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# *Interactive comment on* "Whole-lake spatial variability of organic matter molecular composition and elemental inorganic properties in a small boreal Swedish lake" *by* Julie Tolu et al.

**Anonymous Referee #1**

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General Comments

This study explores the spatial variability in sediment geochemistry of a small boreal lake in order to better understand the processes that influence the concentrations of organic and inorganic constituents across a lake bottom. It analyzes a large array of surface sediment samples for major and trace elements and the molecular composition of organic matter (by pyrolysis-GC-MS) and uses standard multivariate methods (PCA, cluster analysis) to summarize a spatially coherent set of sedimentary "facies" that demonstrate correspondence between the organic and inorganic constituents. The results are interpreted in terms of organic matter sources (algae, aquatic plants, terrestrial plants), physical transport within the basin (focusing) and chemical transforma-



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Discussion paper

tion (decomposition, redox cycling) within the lake. In the deeper main basin of the lake, focusing is a dominant driver (as would be expected), although differences in OM mineralization between shallow (oxygenated) and profundal regions are an important overprint on algal OM composition. In a separate and shallower subbasin, there is less spatial differentiation in sediment quality, which is attributed to inhibition of focusing by macrophytes that dominate the OM molecular signal in this part of the lake.

Overall this is a fine study that builds on previous investigations of sedimentary processes in lakes. Its major contribution is the addition of detailed OM signatures that reveal both local provenance and degradation processes as well as a secondary influence on the distribution of inorganic (elemental) constituents. Interpretations are largely sound, though they are mostly descriptive explanations for the observed patterns. The larger implication of the paper is that care must be taken in using a single (or few) sediment sample(s) to characterize sediment composition of an entire lake. In itself, this is not a particularly novel idea, but is rather well documented in this careful and comprehensive study. One might have hoped to see a quatititvie exploration of how far off the mark would be a single sediment sample from the “deep hole” – as might be sampled in a more typical lake survey or paleolimnological study.

Specific Comments

(1) The title does not mention “sediments”, which is a key word in the study, and the term “whole lake” is superfluous; suggested rewording: “Spatial variability of organic matter molecular composition and elemental geochemistry of sediments in a small boreal Swedish lake”.

(2) A short methods description for sample collection and processing is needed.

(3) In several places in the results section, the molecular signatures of higher (or terrestrial) sourced organic matter is attributed simply to “plants” (e.g. lines 279, 380, 465, 466, 503). To some readers, this might also mean algae or aquatic macrophytes. Suggest changing to “terrestrial plants” or (if including macrophytes) “higher plants”.

(4) In lines 438-441 an interesting trend of decreasing bSi from shallow to deep is attributed to the predominance of benthic diatom production in this clear, acidified lake. This is a reasonable argument, but it stops short of saying that there is lower diatom production in off-shore regions, presumably because of light limitation with increasing water depth.

(5) In lines 449-453 the depth-linked trend in algal OM degradation is attributed to greater exposure of shallow-water sediments to oxygen (as compared to profundal sediments). However, there could be another factor at play here – higher rates of sediment burial in deeper regions owing to focusing, which would also enhance preservation.

(6) Redox conditions are used to explain (in part) the distribution of Fe, Mn, P, etc., which is quite reasonable, as far as it goes. But much of the amorphous Fe and Mn entering lakes is delivered via shallow groundwater discharge, and it is not uncommon to find Fe enriched surface sediments in areas that such waters are discharged. Also Fe and Mn enrichment can be enhanced by diagenesis and diffusion within the sediment column. The discussion of redox elements needs to take these other processes into account.

(7) Elemental geochemistry was analyzed by WD-XRF, and as such represents bulk properties of the sediment. This is fine for elements that are largely confined to the silicate fraction of the sediment (e.g. Mg, Na, K), but can be misleading when there are multiple phases with different provenance – which is especially so for Fe, Mn, Ca, and sometimes Al. While most interpretation of these "mixed-phase" elements seem correct, there should be some mention of the fact that Fe in particular could reflect both transport of detrital material and solution transport of dissolved or amorphous phases.

(8) In lines 536-541 the high concentrations of S along with trace metals, Hg, Pb, Zn are ascribed to the accumulation of atmospheric pollutants in sheltered bays "...more protected from wind circulation". This seems like a pretty weak argument in that it invokes very localized deposition for which there is not much evidence or theoretical

mechanism. An alternative explanation is that the local enrichment is a consequence of the preferential accumulation of metal sulfides – for reasons related to redox cycling or near-shore groundwater gradients.

Technical Corrections

(line 1) Change to read: “The composition of sediment organic matter . . .”

(line 75) Change to read: “Beyond the rapidity of analysis and . . .” (delete “in terms’)

(lines 84-85) Change to read: “. . . which factors or processes (e.g. provenance, transport pathway, mineralization). . .”

(line 93) Change to read: “This culturally acidified, clear-water . . .”

(line 101) Change “which” to “that”

(line 153) Insert “sediments” after “Härsvatten”

(liner 279) Change “On the contrary” to “In contrast”

(line 308) Change “readily assimilated” to “readily mineralized”

(lines 331-332) Change to read: “. . . are resitant to degradation.”

(line 457) Change “bottoms” to “zones” or “regions”

(line 459) Change “south basin are” to “south basin is”

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