Dependence of Total Mercury in Superficial Peat With Nutrient Status: Implications for Stability of Peat as an Archive of Hg Deposition

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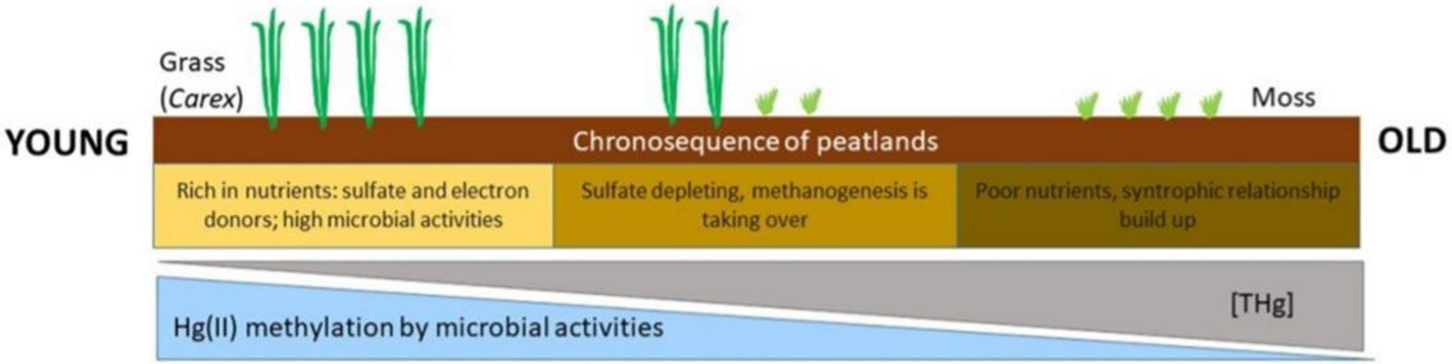
Introduction



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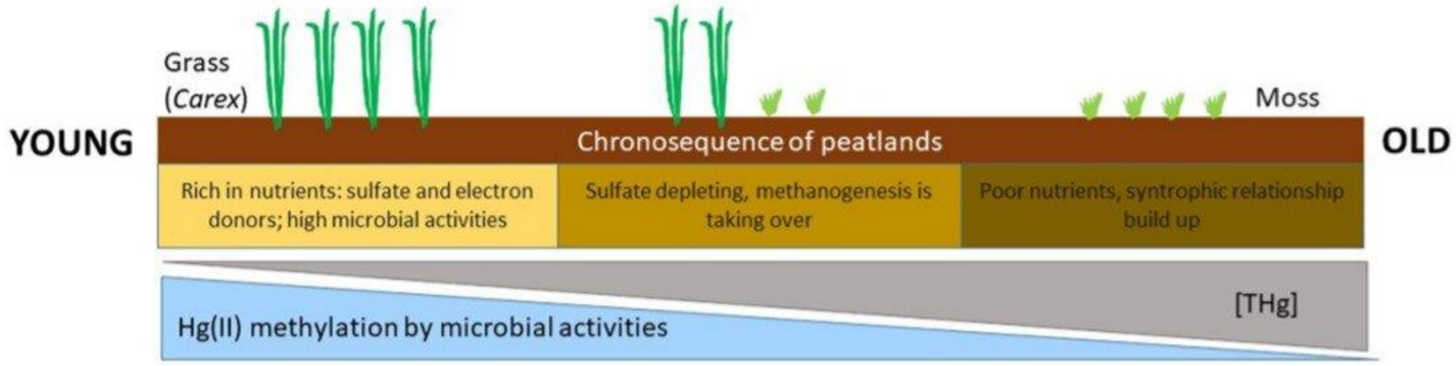
- Though peatlands are widely utilized as palaeoclimatological archives[1,2,3], Hg retention in peat is not fully understood. Hg can for example be re-emitted to the atmosphere after deposition or transported to downstream ecosystems[4]
- At a peatland chronosequence (see figure) near Umeå, Sweden, a study suggested that the mobility of Hg in peatlands was increased with Hg methylation, due to lateral runoff or re-emission (likely the latter)[5]. The basis for this conclusion was that the proportion of methylmercury (MeHg) was correlated with the total Hg (THg). The %MeHg (of THg) were particularly high at young nutrient rich mires. It was also shown that the nutrient rich mires contained less THg, suggesting that the same process that methylates Hg promotes Hg mobility. Based on this, the authors of that study[5] suggested looking more closely at THg content in relation to methylation potential, which correlates with peatland nutrient status and mire age

Introduction



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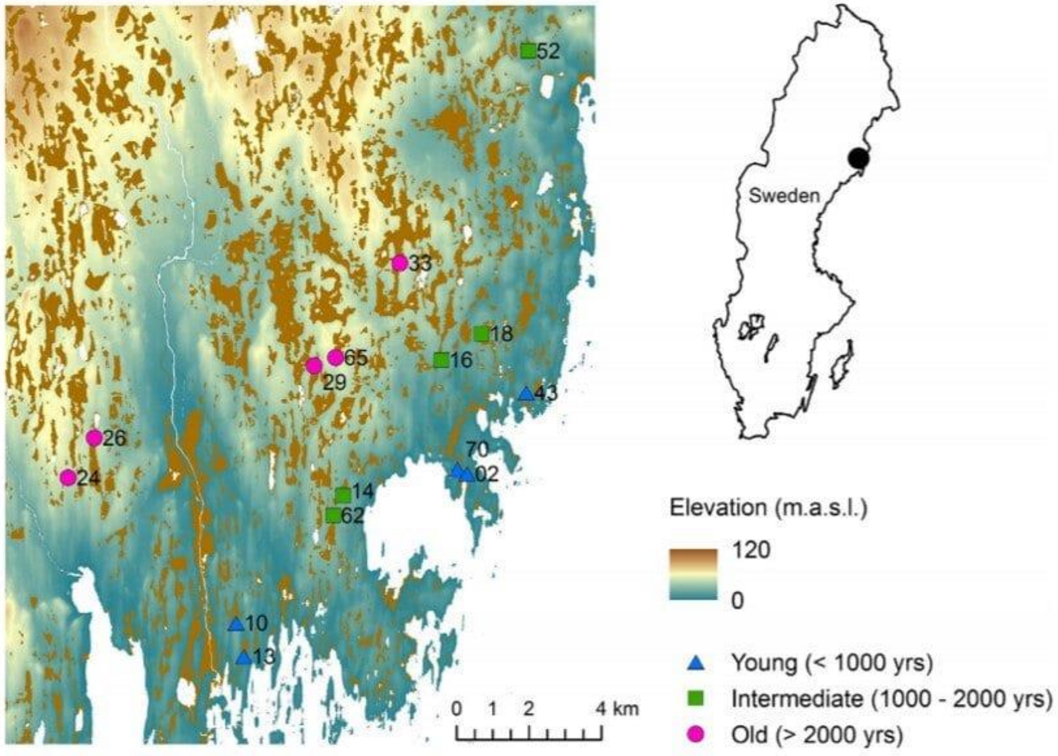
- Based on THg depth profiles in the superficial 50 cm of the mire, this study examines the hypothesis that MeHg makes Hg more susceptible to mobilisation with three research questions:

- [RQ1] *Do the chronosequence mires accumulate Hg from the atmosphere into the surface peat at similar concentrations?*
- [RQ2] *Is the distribution of the Hg in the top 50 cm similar along the chronosequence?*
- [RQ3] *Are the chronosequence mires similar in their retention of Hg?*

Methods – Site description

- The study site is located close to the coast of the Baltic Sea near Umeå, Sweden. The peatlands studied herein are created by the isostatic rebound from the last glacial maximum in Scandinavia. Older peatlands are therefore found as the elevation and the distance from the coast increases
- The peatlands are all located within a distance of 10 km, thus the mire catchments are exposed to similar climate and atmospheric Hg concentration



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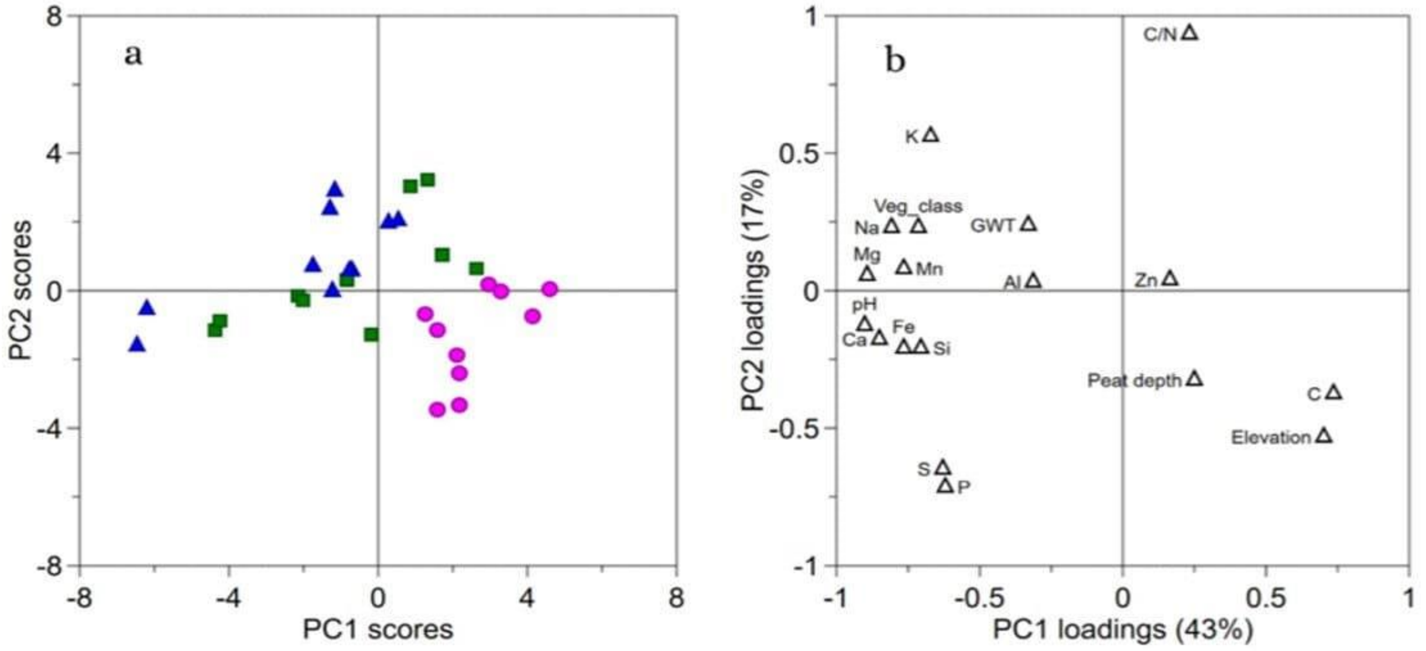
Methods – Site description

- The chronosequence peatlands are divided into three age classes: young (blue triangles) (< 1000 years old), intermediate (green squares) (1000-2000 y/o), and old (pink dots) (> 2000 y/o)
- The defining characteristics for the different age classes are nutrient availability, carbon (C) content, vegetation, pH, and elevation



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Young mire – High in sedges

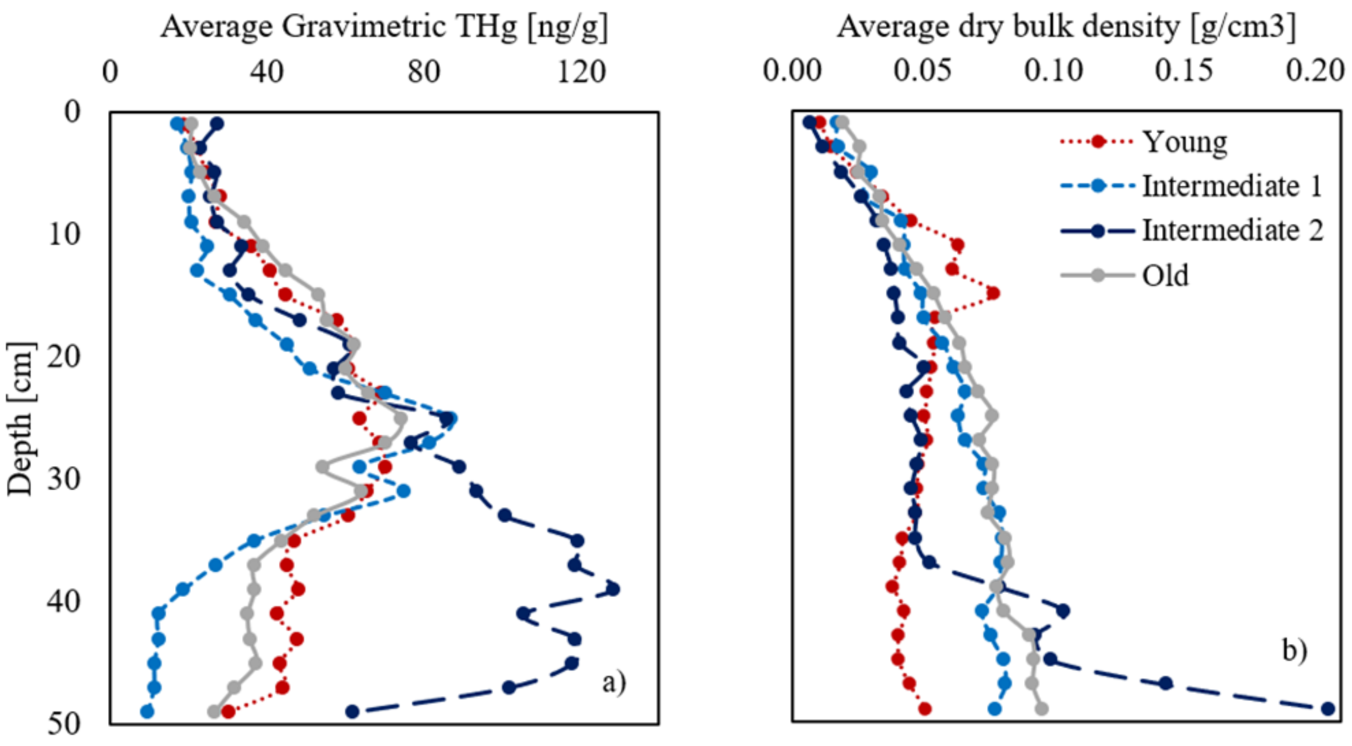
Old mire – Low in sedges

Methods – Sampling

- 20 peat cores (0-50 cm from mire surface) were collected close to the centre of the mire using a circular stainless-steel corer and 15.1 ⌀ cm PVC plastic tubes

Results – THg and dry bulk density profiles (lawn microtopography)

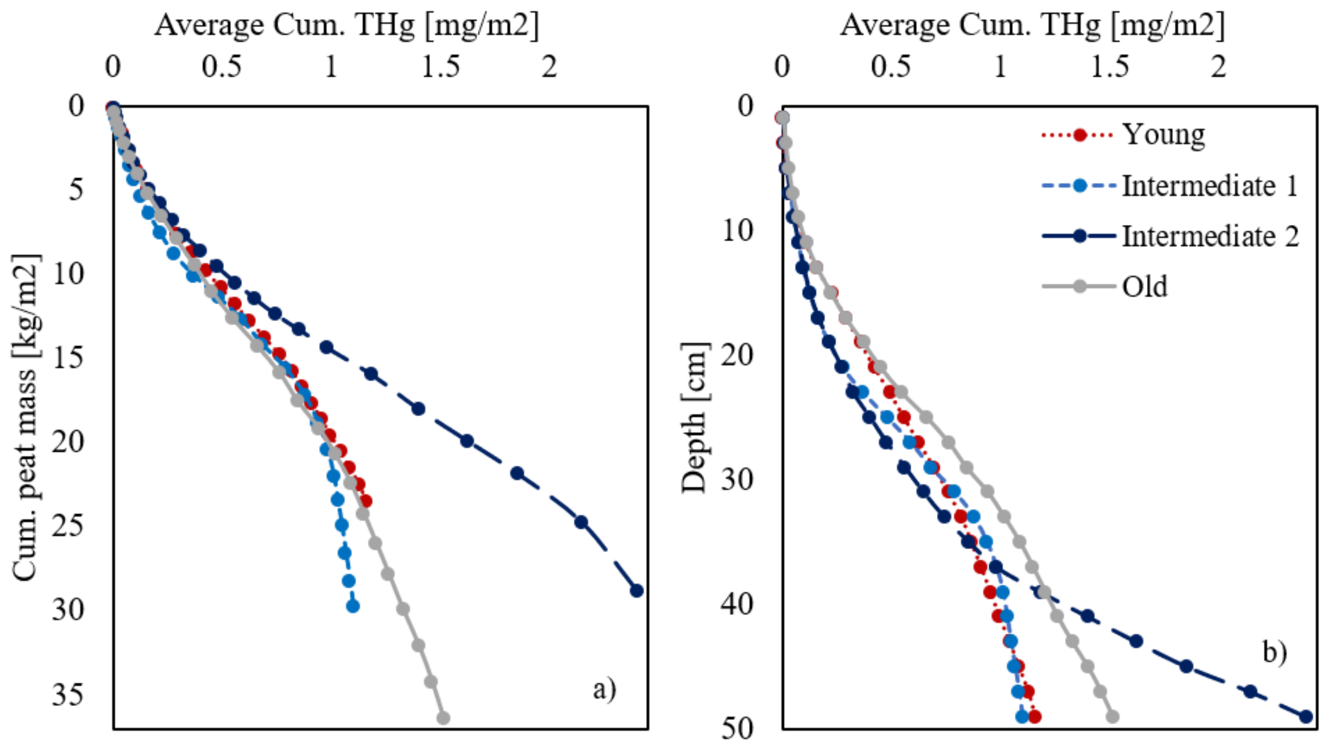
- THg concentration and dry bulk density of young (2 mires, 4 peat cores), intermediate (2 mires, 4 peat cores), and old mires (4 mires, 8 peat cores) (lawn microtopography). There is a strong deviation among the two intermediate mires. They are thus divided into *intermediate mire 1 and 2*
- THg concentrations are generally similar between young and old mires. The dry bulk density is however generally larger for old mires than for young mires



- Small hummocks are scattered over some mires (~25 cm over the base level). These microtopographical elevation maxima are commonly referred to as *hummocks,* while the mire base level is referred to as *lawn* (or *hollow*). A difference between hummocks and lawns is the distance to the groundwater table (GWT). Typical distance to the GWT for hummocks is 25-50 cm, and the lawn is located close to the GWT (typically 5-15 cm). Lawn and hummock profiles are reported separately

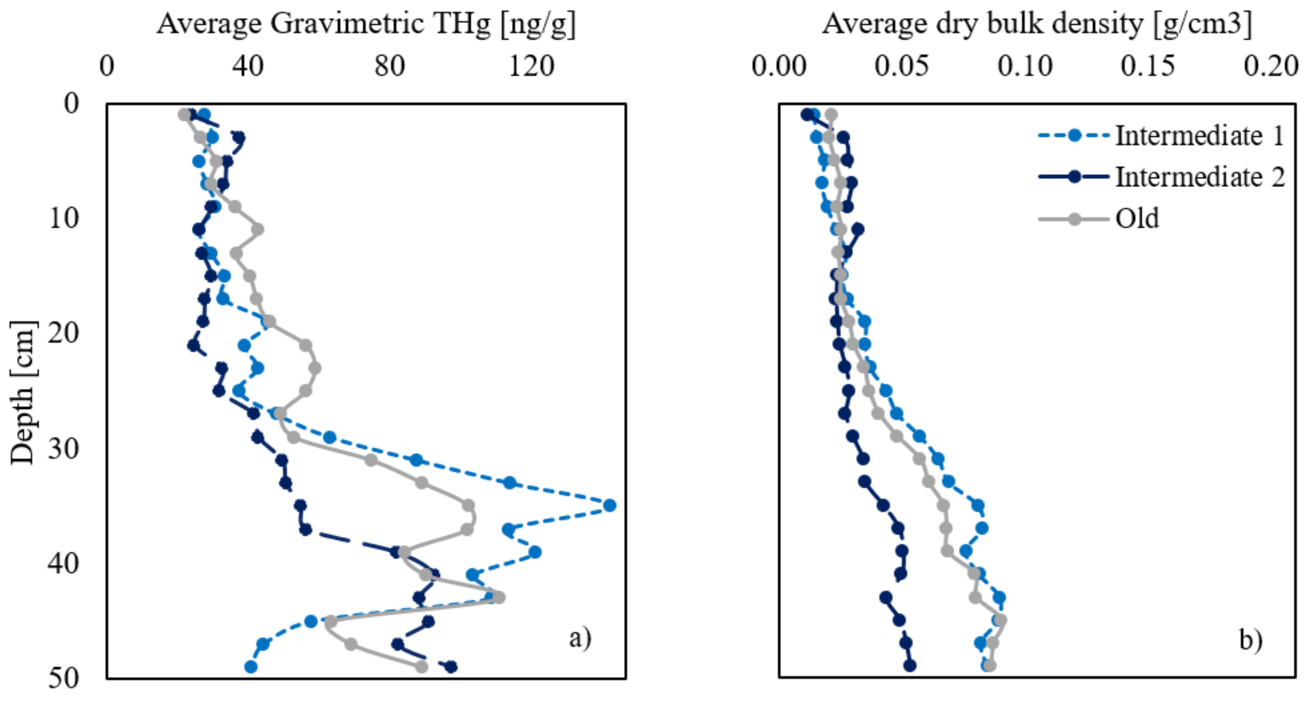
Results - Cumulative THg and peat mass (lawn)

- Cumulative THg vs. cumulative dry peat mass (a) and mire depth (b) for young, intermediate, and old mires (lawn microtopography)
- More THg is accumulated in old mires than in young mires. This difference is however driven by more accumulated peat down to 50 at old mires than at young mires



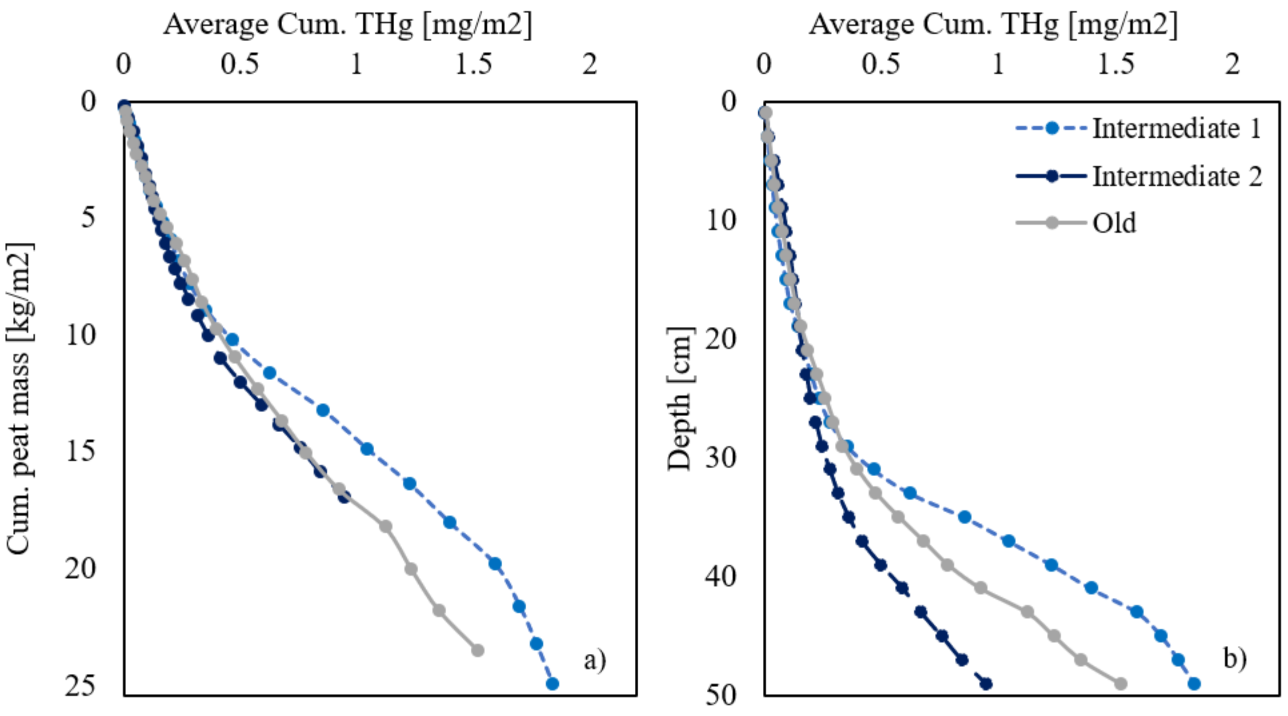
Results - THg and dry bulk density profiles (hummock)

- THg concentration and dry bulk density for intermediate and old mires (hummock microtopography)
- There is no difference in THg concentration and dry bulk density between intermediate and old mires. The deviation among the two intermediate mires is strong also for the hummock microtopography



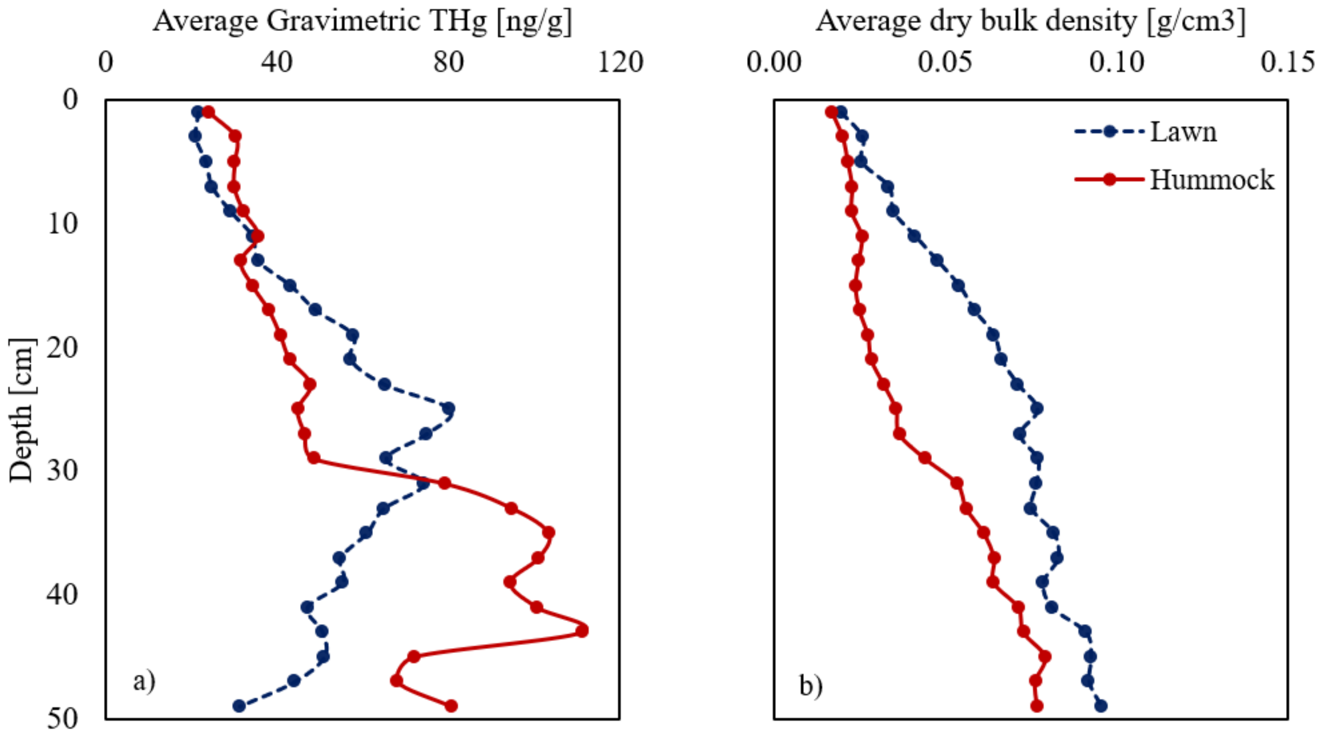
Results - Cumulative THg and peat mass (hummock)

- Cumulative THg vs. cumulative dry peat mass (a) and mire depth (b) for intermediate and old mires (hummock microtopography)
- Cumulative THg is closely related to accumulation of peat



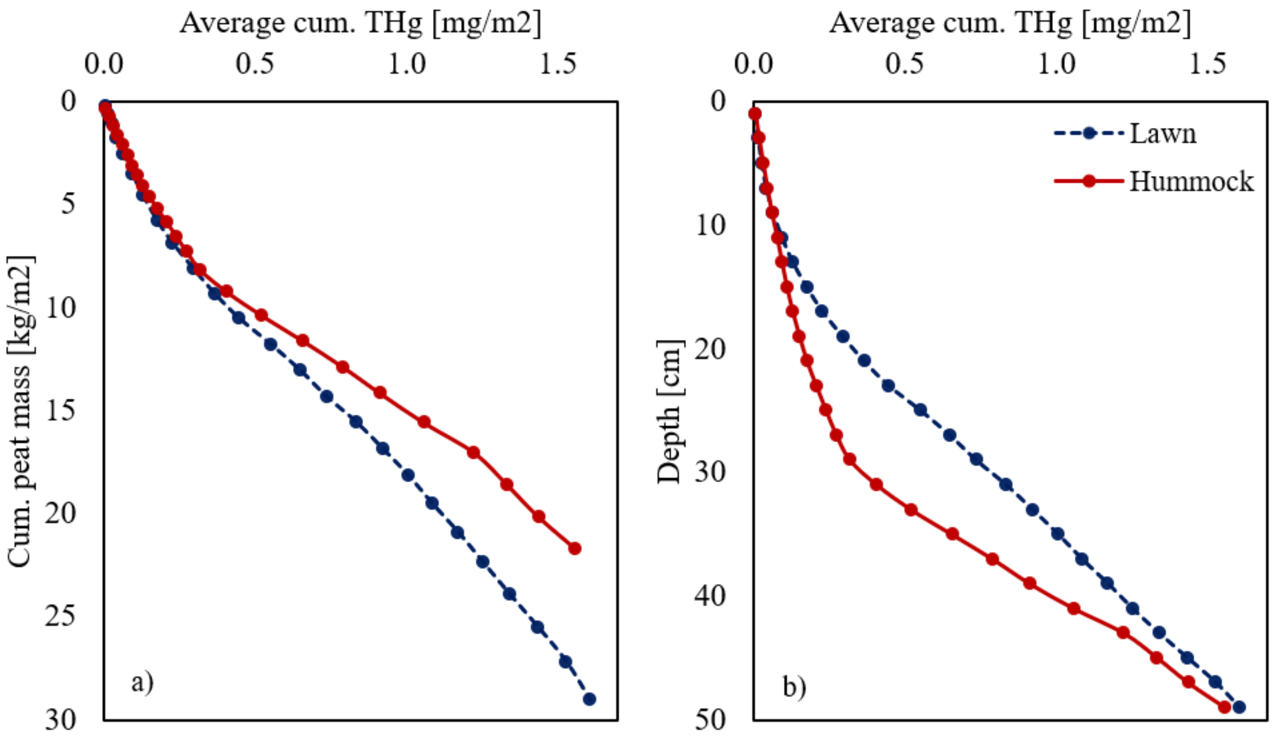
Results - THg and dry bulk density profiles (lawn and hummock comparison)

- Average THg concentration and dry bulk density for lawn and hummock microtopographies
- As stated earlier, a key difference between the two microtopographies are the distance to the GWT. Though the GWT was not measured in the field, it is likely that the THg maximum appears at the same distance to the GWT for hummock and lawns



Results - Cumulative THg and peat mass (lawn and hummock comparison)

- Average cumulative THg vs. cumulative dry peat mass (a) and mire depth (b) for the lawn and hummock microtopography
- More peat is accumulated at the lawn microtopography. The cumulative THg is however similar for lawn and hummocks



Summary of results

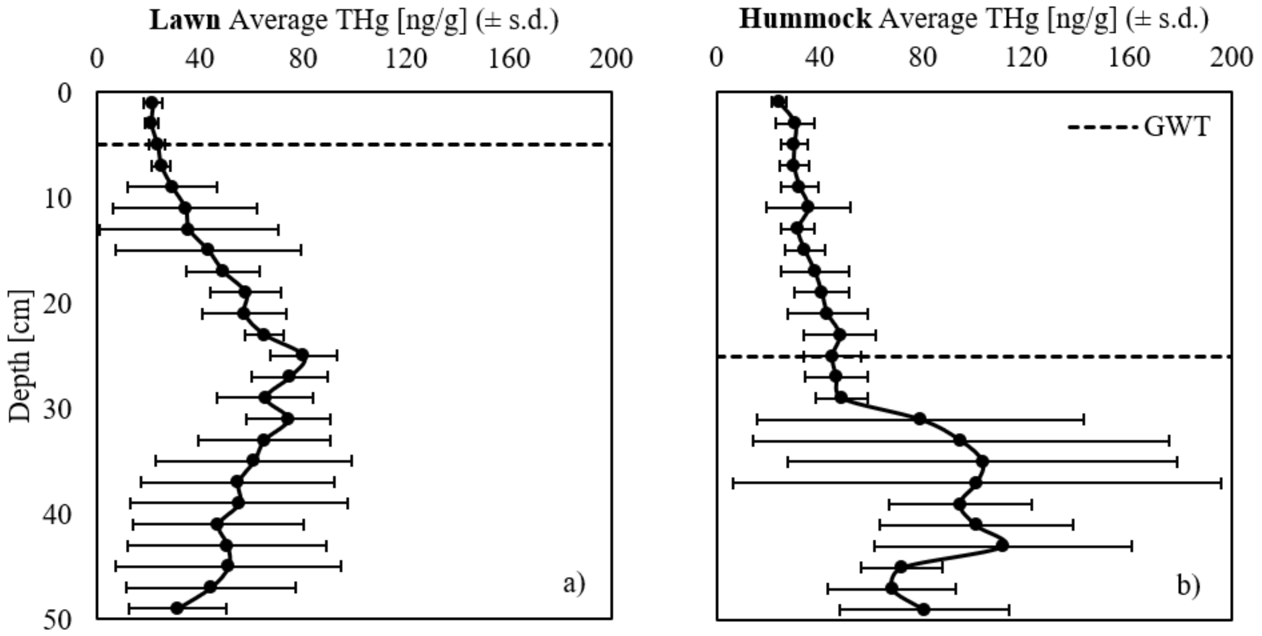
- The average Hg concentrations at 0-2 cm mire depth of young, intermediate, and old mires are not significantly different
- Though the total amount of Hg accumulated in the 0-50 cm peat layer increases with mire age, there is also an increase in peat accumulation (according to peat mass) as the mires age (only considering the superficial 50 cm)

Observation	Young Lawn	Intermediate Lawn	Old Lawn	Intermediate Hummock	Old Hummock
Median cumulative THg [mg m^{-2}]	1.4	1.6	1.3	1.3	1.6
[a]Median THg concentration [ng g^{-1}]	41	41	34	39	52
Median surface concentration [ng g^{-1}]	19	19	20	25	22
Median peak concentration [ng g^{-1}]	75	114	105	129	154
Median bottom concentration [ng g^{-1}]	32	33	21	68	74
Median THg peak depth [cm]	26	31	25	42	43
Median peat bulk density peak [g cm^{-3}]	0.067	0.13	0.10	0.076	0.083
Median peat bulk density bottom [g cm^{-3}]	0.041	0.12	0.093	0.064	0.065
Median total peat mass [kg m^{-2}]	23	30	33	21	22

Discussion

RQ1: Do the chronosequence mires get Hg from the atmosphere into the surface peat at the same rate? (surface peat gravimetric Hg concentrations)

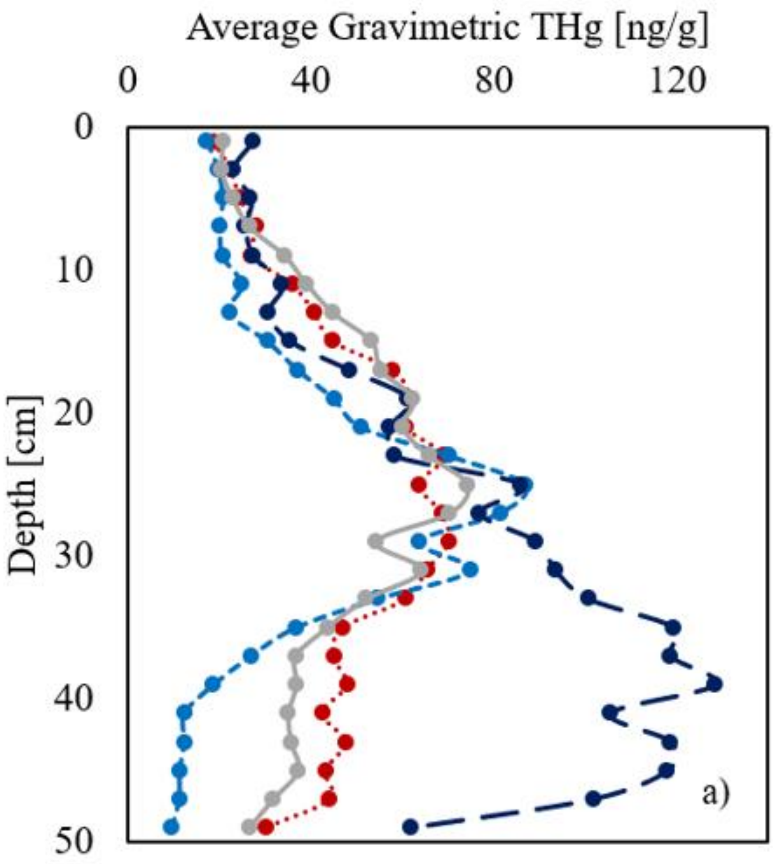
- The THg concentrations at the mire surface and topmost peat, is similar regardless of age classes and mire vegetation
- The similar Hg concentrations between vegetation species suggests that the Hg concentration in mire vegetation is proportional to the Hg concentration in the atmosphere (assuming that atmospheric input is the dominant source of Hg in vegetation)



Discussion

RQ2: Is the distribution of the Hg in the top 50 cm similar along the chronosequence (peak depth and magnitude, as well as bottom concentrations)

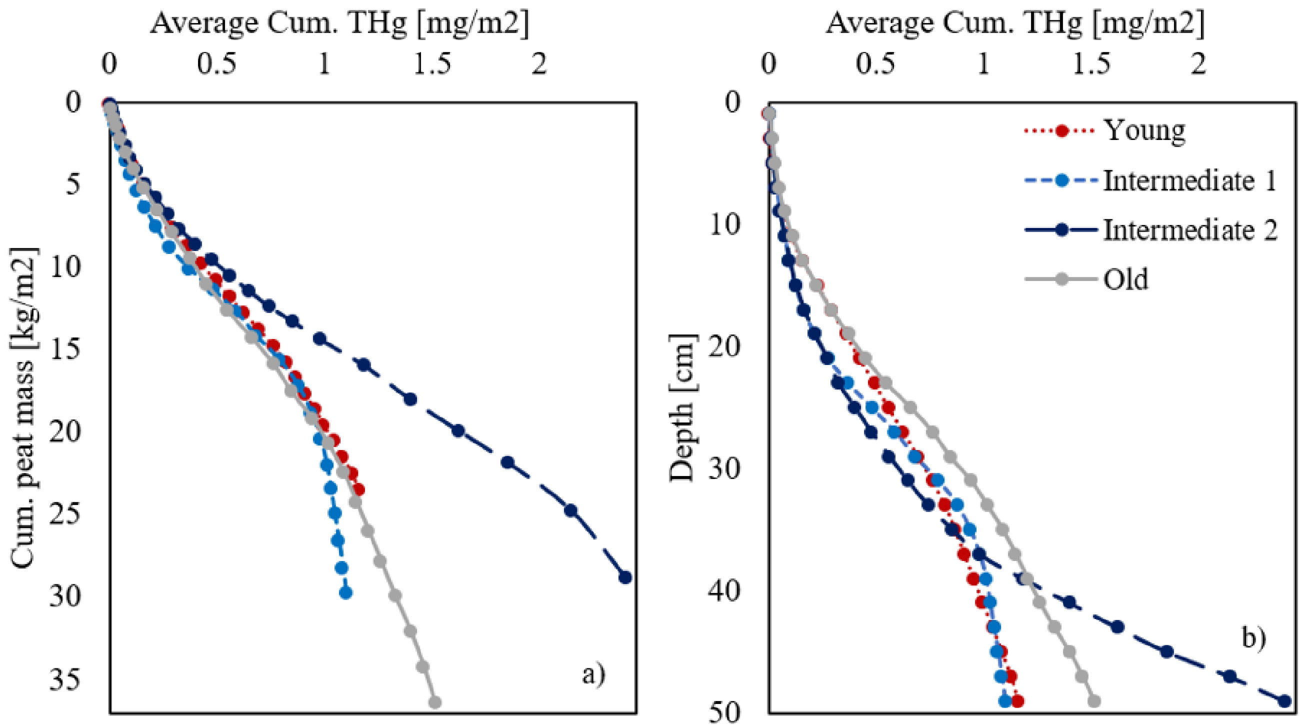
- The THg concentrations that Hg is equally, or even more efficiently, retained in young mires than old ones
- The general pattern of a distinct Hg peak at~ 25 cm (lawn microtopography), likely reflecting the maximum Hg concentration in the atmosphere, is commonly found in peatlands
- Hg enrichment since the industrial revolution is also documented in other archives, such as ice cores, and lake and marine sediments



Discussion

RQ3: Are the chronosequence mires similar in their retention of Hg? (cumulative Hg)

- The cumulative THg follows the pattern of young < old mires at the lawn microtopography (strong deviation among the intermediate mires)
- Hummock samples also indicate an increase in THg with mire age
- This supports the hypothesis that Hg mobility is greater in the younger mires with higher MeHg content
- It is assumed that the age of the superficial 50 cm peat is consistent throughout age classes. There *could* however be a difference in the net peat accumulation between the three age classes, due to differences in peat formation and decomposition rates



Conclusion

- Another study[5] at the site reported an inverse relationship between total Hg and %MeHg, suggesting that the same processes that methylate Hg also make it more susceptible to mobilization. This hypothesis was tested by observing high resolution depth profiles of total Hg content at mire depth 0-50 cm for mires with varying methylation potential (which also corresponds to a gradient; from young high methylating mires to old less methylating mires).
- We confirm that there in fact is a difference in cumulative Hg content along the mire chronosequence: Young mires generally contains less Hg than old mires. This difference is however driven by more accumulated peat down to 50 at old mires than at young mires, though Hg concentrations are generally consistent across the mire age gradient. To answer the question if high methylating mires retains less Hg, it will be crucial to know if the age of the superficial 50 cm peat is consistent throughout the chronosequence. The peat cores were namely not dated in this project.

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