Reconstructing Paleoflood Frequency with Holocene Sediment Records from Seneca Lake, New York

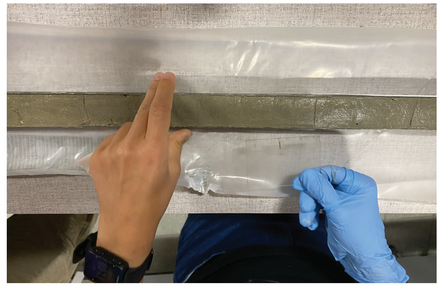
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Introduction

Instrumental records are too short to evaluate long-term flood variability under varying climate conditions. The analysis of layered lake sediments fills this knowledge gap. Sedimentary records of flood events are preserved in lakes as coarse-grained terrigenous layers with inorganic constituents. In the Northeast, these deposits often accumulate as a result of excess rainfall during localized convective storms and mid-latitude cyclones (Noren et al., 2002). The distinction between flood and background conditions leaves a fingerprint that can be studied to compile millennial flood histories.

Few paleoflood records exist for inland lakes in the northeastern United States. Previous studies relied on proxies that required manual sub-sampling at a coarse scale (> 1cm), often overlooking short-lived events responsible for depositing < 1 cm of sediment. This is the first study to use µXRF core scanning at a sub-mm resolution to reestablish paleoflood records in inland lakes. We focus on reconstructing the flood history of Seneca Lake over the past 16,000 years.



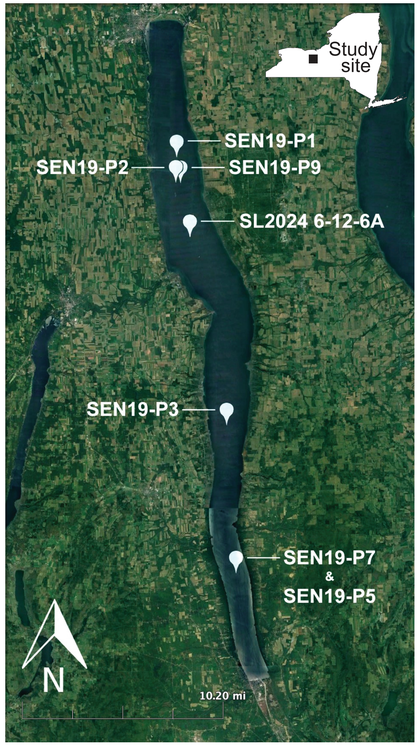
Which elements best represent flood inputs in Seneca Lake, NY?

How does paleoflood frequency differ between the warm Hypsithermal and the cool Neoglacial?

Field and Lab Methods

- **Piston core collection:** A total of seven ~5 m cores were collected from the profundal zone along the N-S transect.
- **Magnetic susceptibility (MS):** Cores measured with Bartington MS2 loop meter at 1 cm intervals.
- **Core preparation:** Cores were vertically sliced, flattened with clean glassware, and covered in Mylar film.
- **X-ray fluorescence core scanning:** Elemental abundance (Mo tube, 30kV, 55mA, 10-sec count time; 500-µm interval) was quantified using Cox Analytical ITRAX on split cores.
- **Data Analysis:** XRF and MS data tidied and analyzed using ITRAX scripts in R.
- **Ca/Fe**: Estimating age by comparison to %carbonate in a radiocarbon-dated core.

Study Site



Limnology of Seneca Lake, NY

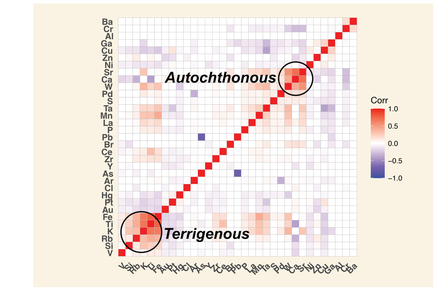
Drainage Basin Area (DA, km^2)	*1181*
Elevation (m)	*134*
Surface Area (SA, km^2)	*175*
Water Volume (km^3)	*15.5*
Length (km)	*57*
Max. Width (km)	*5.2*
Max. Water Depth (m)	*188*
Avg. Depth to Thermocline (m)	*15*
Mixis Type	*Monomictic*
Residence Time (yrs)	*12-17*
Calc. Effective Wave Base (m)	*20*

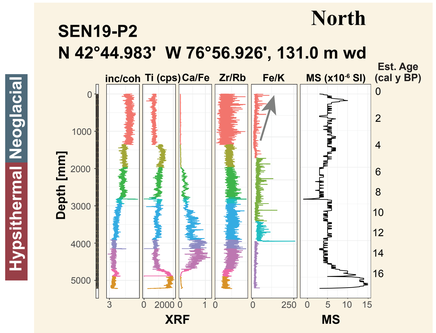
Data from Bloomfield (1978)

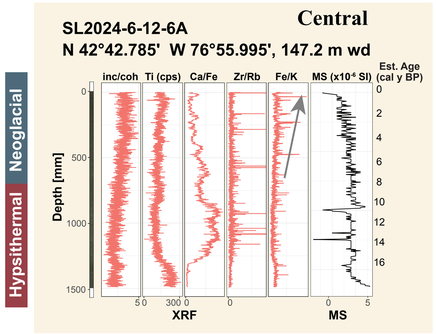
Ideal Characteristics for Paleoflood Analysis in Seneca Lake

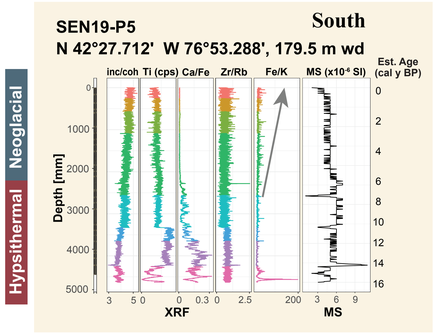
- Large watershed is comprised of easily eroded fine-grained glacial deposits.
- Tributaries convey 70-90% of the sediment that accumulates along the flat lake bottom.
- Profundal zone finely layered sediment is undisturbed by waves and burrowing organisms.

Results









Pearson Correlation Matrix

Log-centered correlation revealed two clusters:

Autochthonous sediment: Ca, Sr

Terrigenous sediment: Fe, K, Rb, Si, Ti

Best proxy for warm summer temperatures:

- ***Summertime lake stratification***: Ca/Fe

Best proxies for paleoflood analyses:

- ***% Organic matter***: Inc/Coh
- ***Terrigenous influx***: MS, Ti
- ***Coarse terrigenous influx***: Zr/Rb
- ***Fine terrigenous influx***: Fe/K

Preliminary Age-depth Model

SEN19-P2: 0.5 mm = ~2.4 yr

SL2024-6-12-6A: 0.5 mm = ~8.8 yr

SEN19-P5: 0.5 mm = ~1.5 yr

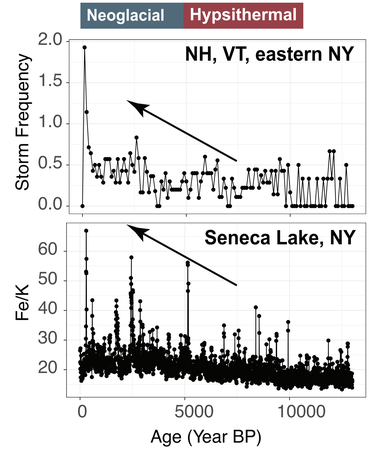
Temporal resolution of XRF data is 2-9 yr.

Cores collected near major tributaries have higher sedimentation rates and a better temporal resolution. *(SEN19-P2, SEN19-P5)*

Storm Records

- Inc/coh likely increases upcore due to more porewater rather than washed-in organic matter.
- MS alone cannot be used to identify events.
- Zr/Rb trends are too noisy to interpret in SEN19-P2 and SEN19-P5.
- Zr/Rb reveals coarse-grained sediment influx events at ~14-11 ka, ~6 ka, ~3.8-3.5 ka, ~2 ka, and 0 ka in SL2024-6-12-6A.
- More fine-grained sediment (Fe/K) washed into the the southern half of the lake since ~8 ka and into northern Seneca Lake since ~ 4 ka.
- Differences among cores may be due localized storm events, shifts in location and/or volume of tributary inflow or inaccurate ages.

Paleoflood Analysis & Main Takeaways



Lakes in New Hampshire, Vermont, and New York all show an increase in storm frequency over the last 4,000 years.

Higher Fe/K values - an indicator of fine-grained sediment - may reflect greater snowmelt around Seneca Lake. Noren et al. (2002) hypothesized that winter storms resulted in terrigenous inwash layers.

Our constituents of interest indicate a higher storm frequency during the Neoglacial period. Storms occur more frequently in the northern region of Seneca Lake; this is demonstrated by higher Fe/K values in our two northernmost cores. This pattern holds true for modern storm tracks.

While our data concerns a longer stretch of time, large peaks in both plots confirm a strong correlation in peak storminess in the northeast as a result of low-phase Arctic Oscillation; this allows Arctic airmasses easier southward travel, increasing storm frequency in mid-latitute regions.

Future Research

1.) Refine age-depth models: Update age-depth models for each core to refine our interpretation of the timing of storm events.

2.) Differentiate storm and snowmelt events: Collect and analyze elemental composition of sediment washed into the lake during storm events and spring snowmelt to determine whether these events have unique chemical signatures.

Acknowledgement and References

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[1] A. J. Noren, et al., Millennial-scale storminess variability in the northeastern United States during the Holocene epoch. Nature, 419, 821-824 (2002)

[2] D. N. Schillereff, R. C. Chiverrell, N. Macdonald, J. M. Hooke, Flood stratigraphies in lake sediments: A review. Earth-Science Reviews, 135, 17–37 (2014)

[3] K. G. Ellis, H. T. Mullins, W. P. Patterson, Deglacial to middle Holocene (16,600 to 6000 calendar years BP) climate change in the northeastern United States inferred from multi-proxy stable isotope data, Seneca Lake, New York. Journal of Paleolimnology, 31, 343-361 (2004).

[4] S. J. Davies, H. F. Lamb, S. J. Roberts, Micro-XRF Core Scanning in Palaeolimnology: Recent Developments. Developments in Paleoenvironmental Research, 17, 189-226 (2015)

[5] T. Bishop, itraxR: Itrax Data Analysis Tools. (2024).

[6] J.A. Bloomfield (Ed.), Lakes of New York State: Volume 1 Ecology of the Finger Lakes. Academic Press, New York, 470 p.

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