Anammox may promote the anaerobic oxidation of methane (AOM) in cold wetland soils

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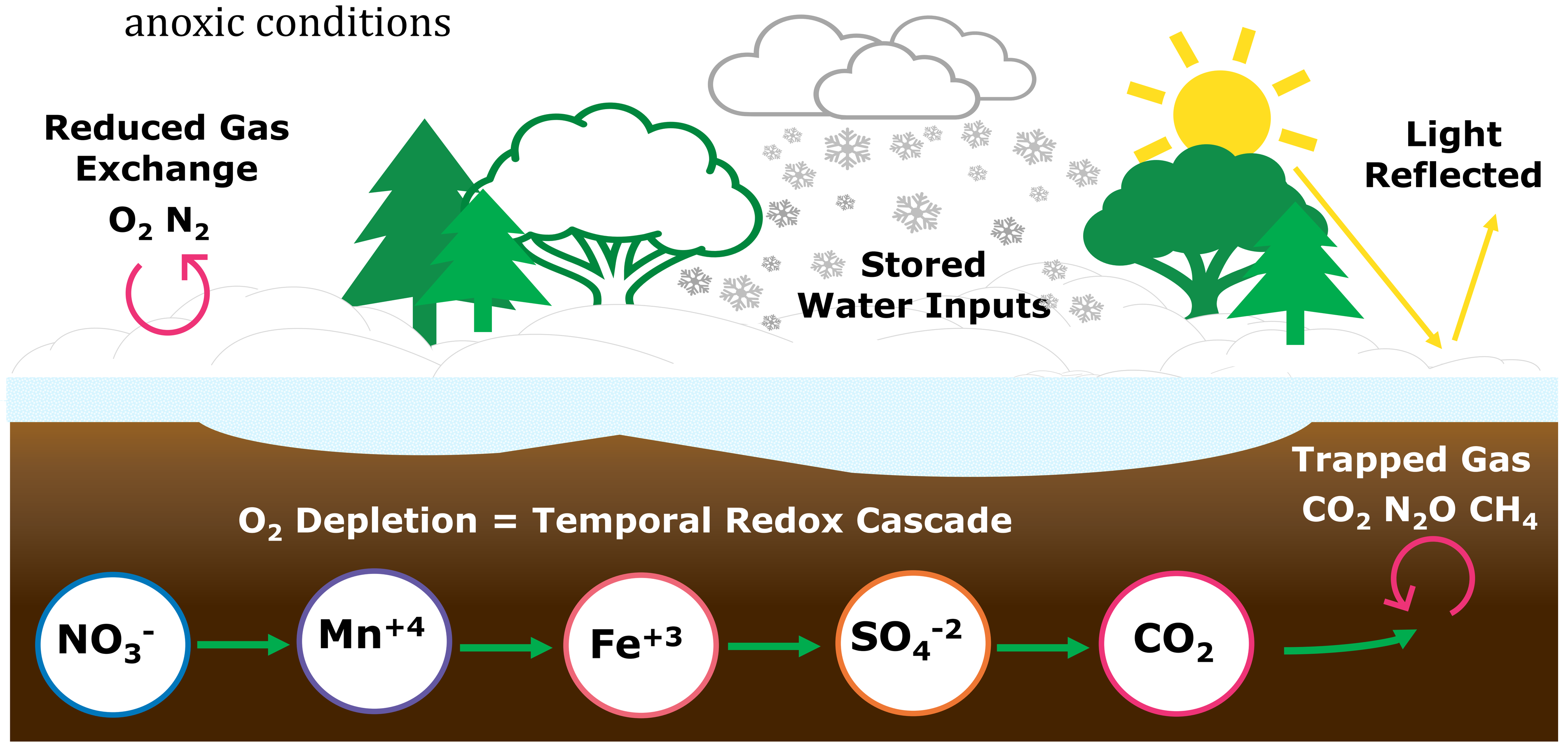
Winter Soil Biogeochemistry

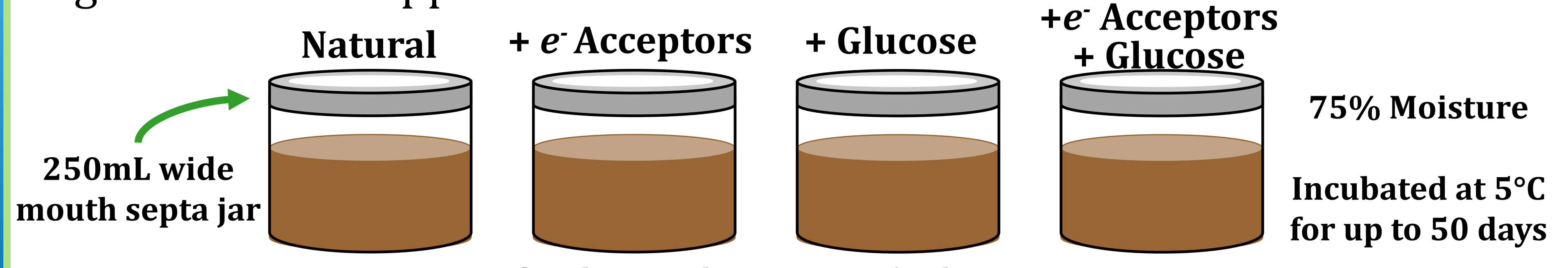
- Snow and frozen soil exert critical control over soil biogeochemistry
  - Reducing or **halting atmospheric gas exchange** and water inputs
- **Rising temperatures** will reduce snowcover and **create colder soils**
  - Affecting soil biogeochemical cycles via enhanced freezing, perpetuating anoxic conditions



- Cold region soils are **seasonally anoxic and closed to the atmosphere**
  - Build-up of "biogeochemical end-products" **reduced e^- acceptors** (*e.g.,* Fe^{2+}, H_2S, and NH_4^+) and methane (CH_4) can be **recycled in future reactions**
  - **Increased potential for the anaerobic methane oxidation (AOM)**
- This research aims to understand the temporal effects of closed and anoxic conditions on soil carbon and nitrogen cycles in cold wetlands

Materials & Methods

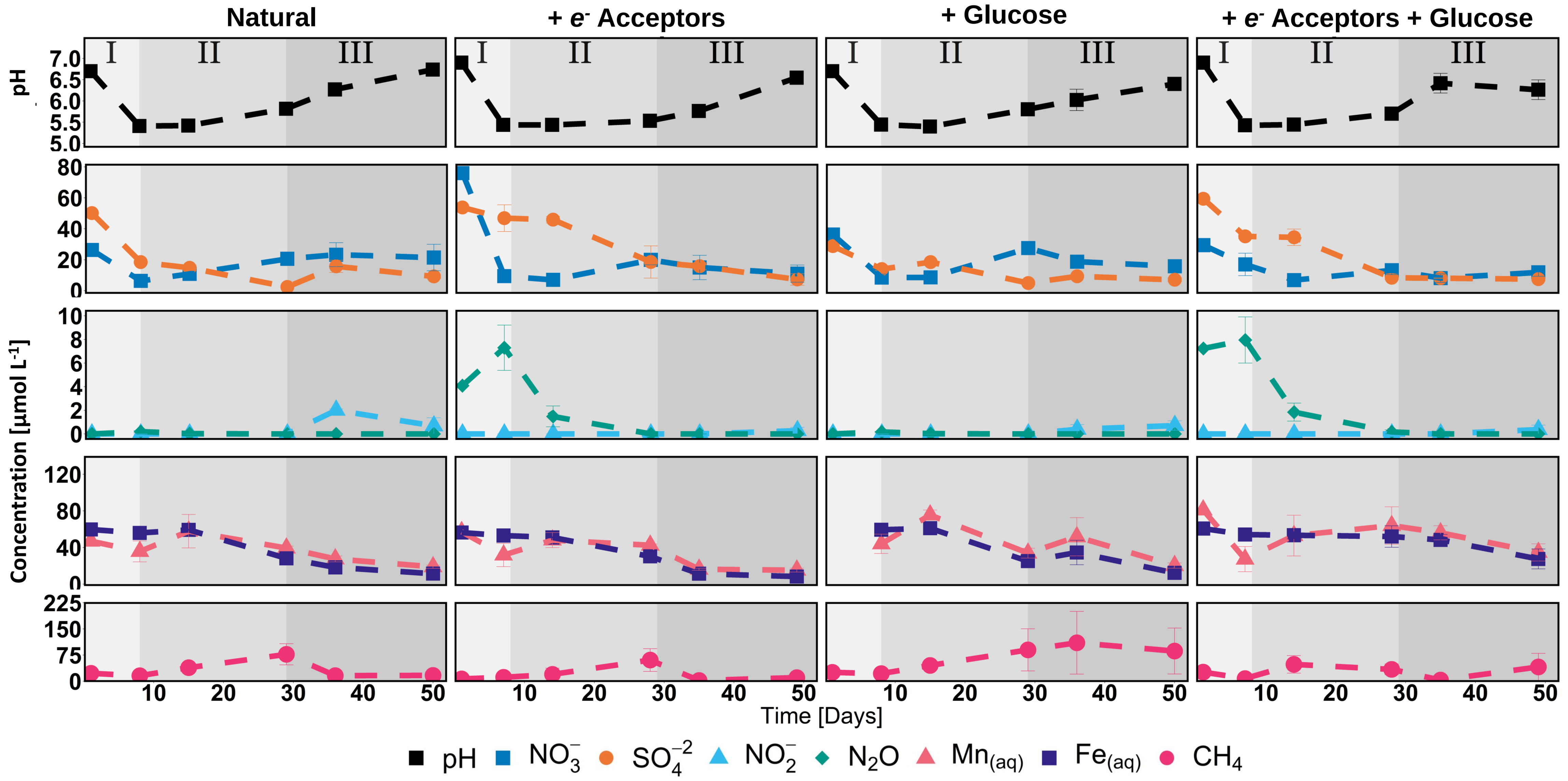
- Organic soil samples were collected from a swamp located at the Turkey Lakes Watershed near Sault Ste. Marie, Ontario
- Controlled concentrations of sulfate (SO_4^{2-}), nitrate (NO_3^-), and glucose were supplied to different soil treatments



Jars were sacrificed in triplicate over 50 days at 6 time points

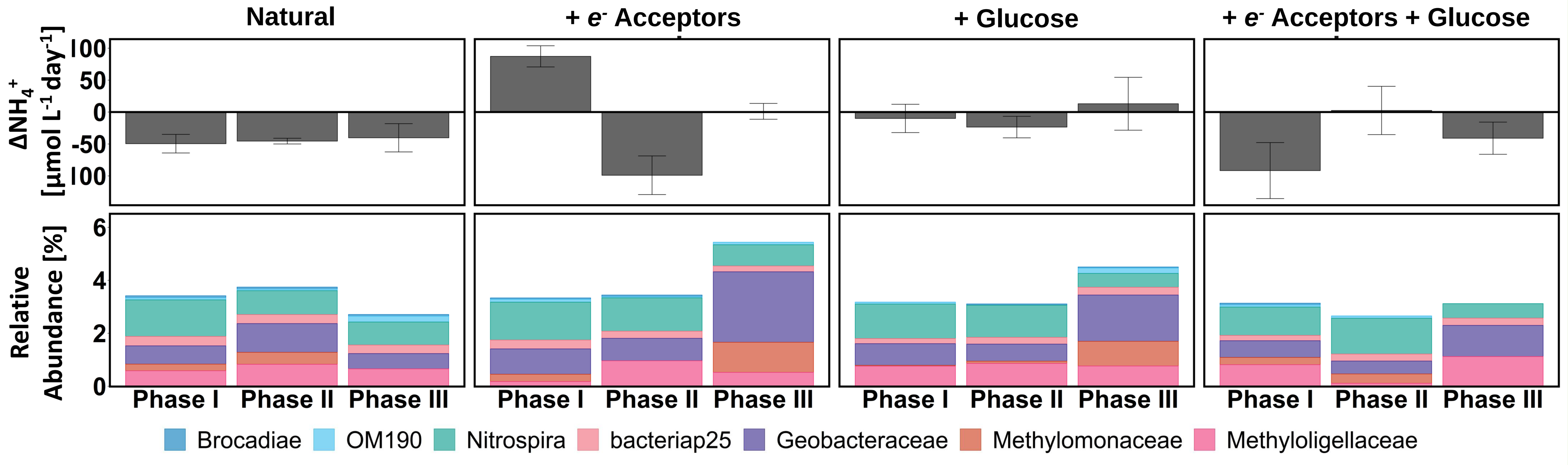
Biogeochemical Trends

- Three biogeochemical Phases (I, II, III) were observed over the incubation:
  - Denitrification (I), Sulfate Reduction & Methanogenesis (II) , AOM (III)



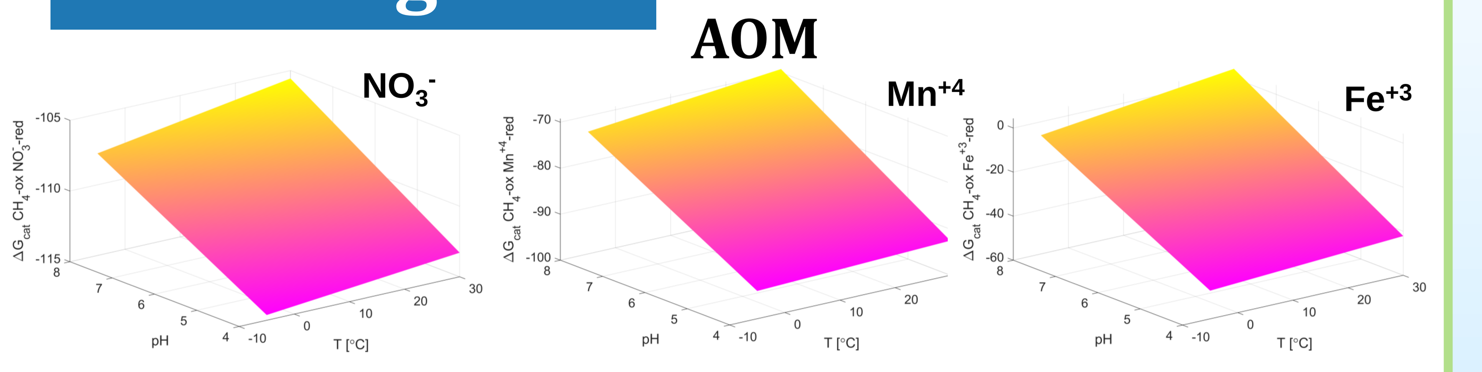
- **AOM** in Phase III significantly **increases pH** without an obvious e^- acceptor for oxidation

Anammox + Mn Reduction?

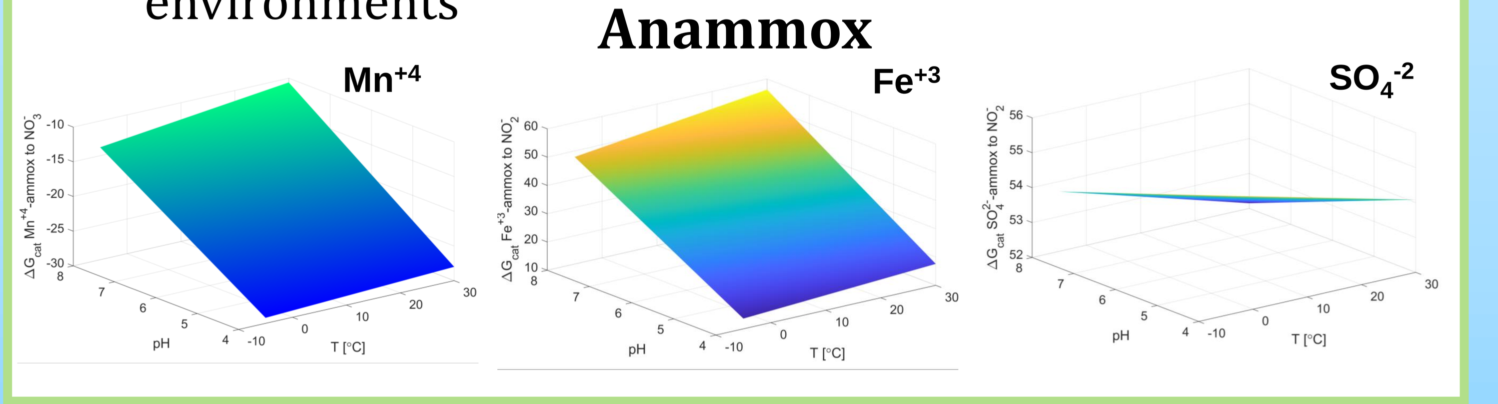


- **Increasing or NO_3^- and nitrite (NO_2^-)** concentrations occur alongside decreasing ammonium (NH_4^+) suggesting **complete anammox**
  - **Manganese (Mn) Oxides** are the only e^- acceptor energetically capable of anammox to NO_3^-
- Increasing Relative Abundances of Mn-reducers (*Geobacter-*) and methanotrophs (*Methyl-*)

Bioenergetics



- **AOM and anammox** are **most thermodynamically favourable under cold and acidic conditions**
  - $\Delta G_R \geq 0$ for SO_4^{2-} and Fe-oxides in warm basic conditions
- **Changes in pH** may **affect** future reaction (*e.g.,* AOM, anammox) **thermodynamics** within the experiment
  - Producing unfavourable conditions in poorly buffered environments



Conclusions

- A **microbial consortium** may couple **Mn-oxide reduction with anammox,** regenerating NO_3^-
  - Produced NO_3^- is used in future reactions, including AOM or dissimilatory NO_3^- reduction, recycling Fe or S
- pH rise from AOM may reduce the energy yields of CH_4 and NH_4^+ oxidation in a negative feedback loop
- **AOM and anammox** are potentially autotrophic, providing a small **seasonal carbon sink**

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