C11D-1069; C11D: Archives and Observations from Subice Environments I Poster

Sediment beneath the Greenland Ice Sheet at Camp Century preserves plant and invertebrate evidence of past climates

Halley Mastro[1,2], Ole Bennike[3], Cat Collins[1,2], Dorothy Peteet[4], Barrett N. Rock[5], Andrew Schauer[6], Juliana Souza[1,2], Eric Steig[6], Paul Bierman[1,2]

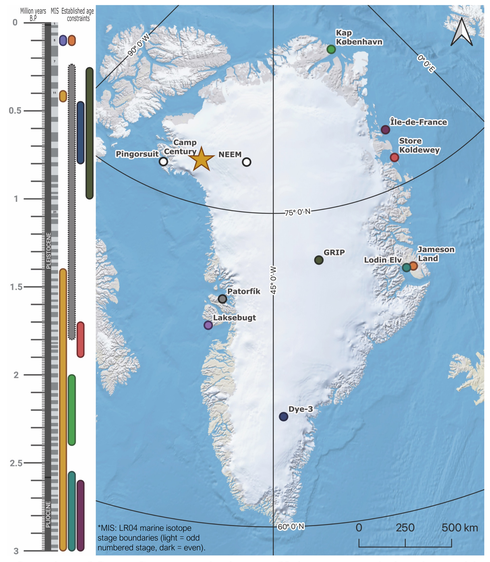
1 The University of Vermont Rubenstein School of Environment and Natural Resources 2 Cold Institute for Environment 3 4 Columbia Climate School Lamont-Doherty Earth Observatory 5 6 University of Washington

Why investigate ancient Arctic ecosystems?

- The Arctic is warming almost 4x faster than the rest of the planet, accompanied by widespread, heterogeneous ecosystem changes.
- The impact these changes will have on global climate and sea level is not well constrained due to interrelated feedback mechanisms.
- Archives of past ecosystem composition can shed light on how the biosphere responded to climate forcing in the past and might respond in the future.

Research Questions

1. What was the composition of emergent ecosystems at Camp Century during the ice-free periods represented in the core?
2. What environmental and climatic conditions would support the development of such ecosystems?



Location of Camp Century and other pre-Holocene organic-bearing archives in Greenland (right) with established age constraints for each (left).

Background

- The 1966 Camp Century ice core retrieved 3.44 m of sediment from beneath the Greenland Ice Sheet that was not fully studied until present.
- This rare sediment archive contains well preserved organic remains.
- Camp Century is located 150 km inside the present-day ice margin.
- Thus, the sediment archive was deposited during interglacial conditions with reduced ice sheet extent.
- Recent work constrained deposition of the uppermost sample to 416,000 years ago (marine isotope stage 11).

Approach

Macrofossil Characterization:

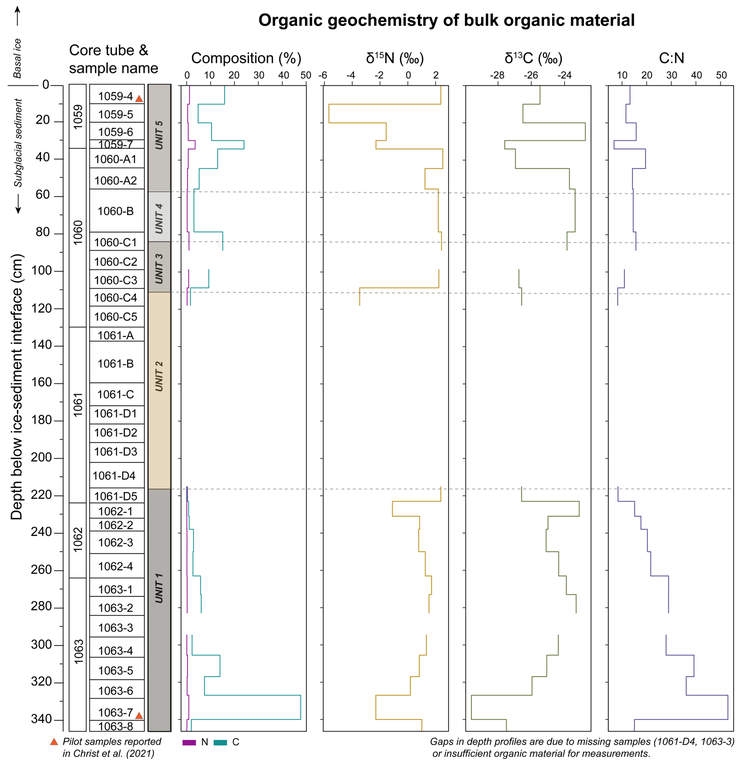
- We isolated organic material from sub-samples of the core at ~10cm intervals and used modern reference texts and collections to identify sufficiently preserved specimens.

Wood Anatomical Analysis:

- We observed diagnostic cellular features for identification of 12 woody specimens using scanning electron microscopy.

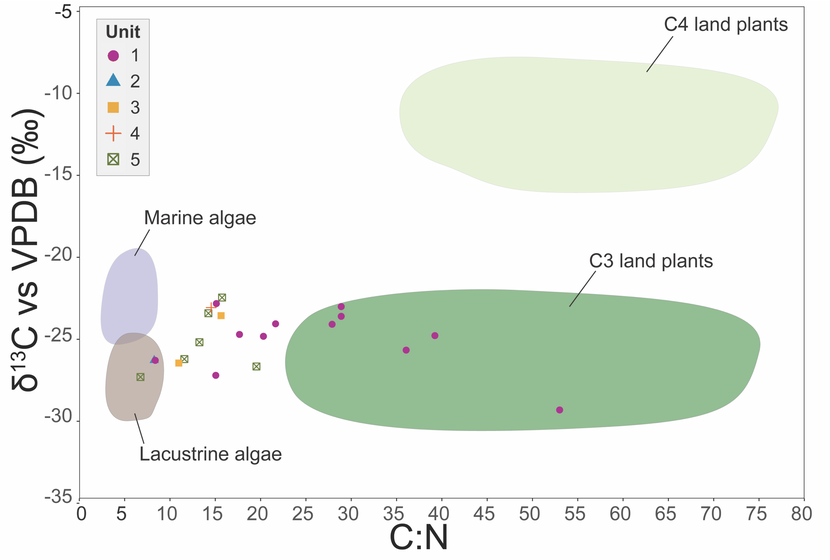
Organic Geochemistry:

- We measured total concentrations of carbon and nitrogen and their stable isotope ratios (δ^{13}C vs VPDB ‰, δ^{15}N vs Air N_2 ‰) in organic material using continuous-flow mass spectrometry.



Findings

1. Invertebrate and plant remains in the subglacial sediment core signify past ice-free conditions at Camp Century, a region currently beneath over a kilometer of ice.
2. So far, identified specimens are found in modern Arctic tundra ecosystems. Quantitative reconstruction to observe differences between depositional units and possible ecosystem change at Camp Century through time are ongoing.
3. Organic geochemistry suggests a shift from terrestrial C3 plants to admixed aquatic and terrestrial matter as the primary input of organic material to the sediment with decreasing core depth.



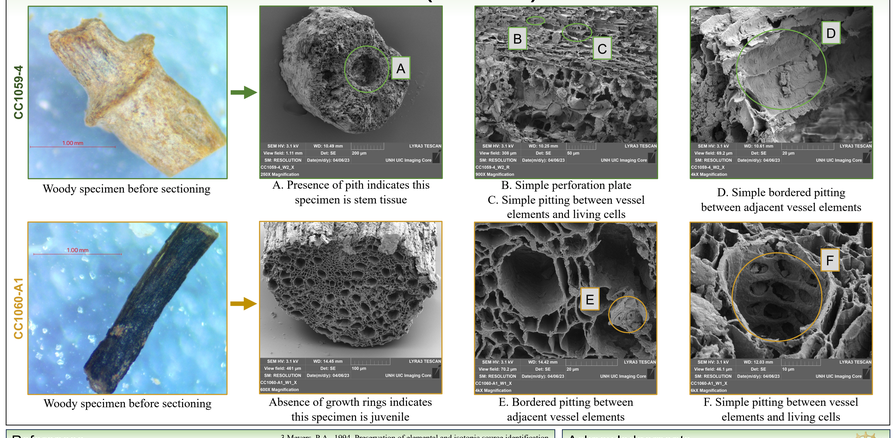
Distinct ranges of C:N ratios and δ^{13}C values in different types of organic matter allow us to trace the origin of bulk organic material in the Camp Century sediment core. Shaded ranges above from Meyers (1994).

Moss, freshwater invertebrate and terrestrial plant macrofossils illustrate Arctic tundra conditions

Unit 1	Unit 3	Unit 4	Unit 5	
CC1063-5	CC1060-C2	CC1060-C1	CC1060-A1	CC1059-6
Sphagnum sp. (moss) leaf	*Daphnia pulex* (water flea) ephippia	Poaceae (grass) caryopsis	*Draba* sp. (whitlow-grasses) seed	*Papaver radicatum* auct. coll. (Arctic poppy) seed
CC1063-5	CC1060-C2	CC1060-C1	CC1060-A1	CC1059-7
Scorpidium scorpioides (moss) stem and leaves	*Lepidurus arcticus* (tadpole shrimp) mandible fragment	Juncaceae (rush) seed	*Saxifraga* cf. *paniculata* (alpine saxifrage) seed	*Ranunculus* cf. *hyperboreas* (Arctic buttercup) seed

*Quantitative reconstructions of species composition in each sample are in progress.

Diagnostic structures observed in woody specimens are characteristic of *Salix* (willow)



References

1.Christ, A. J. *et al.* A multimillion-year-old record of Greenland vegetation and glacial history preserved in sediment beneath 1.4 km of ice at Camp Century. *PNAS* **118**, (2021).

2.Christ, A. J. *et al.* Deglaciation of northwestern Greenland during Marine Isotope Stage 11. *Science (1979)* **1063**, (2023).

3.Meyers, P.A., 1994, Preservation of elemental and isotopic source identification of sedimentary organic matter: Chemical Geology, v. 114, p. 289–302.

4.Myers-Smith, I. H. *et al.* Complexity revealed in the greening of the Arctic. *Nature Climate Change* vol. 10 106–117 (2020).

5.Rantanen, M. *et al.* The Arctic has warmed nearly four times faster than the globe since 1979. *Commun Earth Environ* **3**, (2022).

Acknowledgements

This work is supported by the National Science Foundation Office of Polar Programs grant EAR-OPP-2114629, awarded to P. Bierman and N. Perdrial.