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Evidence on Anaerobic Methane Oxidation (AOM) in a boreal cultivated peatland with natural and added electron acceptors

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Objectives

Anaerobic oxidation of methane (AOM) is a process of methane (CH_4) consumption under anoxic conditions driven by microorganisms, which oxidize CH_4 with various alternate electron acceptors (AEA): sulfate, nitrate, nitrite, metals-(Fe, Mn, Cu), organic compounds. Despite the global significance of AOM (up to 80% of the production!), the exact mechanisms and relevance of the process in terrestrial ecosystems are almost unknown. Therefore,

- AOM was measured in a **cultivated peat soil**
- $^{13}CH_4$ was used to estimate $^{13}C\text{-}CO_2$ as the product of AOM
- Two common AEAs were tested: **sulfate** (SO_4^{2-}) and **iron** (Fe^{3+})

Methods

- **Site:** Linnansuo, Eastern Finland (62°31'53.9''N 30°24'39.5''E) cultivated with energy crop *Phalaris arundinacea* (reed canarygrass) (**Fig. 1**)
- **Soil:** Cultivated Histosol (two horizons: 30 and 40 cm) and mineral sub-soil (sand, 50 cm)
- **Incubation:** 20 ml slurry in 100-ml N_2-flushed glass vials with 0.5-0.8% $^{13}CH_4$ (4.9 AT%) and 0.5 mmol K_2SO_4 and $FeCl_3$
- **Measurements:** [CH_4], [CO_2], [O_2], $\delta^{13}C$- CO_2 (in a glovebox)
- **Calculations:** isotope mixing model for AOM amount-

$$CO_{2_{AOM}} = \frac{\left(\left(CO_{2_{total}} * AT\%^{13}CO_{2_{total}}\right) - \left(CO_{2_{total}} * AT\%^{13}CO_{2_{respiration}}\right)\right)}{\left(AT\%^{13}CO_{2_{AOM}} - AT\%^{13}CO_{2_{respiration}}\right)}$$

Results

1. Oxygen dynamics revealed negligible O_2 contamination during incubation and its trace amounts (0.05-0.8% from the atmospheric) were accounted in the net CH_4 uptake.
2. The highest $^{13}CO_2$ enrichment (up to 60‰), was observed in mineral sub-soil (**Fig. 2**)
3. However AOM was quantitatively more pronounced in the upper 30 cm horizon (2138 vs. 210 ng CO_2 g soil DW^{-1} in the 50 cm sub-soil) (**Fig.3**)
4. The highest AOM rate of 8.9 ng CO_2 g soil DW^{-1} h^{-1} was estimated for the control treatment where no AEAs were added indicating sufficient amount of naturally available AEAs, likely organic compounds (**Fig. 4**)

Fig. 1 Linnansuo Research site, Eastern Finland

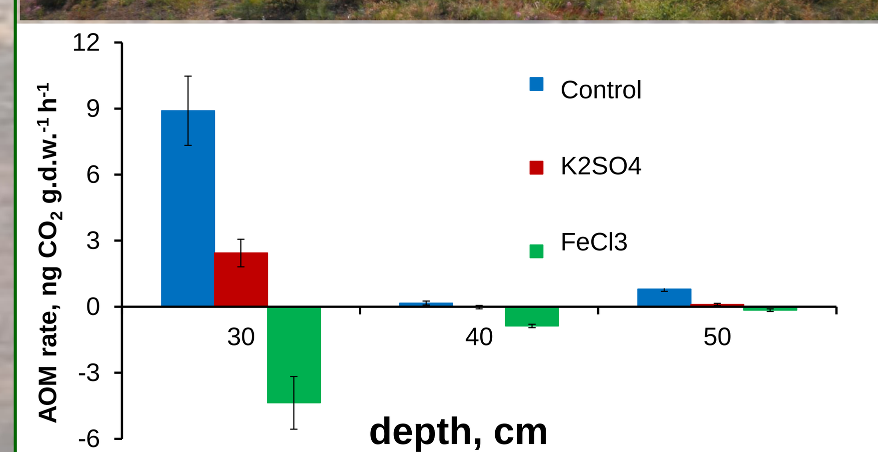

Fig.4 AOM-CO_2 rate in peat soil (30 and 40 cm depth) and mineral sub-soil (50 cm) amended with K_2SO_4 and $FeCl_3$. Negative AOM-CO_2 indicates either lack of the process or AOM is masked by intensive SOM-derived CO_2. Values are average of replicates (n=3).

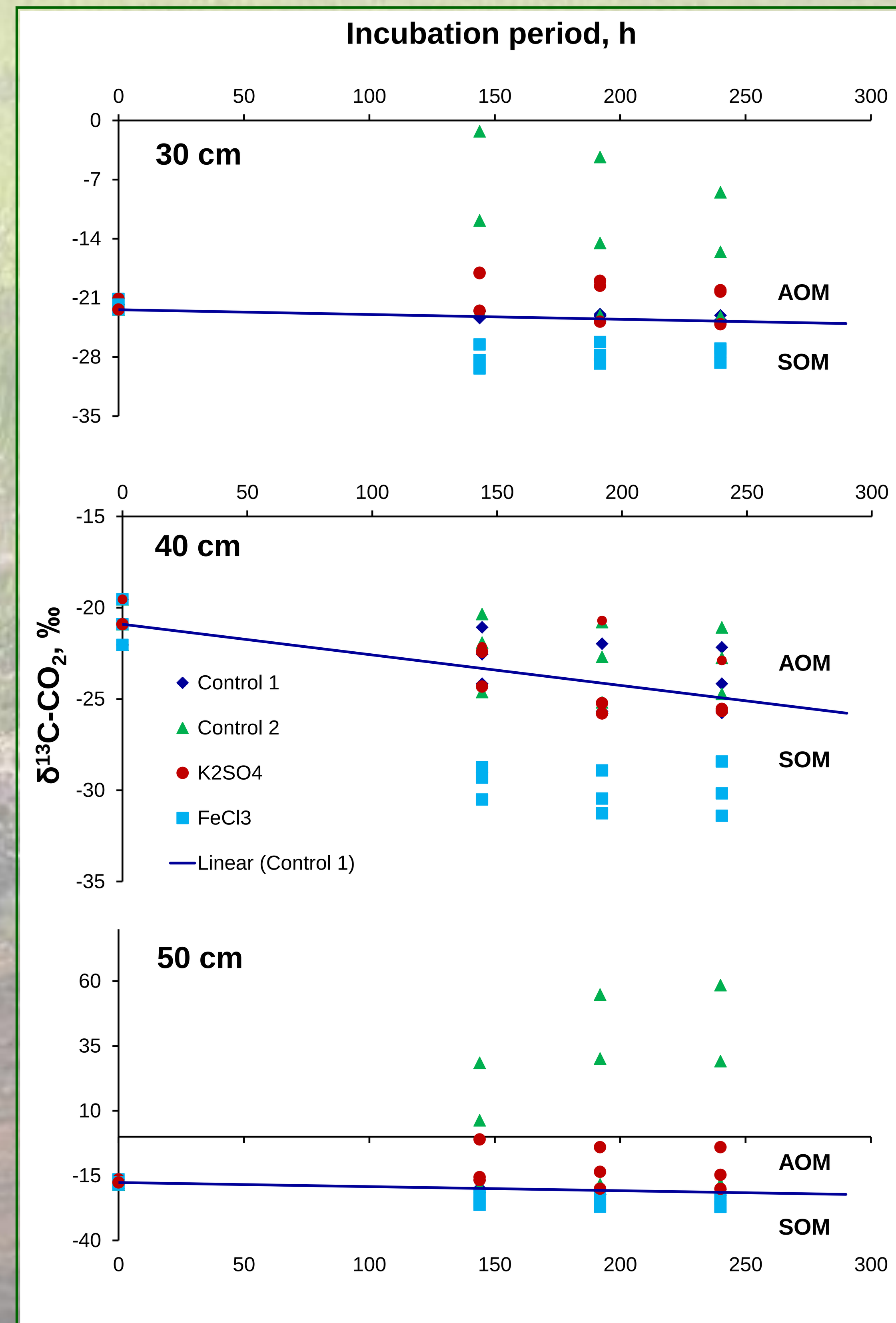

Fig.2 Isotopic composition of CO_2 during incubation of peat soil (30 and 40 cm depth) and mineral subsoil (50 cm) amended with K_2SO_4 and $FeCl_3$. Labeled CH_4 (4.9 AT%) was added to treatments Control 2, K_2SO_4 and $FeCl_3$. Enrichment of CO_2 above Control 1 indicates contribution of $^{13}C\text{-}CH_4$, e.g. AOM, whereas depletion corresponds to SOM decomposition. All replicates (n=3) of each treatment are shown.

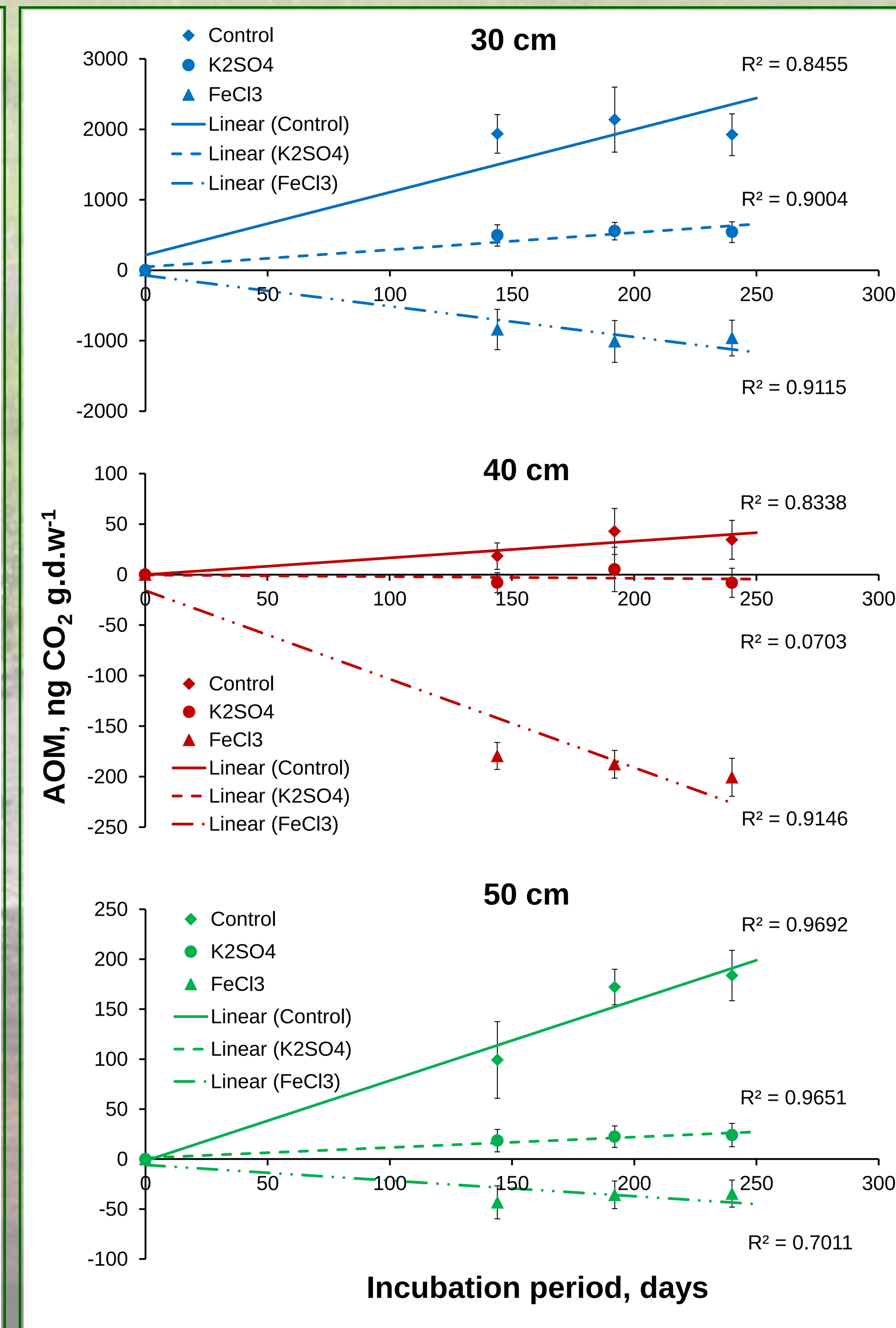

Fig.3 AOM as amount of CO_2 in peat soil (30 and 40 cm depth) and mineral subsoil (50 cm) amended with K_2SO_4 and $FeCl_3$. AOM-CO_2 was estimated with an isotope mixing model. Values are average of replicates (n=3).

Conclusions

- AOM occurred in profile of organic soil of a cultivated peatland under reed canarygrass. The rate was 50 times more intensive (on the C basis) than the CH_4 production potential of the same soil
- External AEAs decreased AOM rates but added Fe^{+3} stimulated decomposition of native SOM
- *Further AOM assessments may change the existing concept of carbon/CH_4 cycling in terrestrial ecosystems and could improve current process-based models of regional and global carbon balance*

SOIL SCIENCE of Temperate Ecosystems

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