**Effect of changing oxygen conditions on iron-bound organic carbon in lake sediment**

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**Proposal Narrative**

## Background Information

Associations between iron (Fe) and organic carbon (OC) play a critical role in marine carbon burial (1,2). However, the importance of these associations in freshwater sediment is poorly quantified (1,3–5). This presents a critical research gap, as reservoirs alone may bury more OC than marine sediments each year (6–9). Moreover, hypolimnetic oxygen concentrations are decreasing in lakes and reservoirs around the world (10,11), and it remains unknown whether water column anoxia will weaken the strength of iron-bound organic carbon complexes (Fe-OC) in sediment (Figure 1; 4,5). Better quantifying Fe-OC dynamics under varying oxygen conditions is essential to be able to predict the role of lakes in the global carbon cycle under interacting systems of global change.

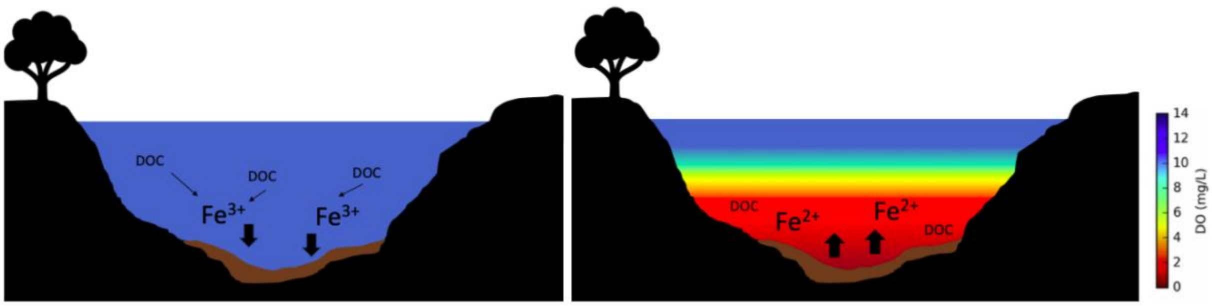


Figure 1: Co-precipitation and reductive dissolution Fe-OC complexes are predicted to play an important role in freshwater carbon cycling. Left: under oxic conditions, Fe co-precipitates with OC, sequestering the carbon in the sediment. Right: under anoxic conditions, Fe is reduced, releasing OC back into the water column.

## Hypotheses and Methods

In this study, I will use a combination of sediment incubations and whole-ecosystem experiments to determine the significance of changing oxygen levels for Fe-OC and long-term carbon storage in sediments. I will test two hypotheses:

**Hypothesis one:** Anoxia promotes reductive dissolution of Fe-OC complexes, releasing Fe and OC into overlying water (Figure 1).

- I will test this hypothesis mechanistically using four-week microcosm incubations (Figure 2). Half of the microcosms will start under anoxic conditions and half will start under oxic conditions. After two weeks, half of the microcosms from each treatment will be switched, generating a total of four oxygen regimes (anoxic, oxic, anoxic switched to oxic, oxic switched to anoxic). I predict that Fe-OC will be highest in oxic sediment and dissolved Fe and OC will be highest in anoxic water. At the transition from anoxic to oxic conditions, I will use a mass-balance approach to determine what percentage of Fe and OC that is removed from the water column can be attributed to the formation of Fe-OC complexes.


Figure 2: Proposed mesocosm design, including hypolimnetic water and a layer of homogenized sediment from FCR. Pilot studies confirmed that oxygen concentrations remained >7 mg/L when unsealed (left) and <0.1 mg/L when sealed (right).

**Hypothesis two:** Redox-sensitive Fe-OC dynamics alter biogeochemical cycling at the whole-ecosystem scale.

- Impacts of anoxia on Fe-OC in freshwater sediment could be globally relevant due to the magnitude of carbon buried in lakes and reservoirs. However, small-scale incubations cannot account for all processes that interact to determine biogeochemical cycling at a whole-ecosystem scale. To test the relevance of Fe-OC at the scale of a whole reservoir, I will compare Fe-OC concentrations in sediment from Falling Creek Reservoir (Roanoke, VA), which has been artificially oxygenated since 2013 (12), to sediment from an upstream reference reservoir that exhibits seasonal anoxia (Beaverdam Reservoir; BVR). Through a collaboration with the Western Virginia Water Authority, I also have the unprecedented opportunity to conduct whole-ecosystem manipulations using the oxygenation system in FCR; I will turn off oxygenation for intermittent two-week periods to determine how short-term changes in oxygen concentrations may impact Fe-OC.
- I predict that concentrations of Fe-OC will be higher in FCR than in BVR and higher during oxygenated than unoxygenated periods in FCR. Likewise, Fe and DOC in the water column will be higher in BVR than FCR and higher during unoxygenated periods than oxygenated periods in FCR.

## References


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## Budget

1. **6 oz canning jars**

   $39.99 per case of 30 * 5 cases **= $199.95**

   Sediment will be incubated in the lab under two oxygen treatments for the first half of the experiment and four treatments for the second half of the experiment (see Hypothesis one, above). With eight sampling dates in each half of the experiment and three replicates for each date and treatment, 144 jars are needed to enable destructive sampling for iron-bound organic carbon in sediment (2*3*8 + 4*3*8). Extensive pilot studies concluded that no standard laboratory equipment permitted the establishment of both oxic and anoxic treatments, necessitating the use of these non-standard incubation containers.
   Amazon

2. **Transportation to and from field sites**

   FCR and BVR: $0.40 per mile * 150 miles * 10 sampling dates **= $600**
   FCR only: $0.40 per mile * 100 miles * 1 sampling date = $40

   Sampling both BVR and FCR requires driving 150 miles round-trip, and only sampling FCR requires driving 100 miles. This project will require one sampling date at FCR to collect sediment and water for experimental incubations and 10 sampling dates at both FCR and BVR to conduct whole-ecosystem oxygenation experiments and collect samples for Fe, OC, and sediment Fe-OC.

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| **Total:** | **$799.95** |

### External Funding

This project is partially supported by additional external funding (NSF DEB-1753639) which will provide bottles, centrifuge tubes, and GF/F filters for sample collection, as well as chemicals and glassware for laboratory analyses. External funding will also provide funding for one undergraduate researcher to assist with the laboratory experiment and chemical analyses. The full project budget is $4000, $799.95 of which is requested from Sigma Xi.