Apparent climate and ecological change during MIS 3-MIS 2 in northern Alaska, Itkillik River Yedoma

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1. Context

The cold-arid climate associated with the late Pleistocene environment of **unglaciated Beringia** was favorable to **active sedimentation** processes and accumulation of ground ice leading to the formation of a relic form **of ice-rich syngenetic permafrost**, termed **yedoma**. These periglacial features accumulated during Pleistocene between **MIS 4 and MIS 2**. Yedoma provide interesting **snapshots of well-preserved paleoenvironmental data** which can be linked to the framework established by continuous sequences while providing potentially older information (> 50 000 yrs BP). Also, data can be linked to terrestrial sedimentologic, cryostratigraphic and stratigraphic markers. Warmer conditions through the Holocene and current global warming might cause rapid thawing of these deposits.

2. Objectives

A. Reconstruct vegetation dynamics since MIS 4 (pollen)

B. Recontruct paleoclimate since MIS 4 (Modern Analog Technique (MAT) and δ18O)

C. Link sediment and ground-ice records (C and ice content) to A and B.

3. Study site

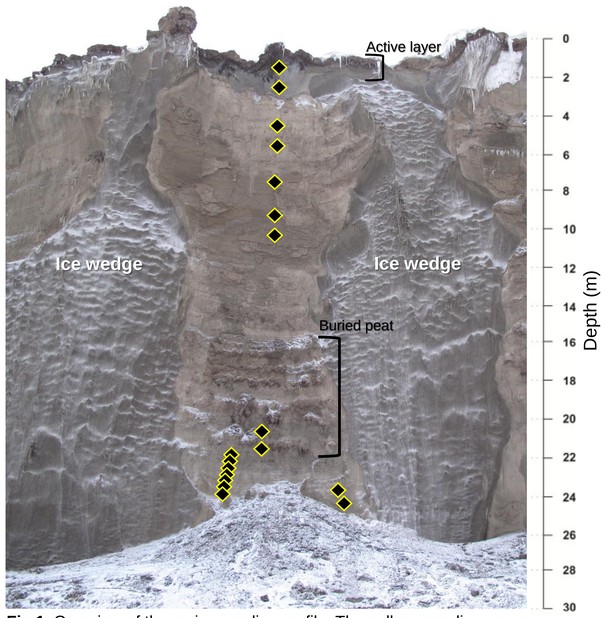

Fig 1. Overview of the main sampling profile. The pollen sampling areas are identified with black/yellow diamonds.

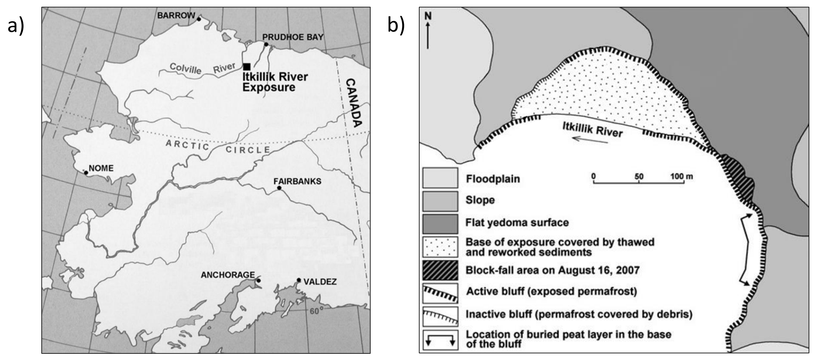

Fig 2. a) Regional location of Itkillik river yedoma in Alaska. B) Location of the main sampling profile on the bluff. Modified from Kanevskiy 2011.

4. Methods

Field work
By rappelling down from the top of the bluff.

A. Pollen extraction: sodium polytungstate density separation
Analysis: 400X – 1000X Leica microscope

B. MAT : Modern pollen data for North America (Whitmore et al. 2005, QSR 24, 1828-1848)
$\delta^{18}O$: Finnigan MAT Delta-S mass spectrometer

C. C : Carbon-nitrogen-sulphur analyzer (Vario EL III, Elementar)
Ice content: wet-dry weight difference

5. Results

A. Palynological record

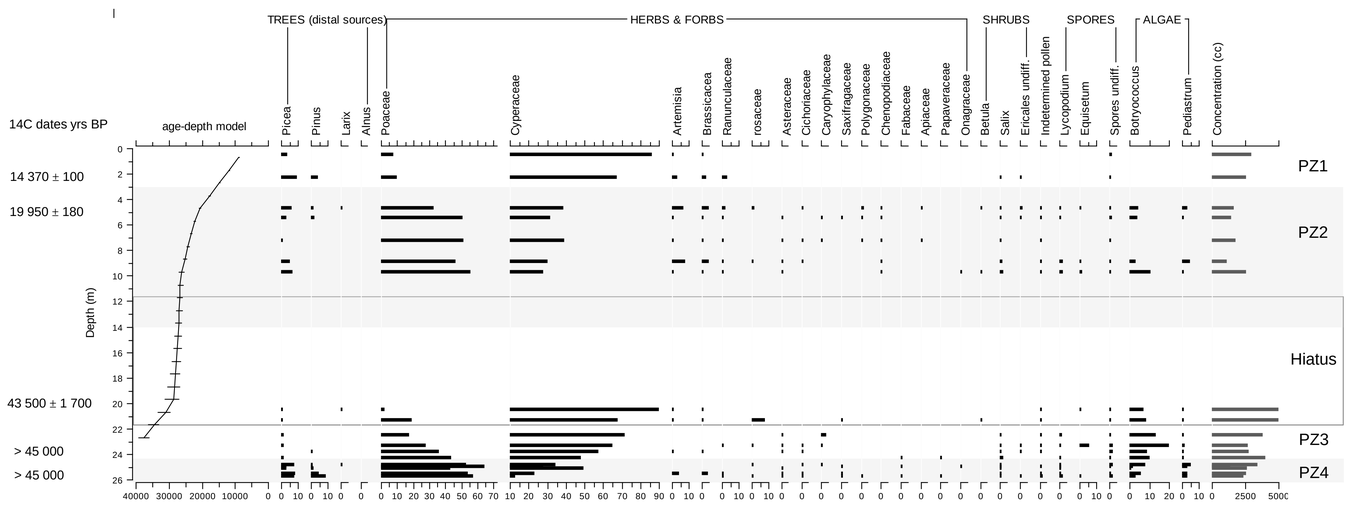

Fig 3. Pollen percentage diagram. Pollen zonation is given at the right side. 14C dates yrs BP represent radiocarbon ages obtained from the main sampling profile and the age-depth model is based on all the dates available from the site (Kanevskyi *et al.* (2011) and Strauss *et al.* (2012)).

B. Paleoclimatic reconstruction

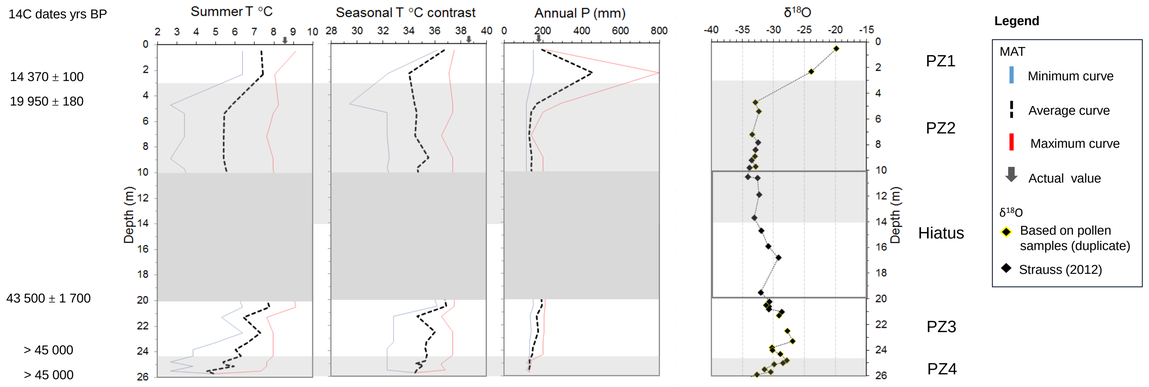

Fig 4. Average paleoclimate curves from MAT and $\delta^{18}O$. Summer T °C = average of june, july and august. Seasonal T °C ranges is based on variation between summer and winter (december, january and february) temperatures.

C. Sediment and ground-ice

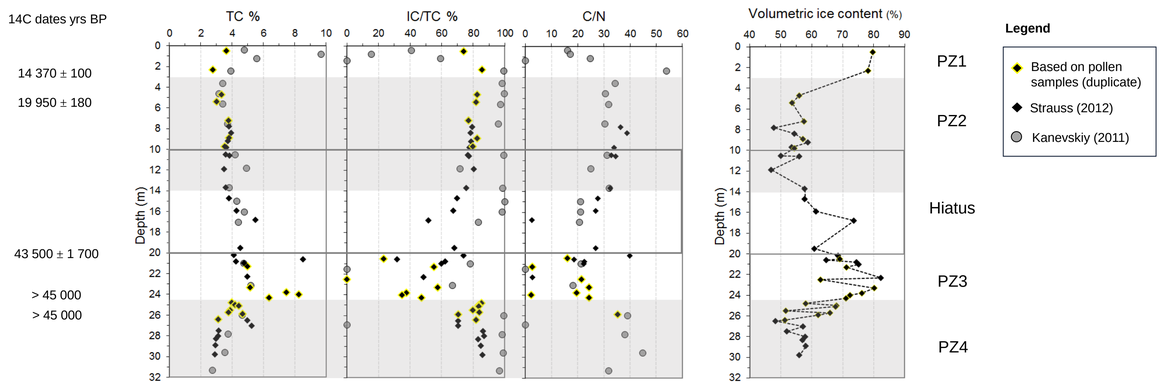

Fig 5. Sedimentological data from Itkillik river yedoma. TC = total carbon. IC/TC = inorganic carbon/total carbon. C/N = carbon/nitrogen.

6. Summary

Palynological records are subdivided into 4 vegetation/climate units that seem largely associated to marine isotopic stage (**MIS 1 (PZ1), MIS 2 (PZ2), MIS 3 (PZ3), MIS 4 (PZ4)**) that represent alternating warm and cool periods in the Earth's paleoclimate. Chronology of the site and δ18O seem to support this hypothesis. Kanevskiy (2011) also concluded that the greatest part of the exposure was formed during the middle Wisconsinan/Karginsky interstadial (MIS 3) and late Wisconsinan/Sartan glaciation (MIS 2). Palynological records are consistent with other sites in Eastern Beringia (Fréchette *et al.* (2008)), but is more easily comparable to sites in Western Beringia due to its older age (> 45 000 yrs BP) and depositional environment .

We observed that vegetation is dominated **by *Cyperaceae* during warmer periods** (MIS 1 (PZ1) and MIS 3 (PZ3). **Summer temperature are higher**, near the actual value (8,6 °C) and **correlated to δ18O variations**. **TC** is low throughout the profile (**4,8%**), but reaches its highest average concentration during MIS 3 (**6,7%** compare to 3,7% in MIS 2). IC/TC is inversely correlated to TC. During MIS 3 and MIS 1 the **C/N** ratio indicates conditions more favorable to decomposition (**21**). The **volumetric ice content** is also higher (**75%**), potentially linked to climatic conditions promoting surface stabilization (indicated by the formation of peat layer) and segregation of ice during synegenetic development of the permafrost.

In contrast, **during cold and dry periods** (MIS 2 (PZ2) and MIS 4 (PZ4)), vegetation is mainly **represented by *Poaceae* and a high diversity of minor herbs and forbs**. TC is low and **IC is dominant** (**84,4%** during MIS 2 compare to 57,8% for MIS3). **C/N** ratio shows that the organic matter is not labile (**35**). **Volumetric ice content** values (**56%**) are lower, probably due to increased eolian sedimentation and faster syngenetic surface elevation, conditions less favorable to ice segregation during syngenetic permafrost development aggradation.

Seasonal temperature contrast and annual precipitation show slight variability throughout the profile, suggesting that they are not the determining factors for carbon accumulation, nor ground ice aggradation.

7. Future work

- Add pollen data from other profiles on the same bluff
- Correlate pollen data with cryostratigraphic units, ice wedge volume and particle size analysis
- Improve the accuracy of reconstructed climatic parameters

References

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