Variation in iron-bound organic carbon across global lake sediments
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Carbon sequestration in soils and sediment plays a critical role in regulating atmospheric greenhouse gas accumulation and, consequently, Earth's climate.[1] Increasing evidence suggests that long-term carbon burial is facilitated by associations between organic carbon (OC) and mineral surfaces (e.g., iron); turnover rates of mineral-associated OC are an average of four times as long as organic matter that is not mineral-associated.[2–6]

Associations between minerals and OC are particularly important and understudied in freshwater lakes and reservoirs (hereafter: "lakes"). Due to high carbon loading from the surrounding land, more OC is buried in lake sediments than in all ocean sediments each year[7–10]. However, few studies have explicitly examined mineral-associated OC in freshwater lakes, and the studies that have been conducted have shown divergent results. Across five Swedish lakes, levels of iron-bound OC were found to be very low, with less than 11% of sediment OC bound to iron[11]. Conversely, pilot studies at two reservoirs in Virginia, USA suggest that up to 50% of OC in these sediments may be bound to iron. With very few measurements of sediment OC from lakes around the world, any attempts to identify the causes of this observed variation remain highly speculative.

Aims and hypothesis

In this project, I will collaborate with members of the Global Lake Ecological Observatory Network (GLEON) to measure iron-bound OC levels in a broad range of lakes around the world. I will analyze sediment data in combination with a suite of environmental data (pH, temperature, and dissolved oxygen content of overlying water, lake trophic status, climate, and catchment vegetation) to determine the dominant drivers of variation in iron-bound OC levels in freshwater sediments worldwide.

I hypothesize that the concentration of reactive iron in sediment is the dominant driver of variation in the percentage of sediment OC that is bound to iron, but this effect can be mediated by pH and catchment vegetation. A dominant effect of iron availability would explain differences in iron-bound OC between the low-iron Swedish lakes and high-iron Virginia reservoirs studied to date. Furthermore, this result would have implications for carbon sequestration in the face of global change, as iron concentrations are currently increasing in many lakes.[12]

International sampling enabled by GLEON connections

GLEON is an international, grassroots network of lake scientists who often collaborate on research projects using environmental sensors and project-specific sampling. I have been actively involved in GLEON for the past six years and have already led one research project.[13]

For the proposed analysis, I will solicit GLEON participants from up to 50 lakes. Participants will be asked to take six sediment cores at the deepest site in their lake, isolate the top 0–3 cm of sediment, freeze dry the sediment, and ship it to me. I will analyze all sediment samples using the citrate bicarbonate dithionite method to determine the amount of iron-bound OC, total OC, and dithionite-extractable iron.[2,11] To enable participation from a broad array of global scientists, I am requesting funding to cover shipping costs for a subset of lakes.

Project Budget

I am requesting $990 of funding from Sigma Xi to lower the barrier to participation for collaborators who may not have funding to ship their own samples, particularly those in areas that would otherwise be poorly represented in the study. Samples are stable once they have been dried, and will not need to be shipped with particular urgency. However, I am also budgeting for four sets of frozen samples to be shipped on dry ice using the highest priority shipping in cases where a freeze dryer is not available to dry sediment samples before transport.

$150 * 4 = $600 high-priority shipments (frozen samples)
$30 * 13 = $390 low-priority shipments (freeze-dried samples)

Additional funding for this project (NSF DEB-1753639) will provide chemicals and glassware for laboratory analyses, as well as funding for one undergraduate researcher to assist with the laboratory experiment and chemical analyses. The full project budget is $4000, $990 of which is requested from Sigma Xi.

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