Dynamics of organic matter decomposition during iron redox fluctuations in soils

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Funding

NSF Critical Zone Observatory Program

–Luquillo CZO

–Calhoun CZO

NSF Ecosystems

NSF Geobio & Chem: Suschem

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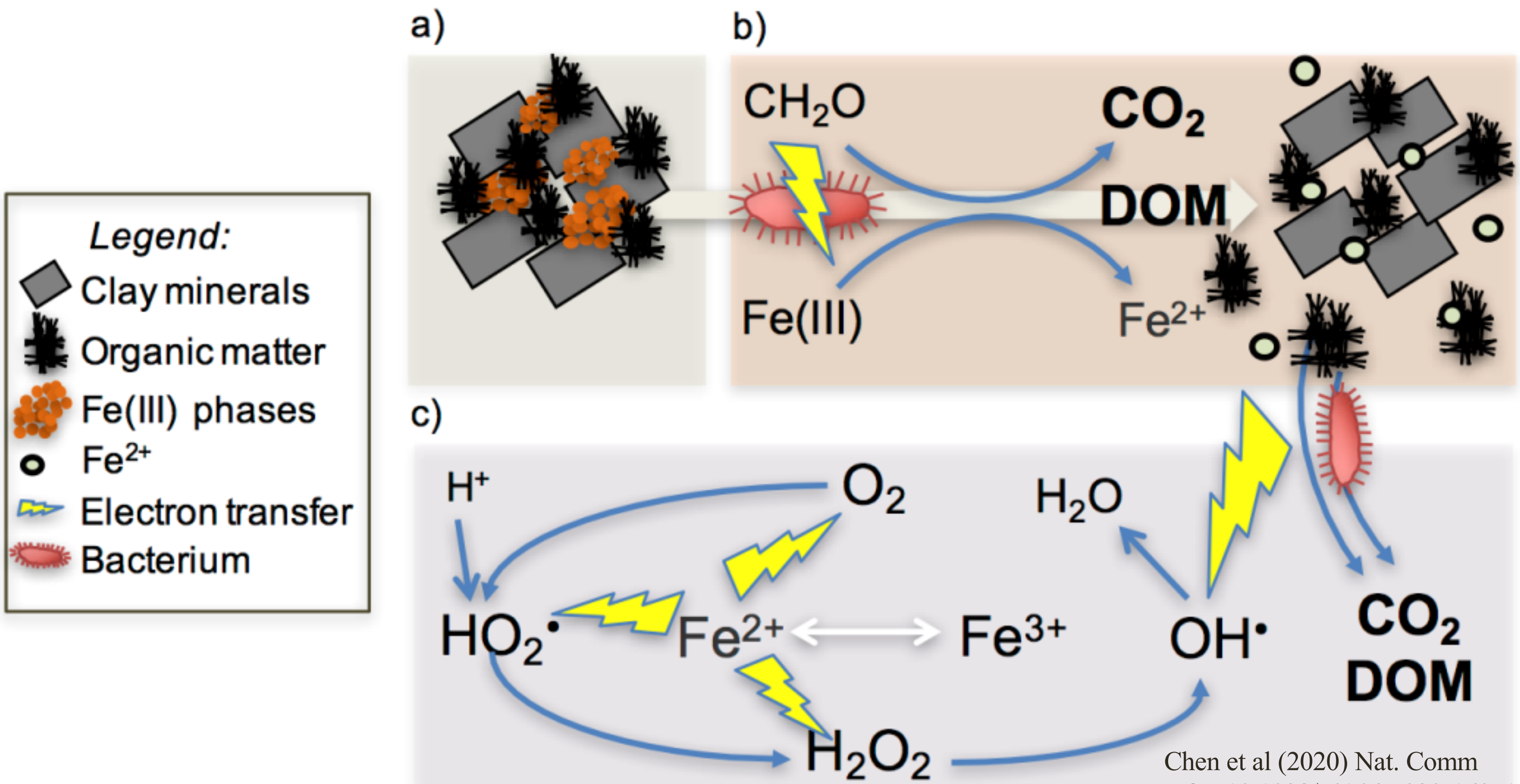
Chen, C., Hall, S. J., Coward, E., and Thompson, A. (*2020*) **Iron-mediated organic matter decomposition in humid soils can counteract protection.** Nature-Communications [*DOI: 10.1038/s41467-020-16071-5*]. (pub. 11:00 CEST May 7, 2020)

Motivation: Fe can promote C persistence under oxic (a) decomposition under anoxic (b) and via Fenton chemistry during redox transistions (C).

Goal: Assess the relative magnitude of Fe promoted OM decomposition and protection in a single experiment where Fe-C associations was a central protection mechanism (i.e., minimize structural protections (macroaggregates, etc.).



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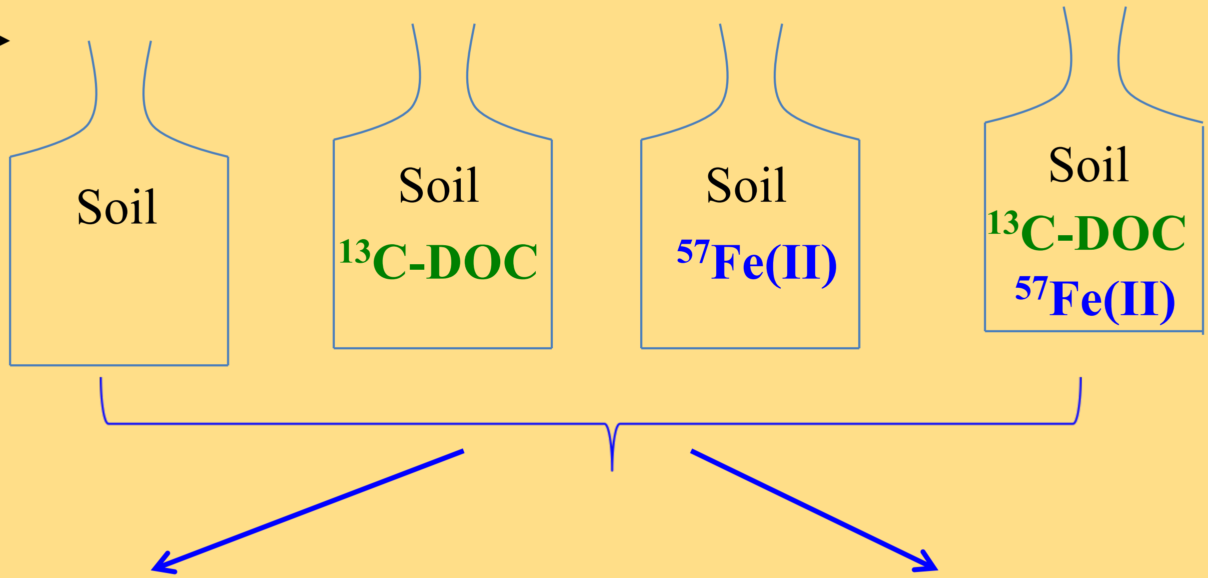
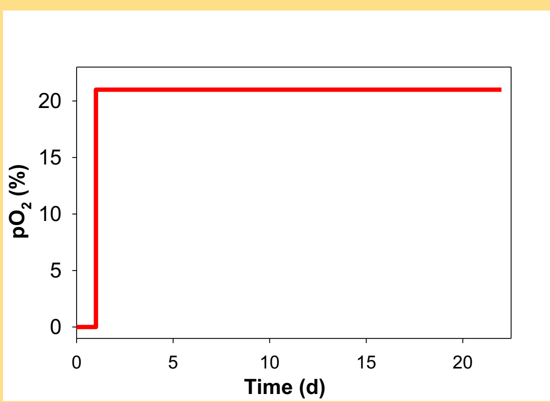
Methods: Incubate redox-dynamic soil from Calhoun CZO in slurry to minimize the influence of soil structure. Add labile ^{13}C-DOC and $^{57}Fe^{II}$ to track Fe-C. Oxidize Fe^{II} to form Fe-C co-precipitates and promote Fenton. Switch (or stay Oxic) to Anoxic to promote Fe reduction.

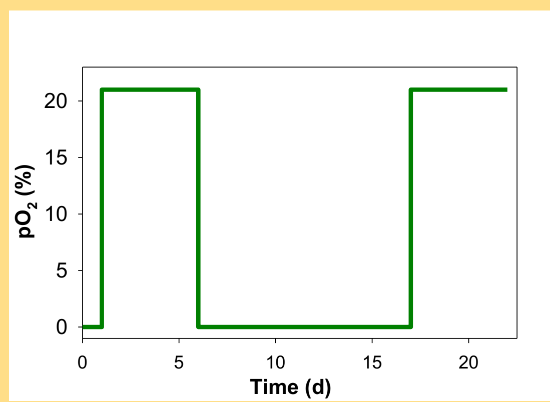


- **Added C/Fe(II) = 3**
- **Tracked ^{57}Fe with ICP and Mössbauer**
- **Tracked ^{13}C-CO_2**

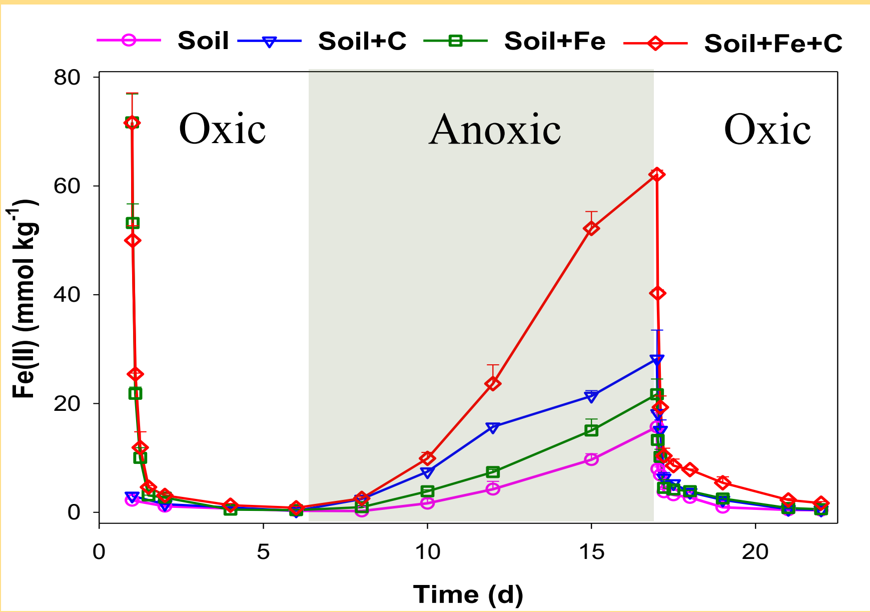
Static oxic

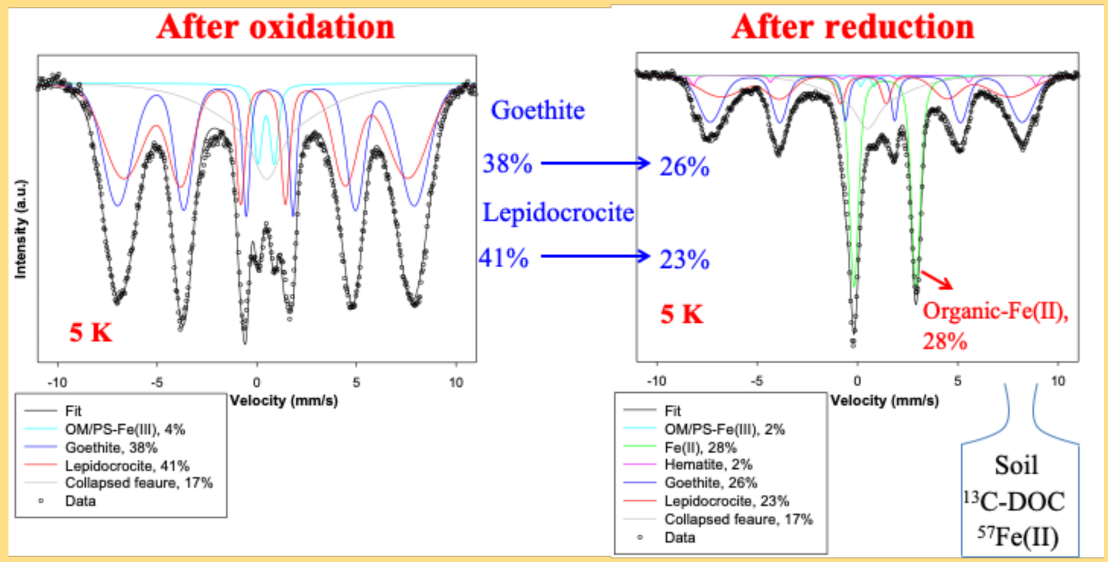


Fluctuating



Fe(II) production: Stimulated by both ^{13}C and ^{57}Fe additions. *De novo* ^{57}Fe-C precipitates more SRO than native Fe and are preferentially reduced.





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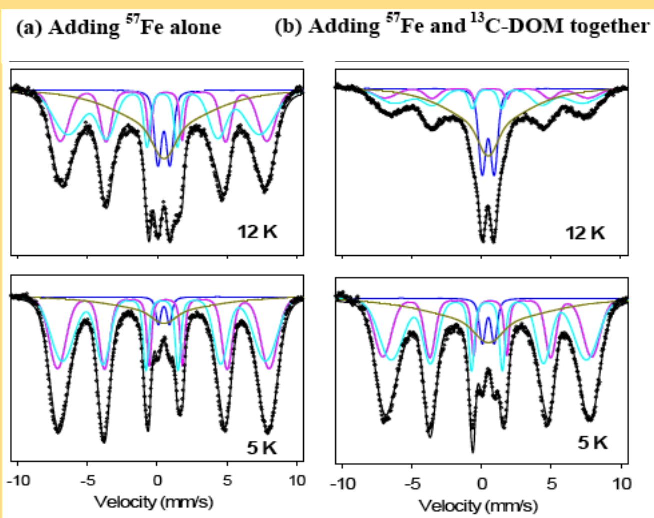
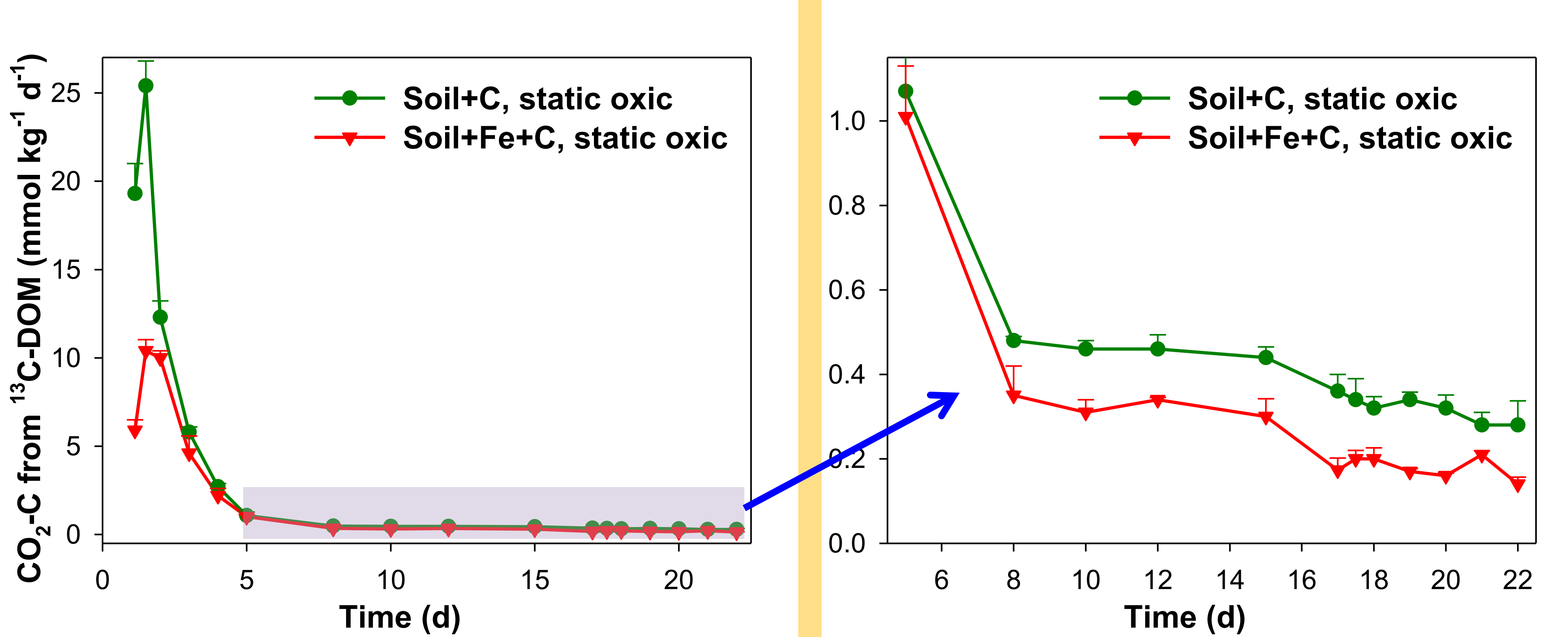


- **Adding Fe & C = more SRO co-precipitates**
  - **note smaller sextet at 12K on right graph**
- ***De novo*** **^{57}Fe phases removed during anoxic**
  - **Organic $^{57}Fe(II)$ is formed (see above)**

Net Fe protection of C: **Only** in Static Oxic + DOC

Fe + DOC +soil: Suppressed DOC → CO_2 production



Fe^{III}-^{13}DOC co-precipitate protects ^{13}C from aerobic degradation

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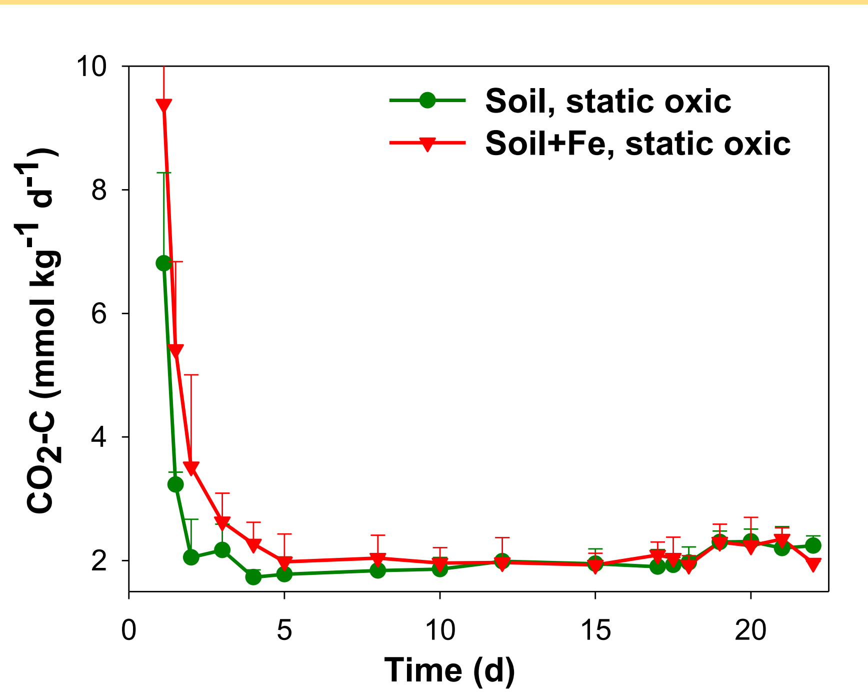
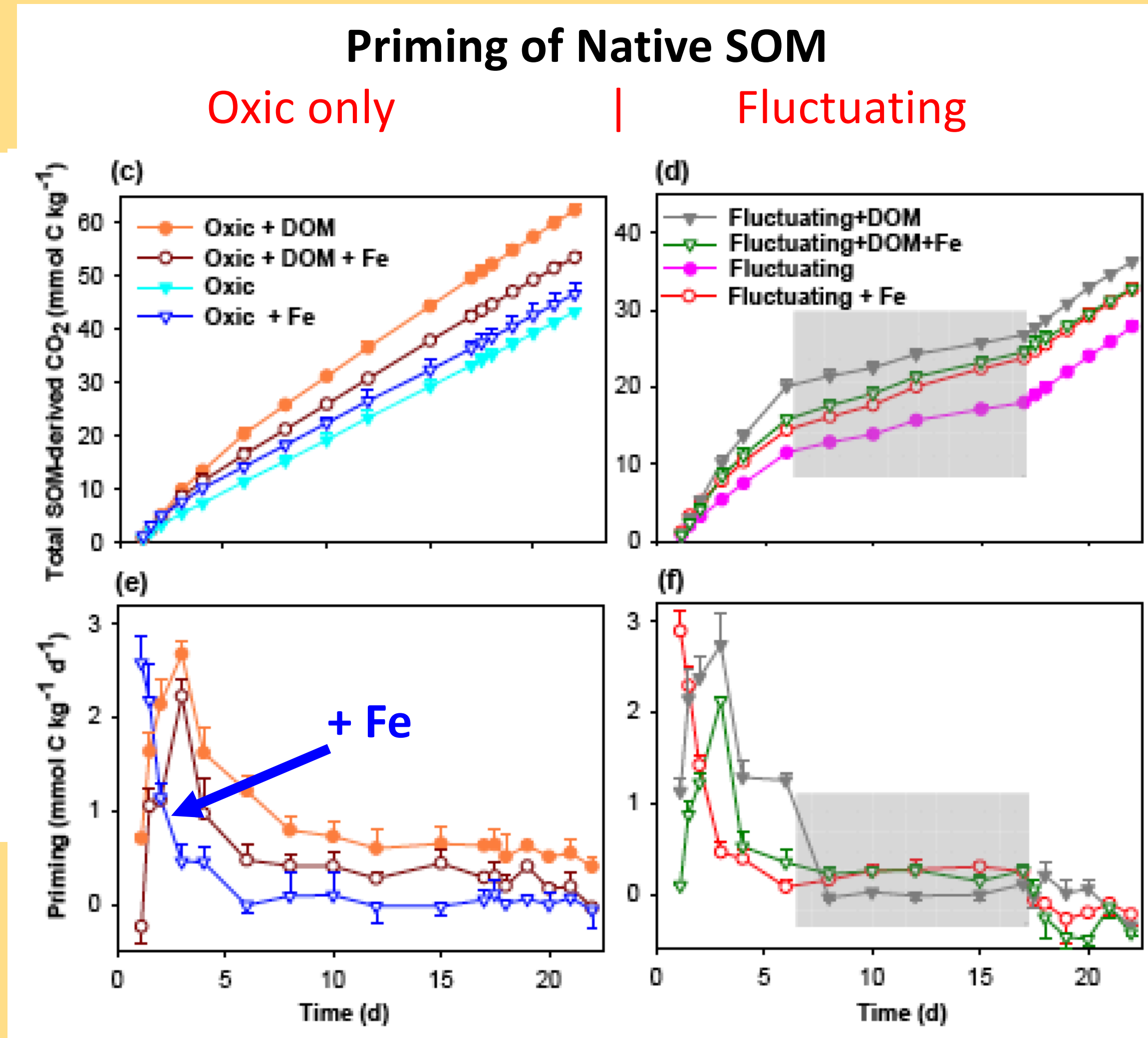
Net Fe stimulation of C loss: Static oxic without added DOC.

Fe + soil (no DOC): Enhanced aerobic CO2 production (Fe priming of SOM)





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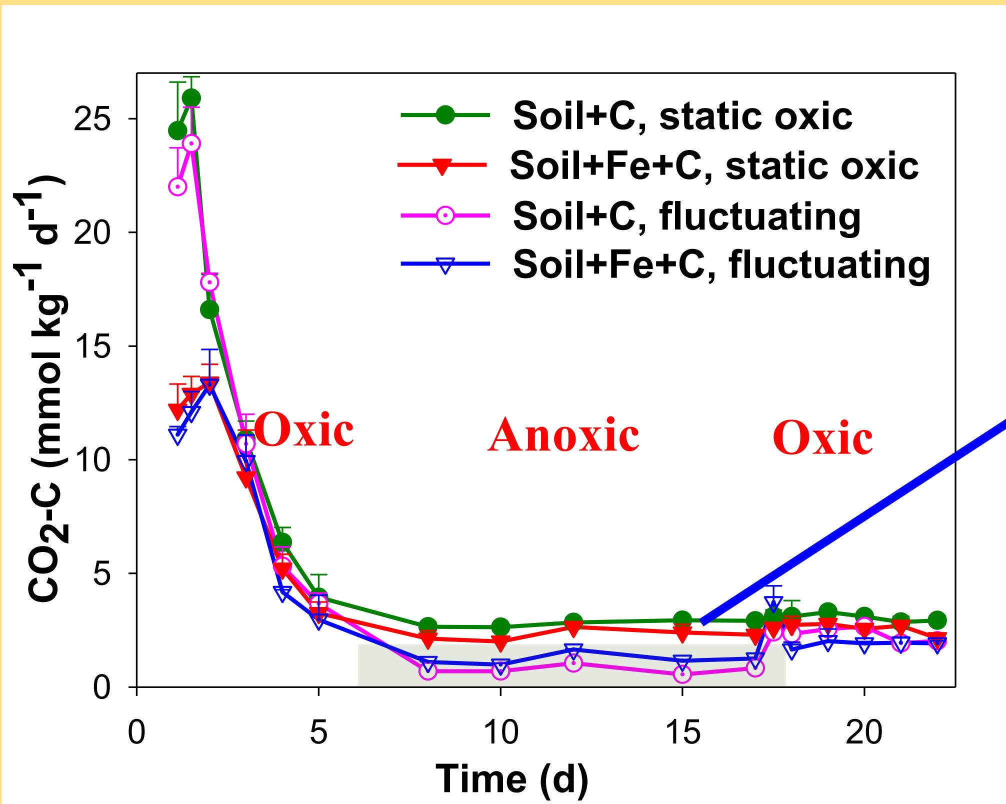
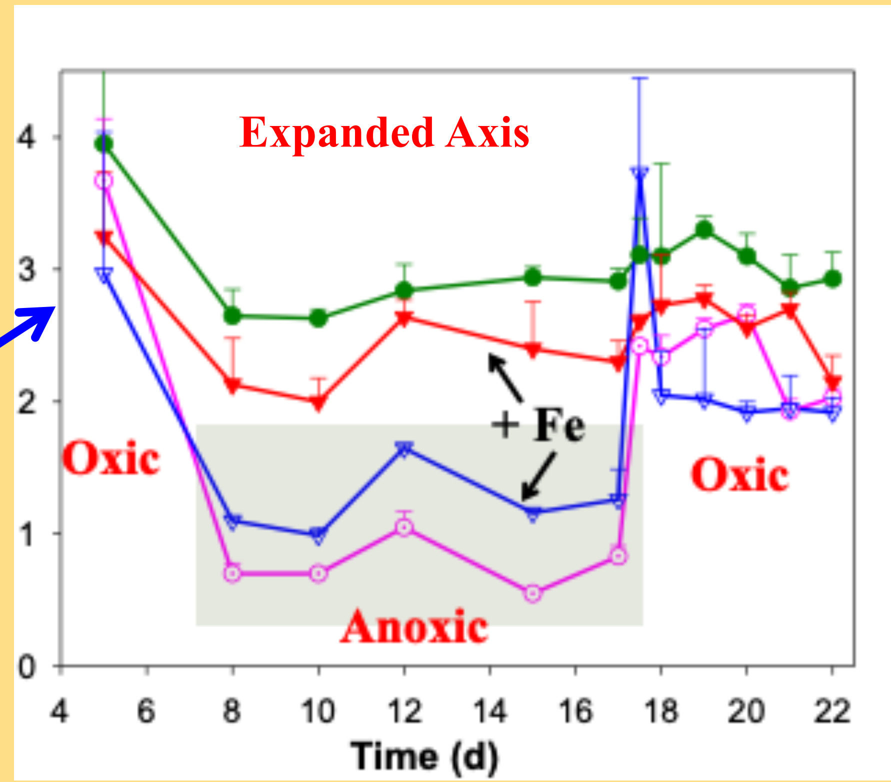
Net Fe stimulation of C loss: CO_2 production higher with Fe and Fe+C additions under fluctuating redox

Total CO_2 production





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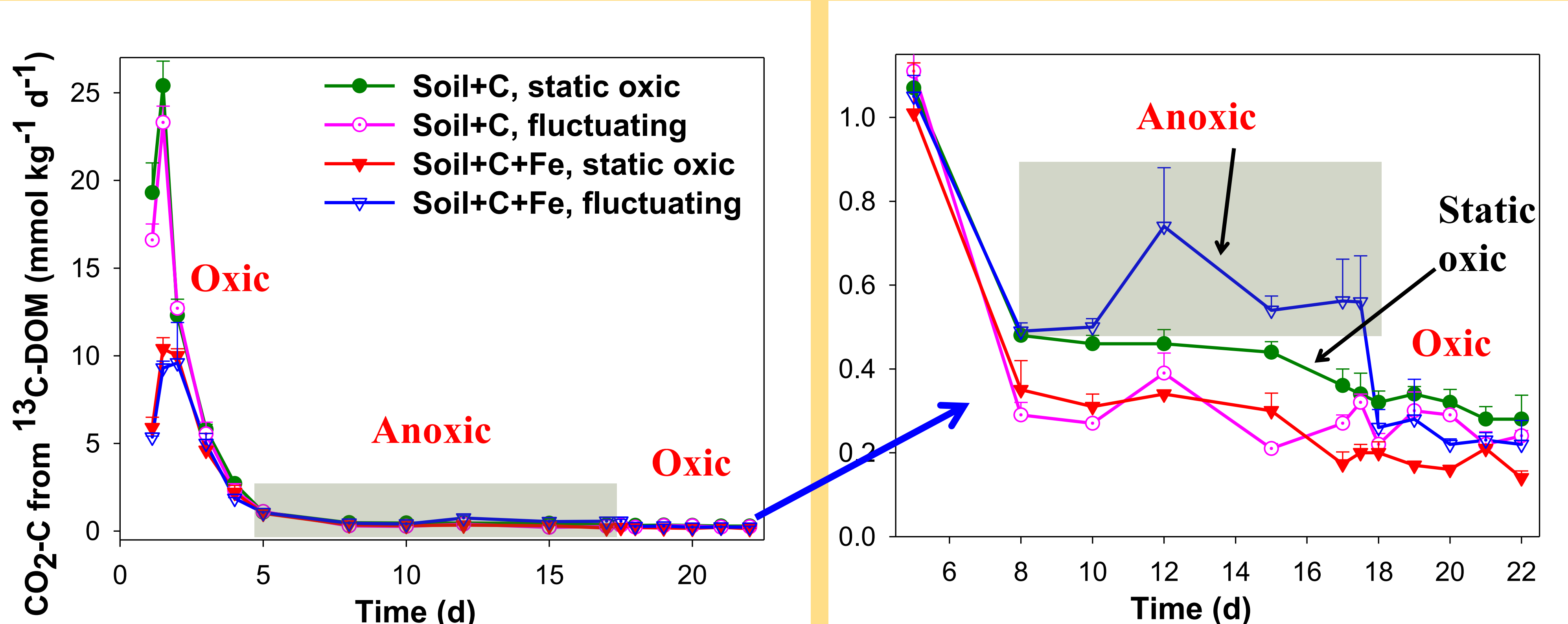
Net Fe stimulation of C loss: Anaerobic $^{13}DOC \rightarrow CO_2$ with Fe added is **higher** even than aerobic $^{13}DOC \rightarrow CO_2$ at the same point in experiment



Strong Fe^{III} respiration leads to greater anaerobic ^{13}C mineralization than aerobic ^{13}C respiration

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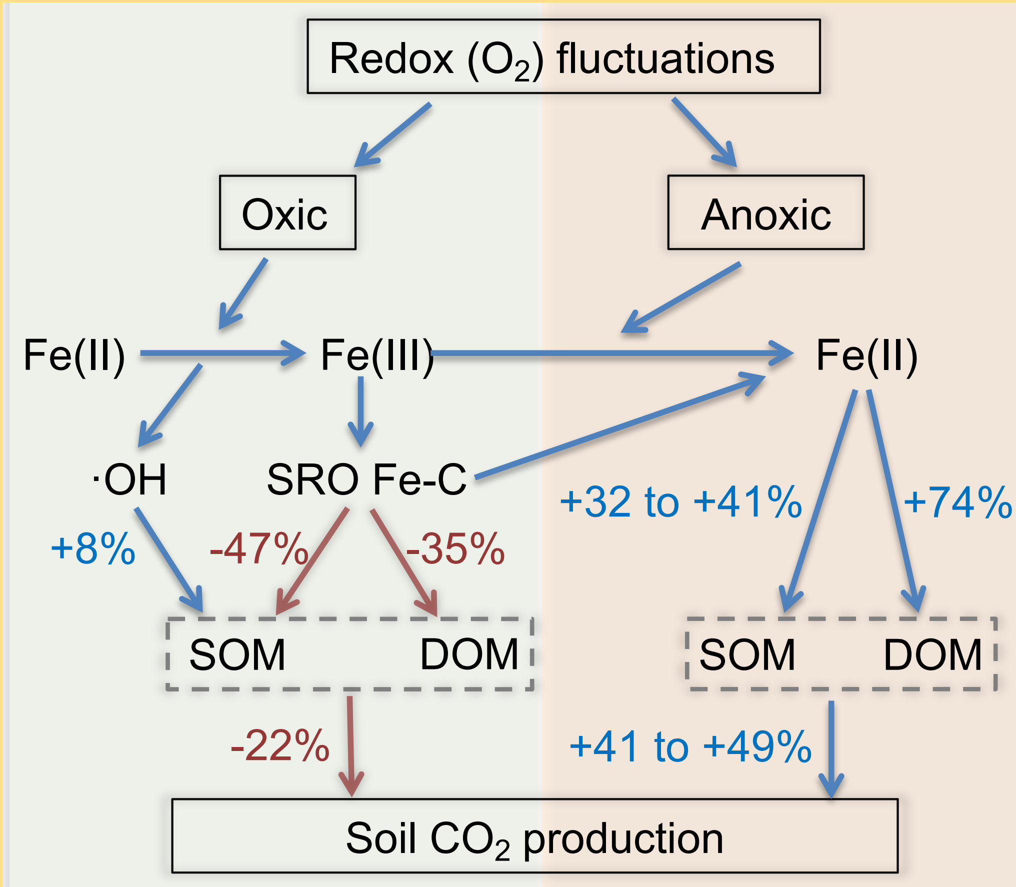
Take-home Messages

- Oxidation of Fe(II) in the presence of DOC preserves DOC under aerobic metabolism, but can stimulate DOC mineralization under anaerobic metabolism.
- Anaerobic metabolism favors decomposition of fresh DOC more than aerobic metabolism.
- While SRO Fe phases do accumulate significant OM, **SRO-Fe likely requires its own protection to contribute to OM persistence.**

Summary of CO_2 production relative to a no-addition control.



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