Sediment dynamics in the western Canadian Arctic since the last millennium: a mineralogical and geochemical approach

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Introduction

The Arctic Ocean currently experiences fast environmental changes due to its high response to global climate change. These changes notably include :

- reduced summer ice thickness and extent;
- reduction in multi-year ice extent;
- altered drift paths;
- major heat flow from Pacific;

The long-term natural variability is poorly constrained, leading to uncertainties in numerical climate models. In this context, sedimentary records are of great importance to decipher the processes controlling the Arctic climate and oceanographic variability for time periods prior to instrumental data.

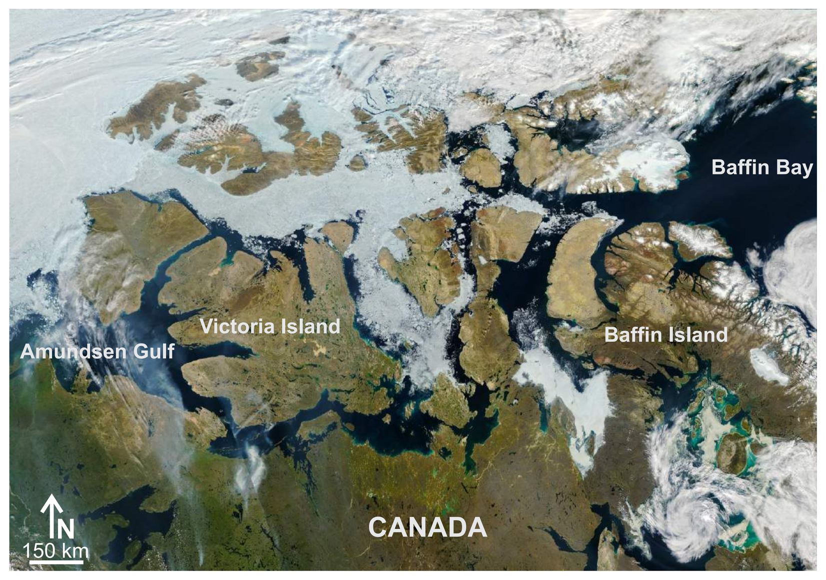


Figure 1. NASA satellite image of the Canadian Arctic Archipelago (August 2016)

Objectives

1. Compare the spatial distribution patterns of bulk minerals and elemental geochemistry during the Little Ice Age (LIA, between 1550 and 1850 AD), the Medieval Warm period (MWP, between 900 and 1300 AD), and the modern warming;

2. Identify different sedimentary provinces, source areas, and transport pathways of terrigenous material during these climatic periods;

3. Better document and understand the fundamental processes controlling the sediment dynamics within the western Canadian Arctic since the last millennium.

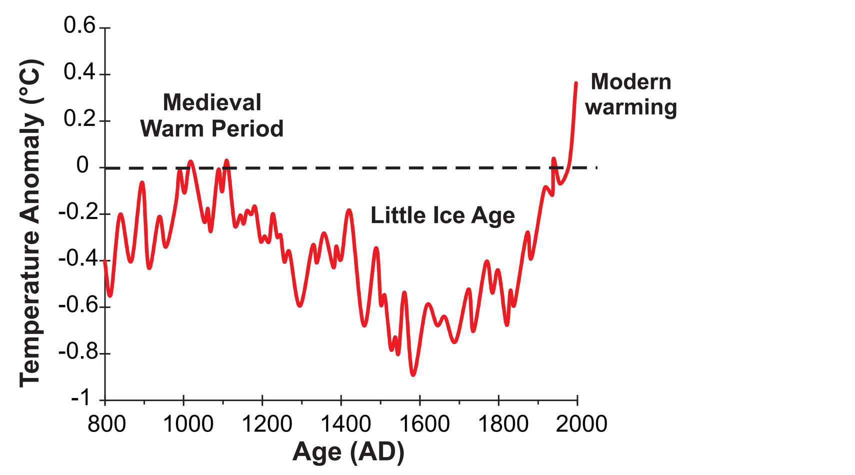


Figure 2. Records of NH temperature variation during the last 800 years (IPCC, 2013)

Samples

-50 box cores were sampled in the Canadian Arctic in 2016 and 2017 on board the CCGS Amundsen as part of the ArcticNet program (Figure 4).

-Sediment box cores are ~40 cm in length.

Figure 3. Recovery of full box core (A) and push cores in open box core (B)

Methodology

Sediment samples

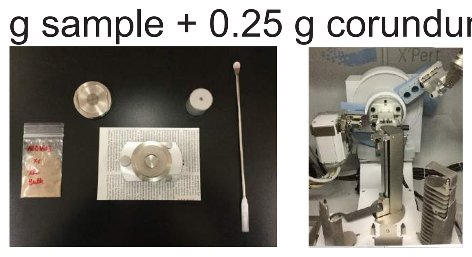
Wet sieving <2 mm

1 ^{210}Pb and ^{14}C dating to determine recent sedimentation rates

Sarah Letaief
ISMER-UQAR
MSc project

2 Bulk mineralogy

H_2O_2 30%
1 g sample + 0.25 g corundum



quantitative X-ray diffraction (qXRD)
(quartz, K-feldspar, plagioclase, dolomite, phyllosilicates)

3 Clay mineralogy

H_2O_2 30% + HCl 10%

X-ray diffraction (XRD)
(smectite, chlorite, illite, kaolinite)

4 Elemental geochemistry

H_2O_2 30%
Loss on ignition (LOI): 950°C
0.6 g sample + 6g lithium borate

energy dispersive X-ray fluorescence (EDXRF)
(Al, Si, K, Mg, Ca, Ti, Mn, Fe, P, Sr, V, Cr, Zn, Zr)

5 Cluster and principal component analysis (log-centered data)

6 Mineralogical and elemental geochemical maps

Ocean Data View
http://odv.awi.de

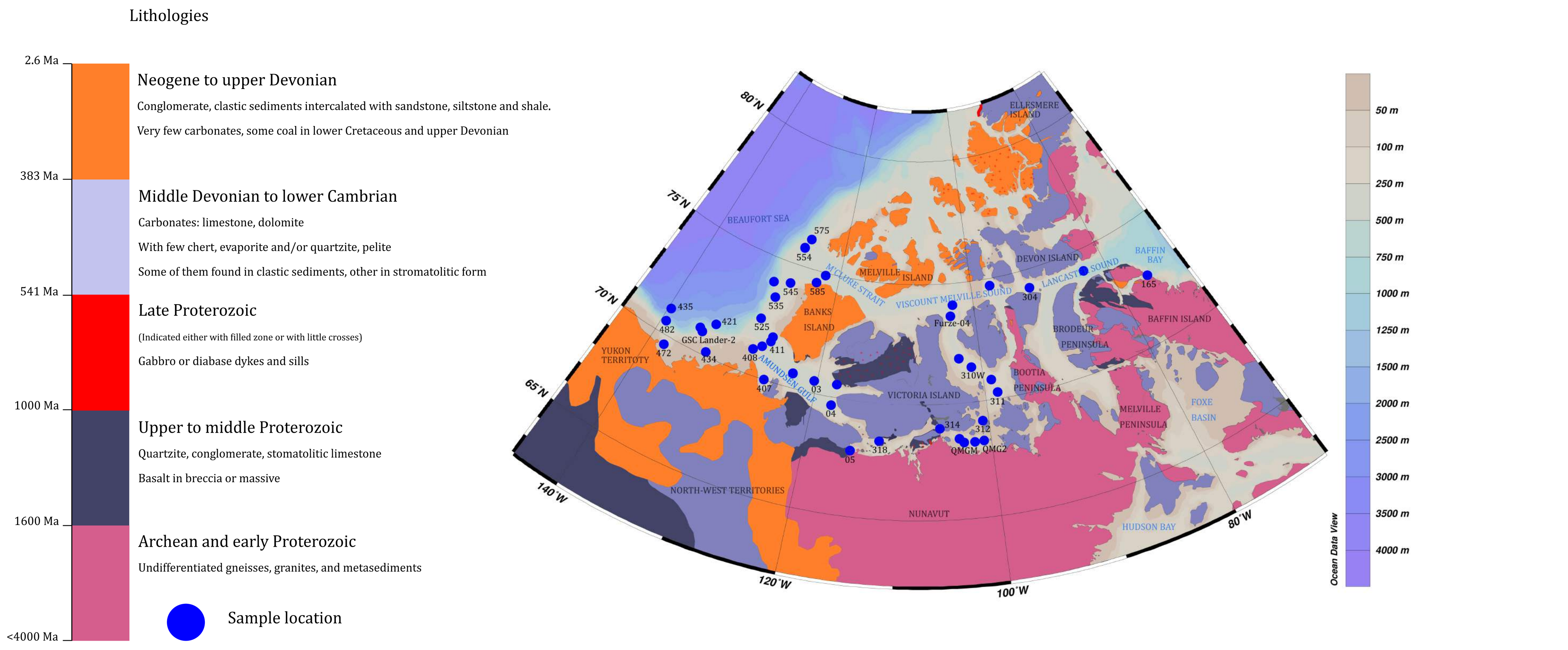


Figure 4. Streamlined geological map of the study area, modified after Ministery of Energy, Mines and Ressources Canada (MERN), the Geological Society of America (GSA) and the Geological Survey of Canada and Ocean Data View software.

Preliminary results

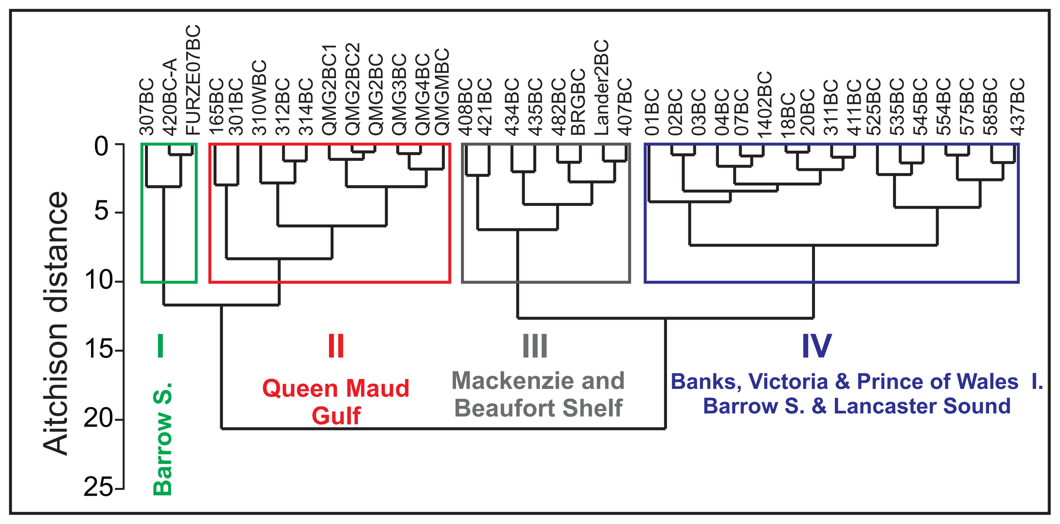


Figure 5. Dendrogram obtained by applying Ward clustering algorithm, based on log-centred bulk mineralogical data.

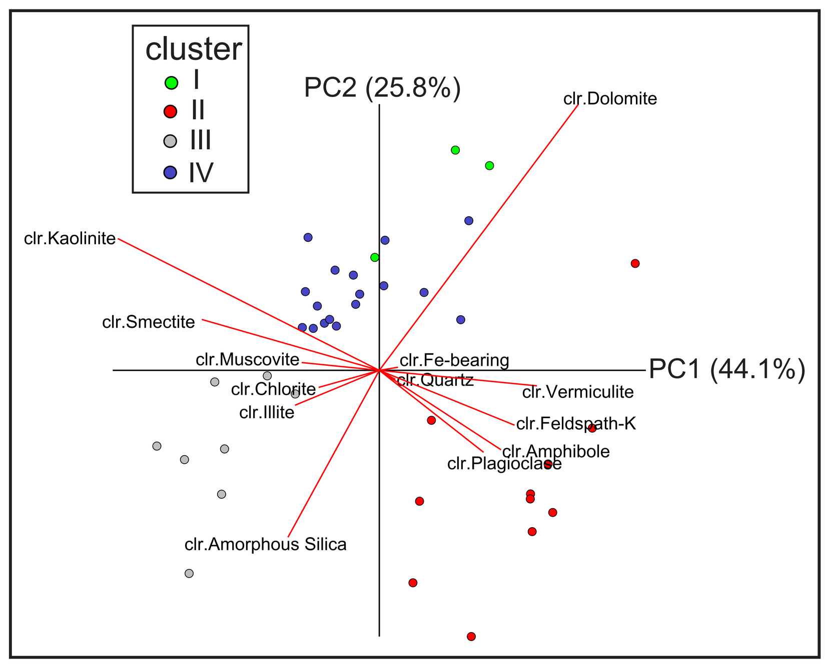


Figure 6. Biplot of the PC1 versus PC2 obtained from the log-centred transformation of the bulk mineralogical data from the surface sediments samples.

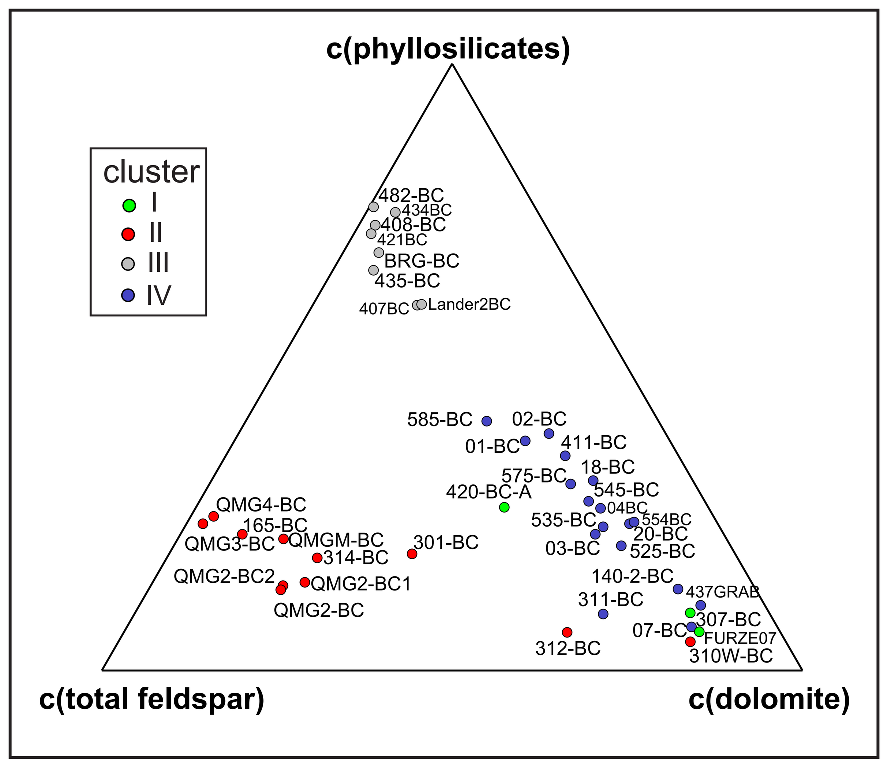


Figure 7. Phyllosilicates-Feldspars-Dolomite ternary plot showing the mineral composition surface sediments.

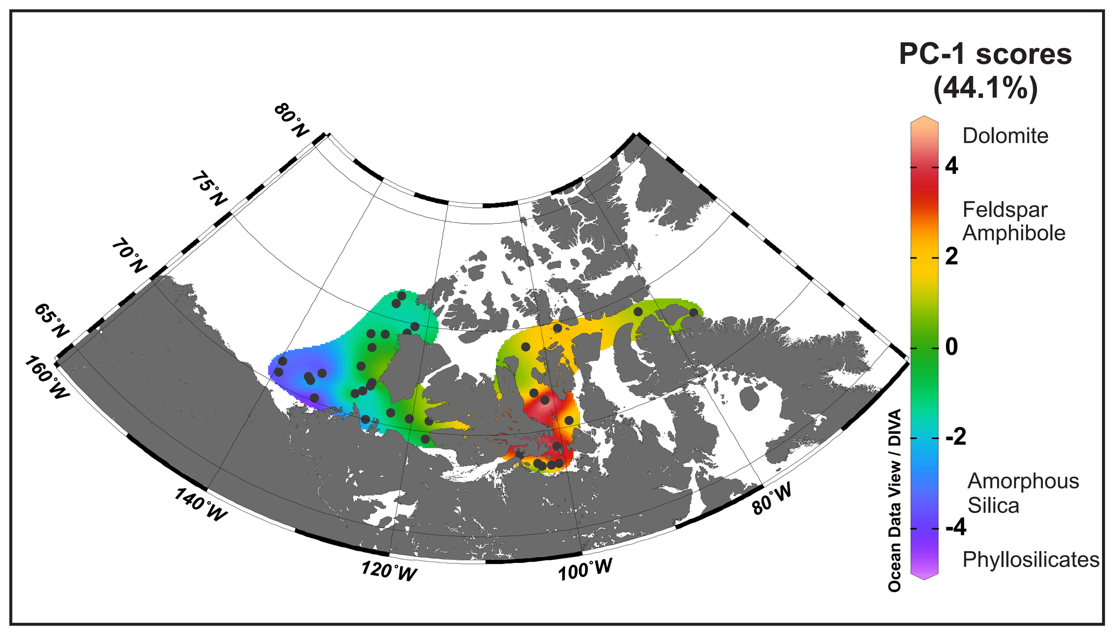


Figure 8. Map of PC-1 scores derived from the bulk mineralogical data from the surface sediments.

Conclusions

-The Canadian Arctic may be separated into three sedimentological provinces:

(1) the Mackenzie Trough-Canadian Beaufort Shelf, characterized by high phyllosilicate (notably, illite, chlorite, muscovite, smectite, and kaolinite) contents which are derived mainly from inputs of the Mackenzie River;

(2) the Queen Maud Gulf distinguished by the association of quartz, feldspars, amphibole, and vermiculite resulting from the Ellice and Back Rivers;

(3) Banks/Victoria/Prince of Wales Islands, Barrow Strait, and Lancaster Sound, characterized by high dolomite and intermediate phyllosilicate contents mainly supplied from coastal cliff erosion of Pleistocene carbonate-rich glacial tills, as well as clastic sedimentary rocks cropping out on the islands.

-Phyllosilicates, total feldspar and detrital carbonate (dolomite) can be successfully used to track changes in terrigenous sediment inputs in the Canadian Arctic.

-This study will complement another MSc project focusing on the sedimentological, physical and magnetic properties of the sediments.It will also provide baseline data for future studies, using mineralogical and elemental geochemical signatures of Canadian Arctic sediments, in order to reconstruct source-to-sink sediment changes related to late Quaternary climate and oceanographic variability

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