Frozen pore water from beneath nearly a mile of ice: geochemical and stable isotope analysis of Camp Century basal sediment

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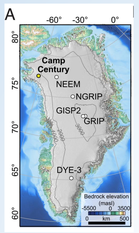
BACKGROUND

Drilling of the ice core at Camp Century base in early 1960`s.



Drilling location of the Camp Century in 1960`s at Northwest of Greenland (Christ et al., 2021)

On the left, the ice core tubes catalog by Fountain, and on the right, the reconstruction from samples cut in 1972 made by Andrew Christ (Fountain et al., 1981; Bierman et al., submitted.)

Cat Collins, Halley Mastro and Juliana Souza with the original Camp Century sub-ice sediment box in the Niels Bohr Institute Freezer, Denmark

- Camp Century was a military base working as an Arctic research laboratory underneath the Greenland Ice Sheet during the Cold War
- The Camp Century core was collected in 1966 from beneath 1.4 km of ice in NW Greenland (Hansen and Langway, 1966)
- Up to today, it is the longest (~3.5 m) sub-glacial sediment core ever recovered (Christ et al., 2021)
- The core was stored frozen for decades without being thoroughly studied.
- Early studies in the 1980`s were focused on petrologic descriptions, and identification of freshwater diatoms (Whalley, 1980; Fountain et al., 1981; Harwood, 1986)
- When rediscovered in 2017, a pilot study discovered microfossils and biomarkers from ice-free events, Early Pleistocene and MIS 11 (400 Ka) (Christ et al., 2021 and 2023)
- 50 years later, we are able to study and explore this material with a multidisciplinary approach, international cooperation and methods that were not available in the past

METHODS

- Thawed each of 26 frozen sub-samples at 4°C
- Extracted pore water by centrifuging
- Measured pH and conductivity using Myron L meters
- Filtered samples using 0.45 µm PTFE syringe filters (CosmoLab, Univ. of Vermont)
- Measured d^{18}O and dD using a Picarro L2130i Mass Spectrometer (IsoLab, Uni. of Washington)
- Cations concentrations measured by Agilent 7700 ICP-MS (ALEC Univ. Arizona).
- Anions concentrations measured by Metrohm 883/863 Ion Chromatograph (Environmental Analysis Lab, Williams College)

RESULTS

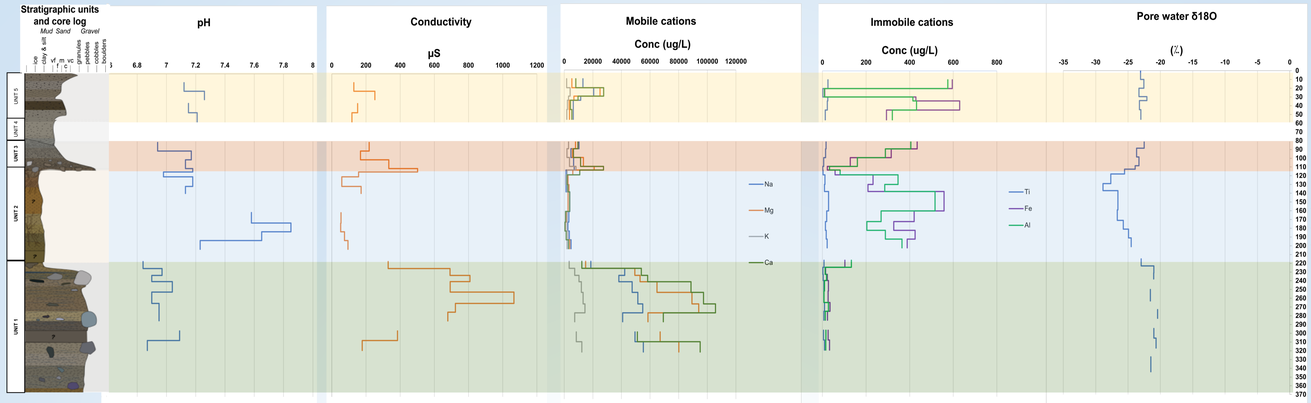


Figure 1. Plots of pH, conductivity, concentration of mobile and immobile cations, and δ18O of the pore water of the subglacial sediment core over depth. Units 1, 2, 3 and 5 are distinguished by the colors green, blue, orange and yellow, respectively. There are no data from unit 4 because the sample was melted before this project.

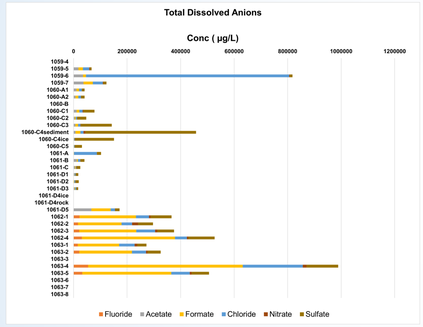


Figure 2. Plot of the concentration in µg/L of the total dissolved anions in each pore water sub-sample.

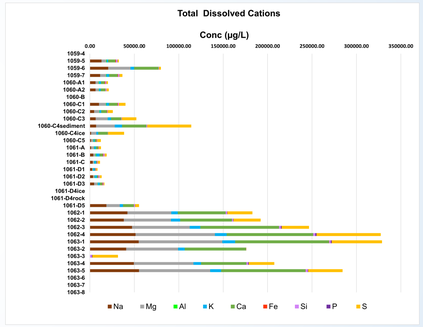


Figure 3. Plot of the concentration in µg/L of the total dissolved cations in each pore water sub-sample.

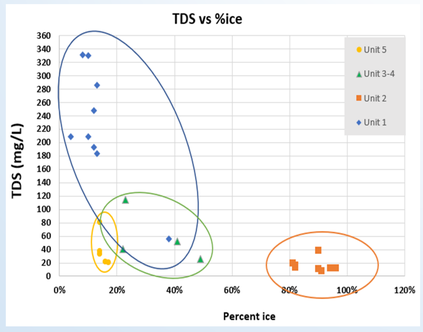


Figure 4. Plot of the concentration in mg/L versus percent of ice of each pore water sub-sample.

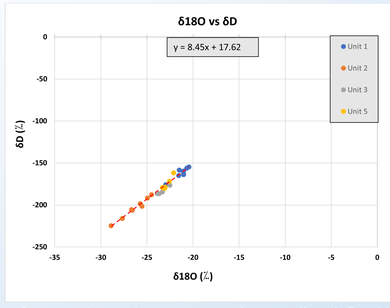


Figure 5. Camp Century meteoric water line defined by the plot of the of δ18O versus δD. The meteoric line has a slope value of 8.45.

FINDINGS

- Cation and anion concentrations indicate more extended sediment/water contact time for unit 1 than for overlying units.
- The concentrations of mobile and immobile cations in pore water samples are inversely related. This may reflect the solubility of different mineral phases due to different degrees of weathering in unit 1 (highly weathered, paleosol pore water) and the other units (less weathered, fluvial and aeolian sediment with significant input of meteoric water).
- δ18O and δD show no sign of phase changes at the bed, and a typical GMWL slope of 8.4
- All units show water stable isotopic composition compatible with an ice-free scenario, except Unit 2,which is more depleted, reaching values closer to the Holocene ice at Camp Century.
- Pore water data suggest: 1) extended weathering of glacial sediment (unit 1) during interglacial conditions, 2) unit 1 was then covered by glacial ice (unit 2), followed by 3) deglaciation and rapid deposition of interglacial fluvial sediment and precipitation derived pore water (units 3-5).

NEXT STEPS

- Geochemistry analysis of the sediment
- XRD analysis of the clay-sized material to determine mineralogy
- Meteoric 10Be profile to determine surface stability

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