Sedimentary architecture of Maine lakes derived with ground-penetrating radar

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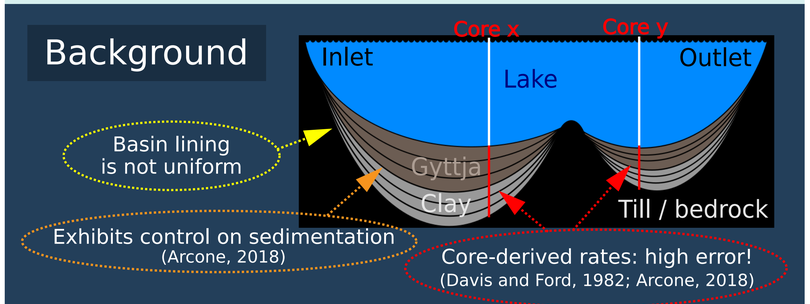
Introduction

Sedimentation has implications for Maine's abundant lake and river systems. However, these influences are poorly understood in most watersheds. Existing studies use sediment cores which are point measurements to estimate sedimentation rate in lakes or ponds. These methods, while informative for paleoclimate study, are not sufficient for other analyses such as overall sediment flux. We use ground-penetrating radar (GPR) to understand spatial variation in sediment thickness and stratigraphic sequencing. This study aims to quantify sediment accumulation volumes since Holocene deglaciation in Maine. Results suggest that Holocene storm turbidites can exhibit significant control on the hypsometry of basins deeper than 10m, and that marine transgression deposits may be evident in geophysical profiles of lakes inundated by the ocean during the retreat of the Laurentide Ice Sheet. Current efforts are focused on assessing whether the installation of dams have altered sediment flux and reworking in lake basins, however results are still inconclusive. This study also shows that knowledge of sedimentary architecture of a basin is critical for sediment core site selection.

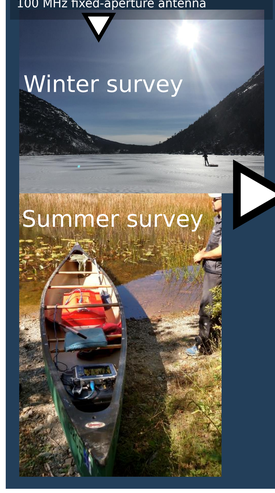
Background

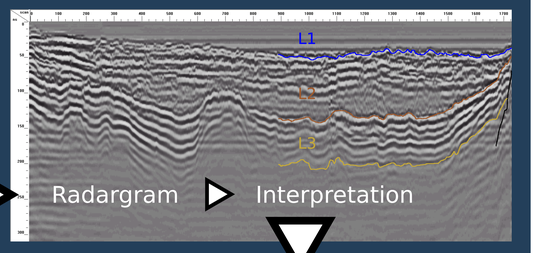


GPR: portable profiling of sediment beneath shallow, fresh water and/or ice

Geophysical Survey Systems Incorporated

100 MHz fixed-aperture antenna

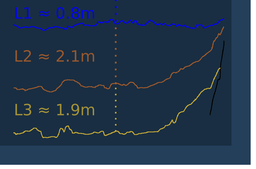




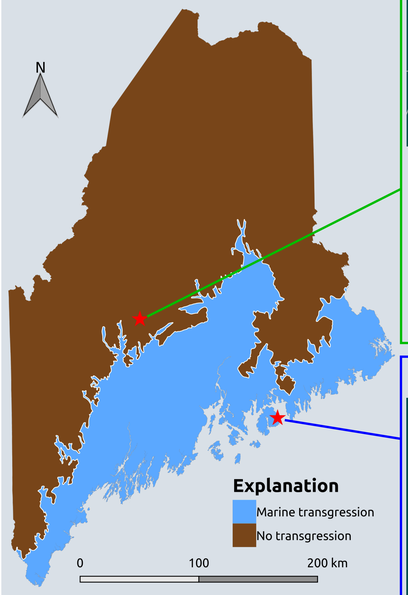
$$d = \frac{t_n - t_{n-1}}{2} * \frac{c}{\sqrt{\varepsilon_r}}$$

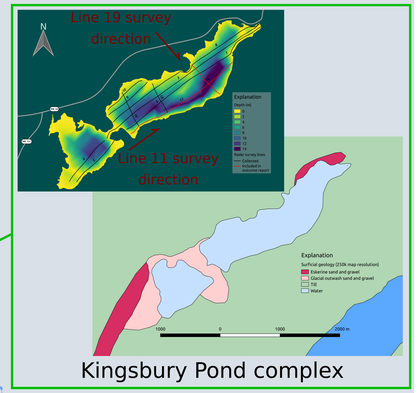
d — depth (m)
t — two-way travel time (ns)
n — layer number
c — speed of light (m/ns)
ε — relative permittivity (μs/cm)

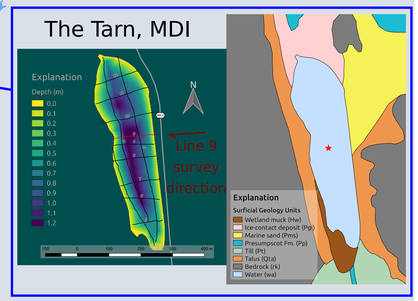
Layer thickness estimates



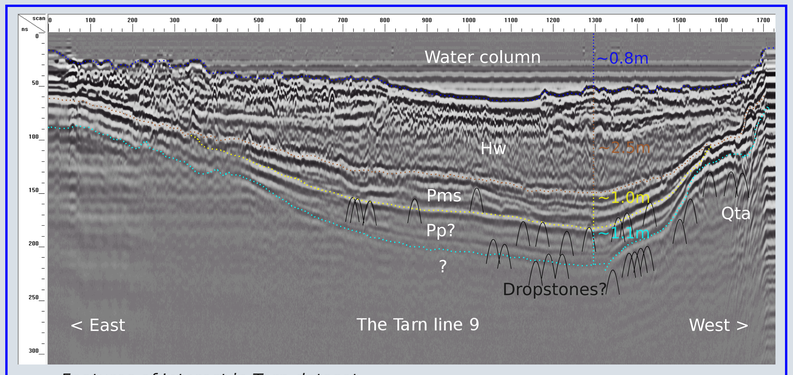
Presented Sites





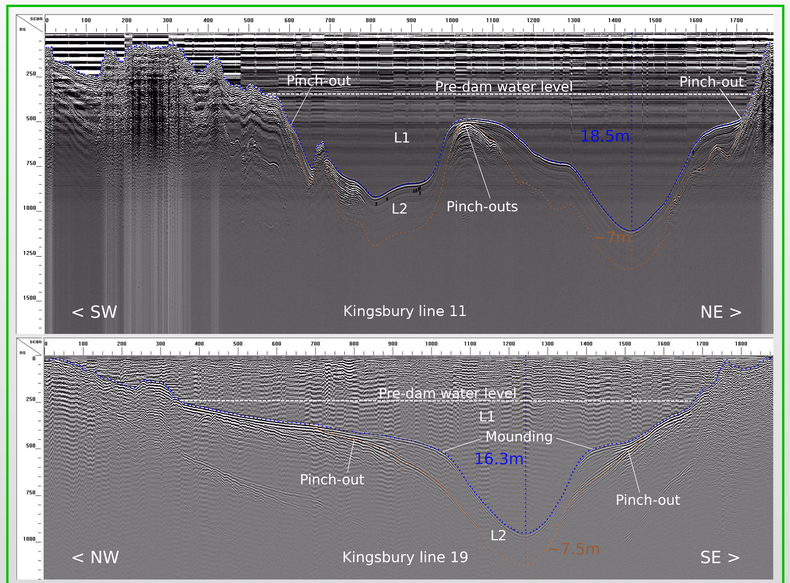


Results and Discussion



Features of Interest in Tarn dataset

- Evidence of multiple stages of Quaternary geologic record
- Multiple unconformity signatures (esp. in unit interpreted as Pms)
- Holocene unit (Hw) is not uniform; possible human influence?



Features of Interest in Kingsbury Pond dataset

- Sediment thickness varies widely across space
- Evidence of erosion, turbidity, and sediment focusing
- Hypsometry at depth controlled by settling of turbidite material
- GPR can provide stratigraphic context to inform coring location
- Pre-dam sediment dominates, unsure if dam-related signal

Conclusions and Future Work

- Profiling is more effective than spot measurements due to high spatial variability of sediment thickness.
- Sediment thickness maps will facilitate estimate of total volume delivered to basins over the course of the Holocene. Higher-frequency GPR may further resolve human influences on sedimentation.
- Correlation of radar reflectors with literature core records where available will allow better contextual analysis of stratigraphy.

Arcone, S.A., 2018, Sedimentary architecture beneath lakes subjected to storms: Control by turbidity current bypass and turbidite armouring, interpreted from ground-penetrating radar images (N. Mountney, Ed.): Sedimentology, doi: 10.1111/sed.12429.

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