Proxy-based reconstructions of Arctic paleoclimate

Boothia Peninsula, Nunavut

Prof. Sarah Finkelstein
Earth Sciences, University of Toronto
Finkelstein@es.utoronto.ca
Outline

• Why does climate change and over what time periods?
• Early Cenozoic: warmer and wetter, forested Arctic
• Quaternary ice ages
• Holocene paleoclimates
• Recent changes
Strathcona Fiord Fossil Forest, Ellesmere Island (J. Eberleye)
• Continental configurations similar to today but warmer, wetter Arctic
• Role of meridional heat transport, ice-albedo feedbacks, CO$_2$
• Ice-free Arctic may be significantly different
Stable isotopes from fossil material used to infer summer paleo-temperatures of ~20°C, winter temperatures above freezing and water vapour concentrations 2x present day
The Quaternary Period

- Oscillations between warm(ish) and cold periods linked to orbitally-mediated changes in timing and spatial distribution of solar radiation (Milankovitch cycles)
- **Glacials**: long cold periods (~10^5 yrs), continental ice sheets, alpine glaciers
- **Interglacials**: warmer periods (~10^4 yrs) of ice retreat, increased biological productivity
- Large-scale movement of biomes, changes in atmospheric CO₂ and CH₄ concentrations
Palynology: fossil pollen and spores

- Pollen grains produced in abundance by plants
- Dispersal, preservation and accumulation
- Reflects paleo-vegetation and is a key indicator of paleoclimate

Indicator taxa: *Dryas* pollen and the Younger Dryas stadial

Images: www.botany.unibe.ch/paleo/pollen.htm
Modern Analogue Technique (MAT) for paleoclimate reconstruction using fossil pollen data

Fossil sample from core

Modern sample

Location

Mean July Temperature (°C)

Resolute (High Arctic) 4.3
Taloyoak (Mid-Arctic) 6.1
Iqaluit (Low Arctic) 7.7

Modified from Jackson & Williams, 2004
Sprucing Up Greenland

Eric J. Steig and Alexander P. Wolfe

How much did the Greenland ice sheet shrink during previous warm episodes of the Pleistocene (from ~1.8 million to ~11,000 years ago)? This question is central to understanding fluctuations in sea level and the future stability of the ice sheet. On page 1622 of this issue, de Vernal and Hillaire-Marcel (1) report a record of pollen preserved in marine sediments deposited beyond the ice sheet’s margin that sheds considerable new light

- Pollen concentrations higher during past interglacials than during the Holocene
- Smaller Greenland ice sheet
- Boreal conifers established
- Warmer temperatures
The Holocene

• Our present interglacial
• Corresponds to rise of agriculture, cities, human civilizations and The Anthropocene
• Supra- and sub-millennial scale climate changes
• Paleoclimate reconstructed from marine and lake sediment records, geochemical proxies, biological proxies, varves and ice cores, land surface (boreholes, geomorphic evidence...
Holocene paleoclimate: general trends

Redrawn from Fisher et al. (1995) and Berger & Loutre (1991); Finkelstein *in press*. Oxford Handbook of Arctic Archaeology
Lake sediment core collection

- Gravity corer used for upper sediments
- Piston corer used for lower sections

Fosheim Peninsula, Ellesmere Island

Colour change: recent sediments, Lake SP04
Paleo-temperature and precipitation reconstructions from Lake SP02 pollen, Melville Peninsula, Nunavut

- Persistent ice sheet (to 6500 years ago)
- Warmer and wetter early Holocene Thermal Maximum
- Neoglacial cooling
- Error estimates on reconstructions / geochronology / resolution

Iamonaco & Finkelstein, in prep
Putting recent change into perspective

Composite paleo-temperature reconstruction based on 23 high resolution records (~annual). Standardized relative to reference period 980-1800 AD.
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