is presumably not comparable to stabilization processes of soil organic matter (OM) in temperate soils due to freezing-thawing processes. However, we identified distinct soil horizons with a visible structure and measured a nearly linear trend in decreasing 14C contents with depth indicate that the soil is little mixed by cryoturbation. There is a recent PhD-thesis where soil aggregation is identified as existing process in permafrost soils of tussock tundra in Alaska (Simpson 2010, PhD-Thesis, Colorado State University).

"With this respect, I would like to ask the authors to present some data on soil structure in the different horizons. Generally, a soil description is almost completely lacking. What was the sampling strategy, according to soil horizons or to sedimentation layers?"

- We presently performed no investigation of soil structure but focused on analyzing the composition and 'age' of different soil fractions. We added information on soil types,

horizons and texture section 2.1 (lines 115-119) and in Table 1. Because of the results of this study we will analyze Fe and Al oxide in a subsequent study as potentially important structural factor and OM protection mechanism.

"... Indeed it looks like that almost all fractions are showing roughly the same 14C age than the bulk soil; just free particulate organic matter (i.e., fresh plant residues) is younger and the fine sand is older."

- The coarse and medium silt size fraction (6.3 – 63 μm) show depleted 14C contents, which are significantly different 14C contents (2 sigma level) from bulk soil 14C values! The fine fractions (<2 – 20 μm) as well as the density fractions yield quite similar concentrations as the bulk soil but still showed trends of younger material in fPOM and clay.

"... Further, it would be nice if the authors can work out a bit closer what do they mean with recalcitrance. Is it that the plants at the site are build up by recalcitrant substances or is it rather the specific soil environment that is responsible for the high 14C age?"

- Recalcitrance is a term, which is widely used in the soil science community (e.g. Marschner et al. 2008, JSSPN) especially by modellers (e.g. Parton et al. 1987, SSSAJ; Six et al. 2002, Plant and Soil) as well as in the marine community (summarized by Zonneveld et al. 2010; BGS) and thus we decided that it needs no further explanation or definition. We added some information in line 68-70: '... physical protection mechanisms were found to be more important for soil OM stabilisation than (intrinsic) chemical recalcitrance of organic compounds (Marschner et al., 2008).'

Minor comments:

"p. 12344, l. 7 (line 15): "... surprisingly low and strongly increasing apparent 14C ages ..."; "low" has to be replaced by "high", or?"

- Changed as suggested.

"p. 12345, l. 10-12 (line 43/44): There are a few studies dealing with the plant material

and soil organic matter in the hinterland of Laptev Sea."

- To my knowledge no detailed studies to soil organic matter in the hinterland (on land) in the drainage basin of the Lena River exist, except of some studies focusing on methane emissions (e.g. Flessa et al. 2008, JSSPN; Mackelprang et al. 2011, Nature). Furthermore, there are several studies inferring vegetation and soil export to Arctic rivers/ocean from analyses of dissolved and particular organic matter in rivers as well as sedimentary organic matter (rivers, ocean) a (e.g. Schubert and Stein, 1997, Marine Geology; Dittmar and Kattner, 2003, Marine Chemistry; Karlsson et al., 2011, BGS; Semiletov et al., 2011, BGS; Vonk et al., 2012, Nature).

"p. 12348, l. 28: A mass recovery of 97-99%from the 8 fractions is simply great."

"p. 12351, l. 6 (line 204-206): What is "decomposed organic litter layer"? Decomposition of litter usually leads to the formation of Oe or Oa organic surface layers, or – as is the case here, considering a total organic carbon concentration of 30 g/kg – to incorporation into the mineral soil and formation of a mineral A horizons."

- We changed the sentence to the following: 'The active layer consists of an upper 6 cm mineral soil layer with high root penetration and a 19 cm thick mineral soil with little root penetration.'

"p. 12351, l. 7-8 (line 207-208): Mosses do not have roots."

- The sentence was corrected, mosses have been excluded.

"p. 12351, l. 12-13 (line 208-209) : The authors report that they were sampling a sand lense (from 6-11 cm). Is it really just a lense or is it rather a whole layer, characterizing some sedimentation events. Again, this stresses on the importance of a more representative soil sampling."

- We changed this to 'sandy layer' because it appeared to be present in a larger area.

"p. 12354, l. 9 (line 291): The term "upper permafrost soil" is not correct, as the active

layer is also part of the permafrost soil; rather call it "upper permafrost layer”."

- Throughout the whole paper the term “upper permafrost soil” was changed into “upper permafrost layer” or “uppermost still frozen permafrost (layer)”.

"p. 12357, l. 6 (line 374): Here, the authors are stating that there is no cryoturbation in the soil, while at p. 12356, l. 20 the texture difference was explained to be partly due to cryoturbation. What is true?"

- The nearly linear 14C decreasing with depth suggested that there was little cryoturbation in the polygon rim therefore the sentence at p.12356, l. 20 (line 362) was changed.

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*Line numbers in brackets refer to lines in revised word-document.

Interactive comment on Biogeosciences Discuss., 9, 12343, 2012.