Oxygen Isotopes, Sedimentology And Geochemical Research For Two Permafrost Cores Eskimo Lakes Area, NWT, Canada

Kethra Campbell-Heaton, kcamp109@uottawa.ca
Department of Geography, Environment and Geomatics , University of Ottawa, Ottawa, Ontario

uOttawa

Abstract

The contents of permafrost in many areas of Northern Canada are becoming a highly studied area of research as well as extremely important when considering the possible environmental changes brought on by climate change (Jorgenson et al., 2010). This study focuses on understanding the soil water content and sediment characteristics via excess water and gravimetric water analysis, oxygen isotope analysis, loss on ignition (LOI), grain size, geochemistry and soil colour analysis for two cores extracted from the Eskimo Lakes area, NWT. Samples were taken at every 0.5m of a total length of 20m for core 7 and 10m for core 17. The results from this study show a high ground ice content in both cores. The oxygen isotope data reveals warming climate conditions. The LOI data illustrates a lack of water movement through the soil column. Grain size of the samples ranges between 10-200µm, sample composition ranges from high sand content to high clay content. Geochemistry data reveals high levels of $CaSO_4$ in both cores and soil colour analysis reveals possible active layer depth at approximately 1m in both cores.

Research Objective

The objective for this study is to analyze the ice and sediment content of each permafrost core via a variety of analyses to better understand the underlying processes that operate within permafrost environments.

Methods

Two sediment cores (7 & 17), extracted from continuous permafrost near the Eskimo Lakes (NWT), were assessed via water and sediment analyses. The water analyses included evaluating the excess water content, the gravimetric water content and the oxygen isotopes in each core. The sediment analyses conducted on the two cores included LOI, grainsize, geochemistry and sediment colour. The following list outlines how the analyses were conducted:

- Excess water content: compared supernatant water to total volume. For this analysis, 74[1] samples were evaluated for core 7 and 39[1] samples for core 17.
- Gravimetric water content: compared wet to dry weight; 74[1] samples were evaluated for core 7 and 39[1] samples for core 17.
- Oxygen isotopes: this analysis was conducted using the Los Gatos Research (LGR) Liquid Water Isotope Analyzer. 32[1,2] samples from core 7 and 38[1,2] samples from core 17 were processed .
- LOI: analysis was conducted using the LECO TGA701 Thermogravimetric Analyzer, 32[3] samples were analyzed from core 7 and 15[3] samples from core 17.
- Grainsize: the analysis was conducted using a Particle Size Analyzer Microtrac S3500. 32[3] samples from core 7, were analyzed and 12[3] samples from core 17.
- Geochemistry: this analysis was conducted in the uOttawa ARC facility. 40 samples from core 7 were analyzed and 20 samples from core 17.
- Sediment colour: this analysis was conducted using a Munsell Colour Chart. 30[3] samples were analyzed for core 7 and 6[3] from core 17.

[1] Multiples of samples were evaluated separately for this analysis
[2] Some samples did not contain any excess water
[3] Could not sample all samples due to a lack of sample; total number of samples for core 7 is 40, and 20 samples for core 17.

Results

Core 7

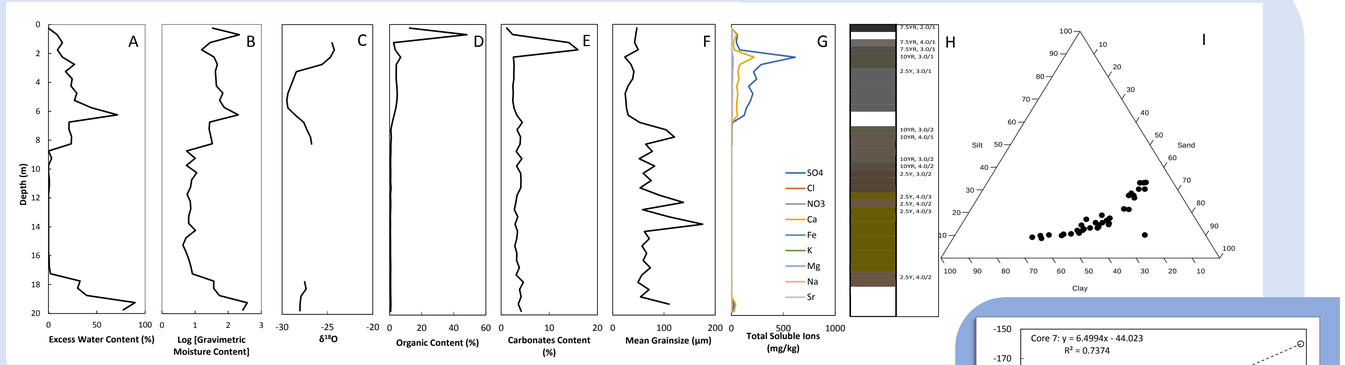

Figure 2. Compiled results for Core 7. The results for the following analyses are illustrated: excess water content (A), gravimetric water content (B), oxygen isotope (C), loss on ignition (D & E), grain size (F), geochemical (G), sediment colour (H) and sediment composition (I).

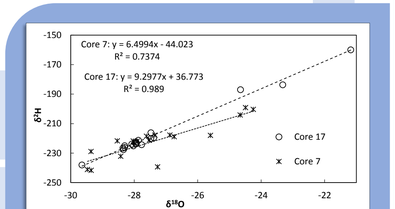

Figure 2. Scatter plot of collected $\delta^{18}O$ data in relation to data for $\delta^{2}H$ for sediment cores 7 (star) and 17 (circle).

Core 17

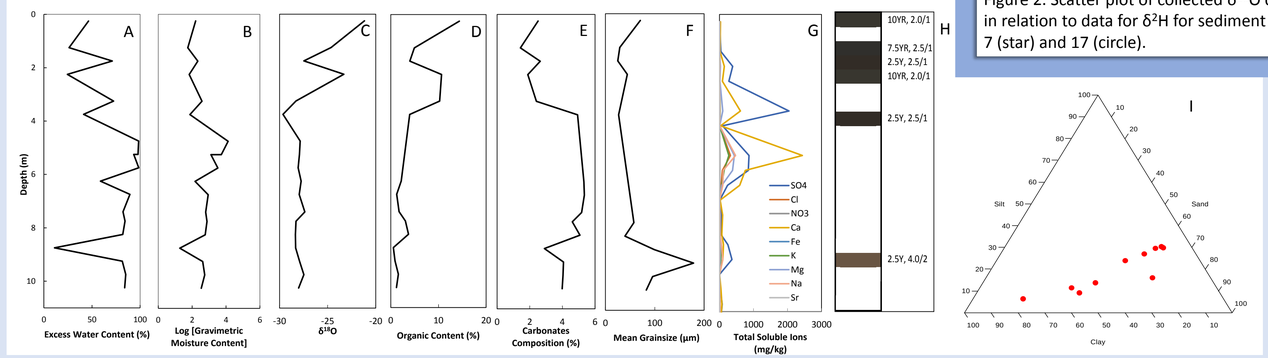

Figure 3. Compiled results for Core 17. The results for the following analyses are illustrated: excess water content (A), gravimetric water content (B), oxygen isotope (C), loss on ignition (D & E), grain size (F), geochemical (G), sediment colour (H) and sediment composition (I).

Study Site

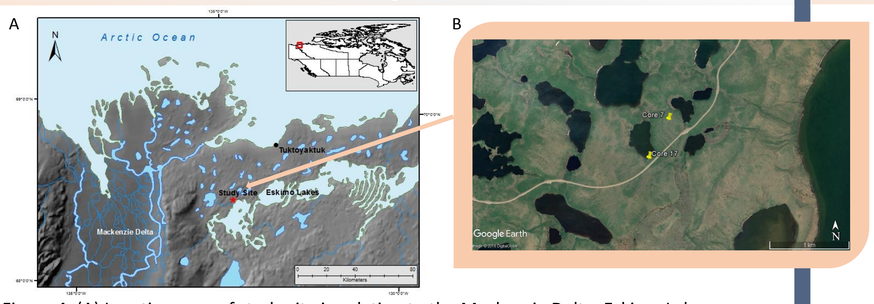

Figure 4. (A) Location map of study site in relation to the Mackenzie Delta, Eskimo Lakes, Tuktoyaktuk and the Arctic Ocean, data collected from Open Data Canada, map created in ArcMap. (B) Google Earth satellite image of study site with core 7 and 17 locations.

Laurentide Ice Sheet Extent

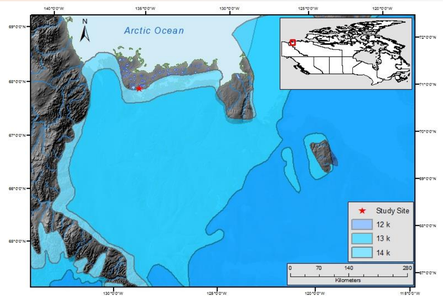

Figure 5. Map extent of Laurentide ice sheet retreat for 14ka (light blue), 13ka (blue) and 12ka (dark blue) in relation to the study site (red star).

Discussion

The results from this study determined:

- The presence of segregated ice in the soil column where excess and gravimetric water were particularly high, over 70%, in core 7 excess water content reached values of 98%. See Fig. 1A & B and Fig. 3A & B
- Oxygen isotope analysis revealed past climate conditions were colder than present, current mean temperature is -8°C. Values range from -29‰ to -21‰, there is a significant increase from 4m to the surface which is most likely attributed to recent climate change. See Fig. 1C and 3C. Fig. 2 shows a positive correlation between $\delta^{2}H$ and $\delta^{18}O$.
- LOI analysis revealed a decrease in organic content for both cores with depth, this is attributed to the lack of vertical movement through the soil column due to the existence of permafrost. See Fig. 1D and 3D. The carbonate content of both cores increases with depth but only varies between 1-5% composition, the presence of carbonate points towards glaciofluvial deposition of carbonate-rich parent rock. See Fig. 1F and 3F.
- Grain size analysis illustrated a change in depositional environment with depth where larger particles represented high-energy depositional environments and fine-grain particles represented low-energy depositional environment. Fig. 1E and 3E. Fig 1I and 3I illustrate the sediment composition with low silt content as well as high sand and clay content.
- Geochemical analysis revealed high levels of $CaSO_4$ in both cores, parent rock is likely gypsum ($CaSO_4 \cdot 2H_2O$) See Fig. 1G and 3G.
- Sediment colour analysis revealed information on sediment oxidation at depth as well as the extent of the active layer in the soil column. See Fig. 1H and 3H.

Overall, the results from this study fit with similar research on paleoclimate reconstructions. The presence of carbonates in the soil can be linked to sedimentary parent rock located in southern parts of the Mackenzie River, see Fig. 5 for reference. The results of the oxygen isotope analysis provide climate reconstruction information for this area. If dated it could be used in tandem with the grain size data to determine at what point the Laurentide ice sheet left the Eskimo Lakes area; most likely before 14 k based on Fig. 5. The results of this project improved information about the permafrost and ground ice content for this region as well as provided information about the movement of water through the soil column at the local scale.

References

Jorgenson, M.T., Romanovsky, V., Harden, J., Shur, Y., O'Donnell, J., Schuur, E.A., Kanevskiy, M. and Marchenko, S., (2010). Resilience and vulnerability of permafrost to climate change. Canadian Journal of Forest Research, 40(7), pp.1219-1236.

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