Deglacial and Holocene Dolomite delivery to the Arctic Ocean from the Mackenzie River

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Introduction

Carbonate bedrock in the Canadian-Arctic and Northern Greenland are considered the primary source of dolomites in sediments of the Arctic Ocean. Sedimentary dolomite abundance is routinely used as a proxy for ice sheet decay along the Canadian and Northern Greenland coastlines, variations in sea ice production in the Beaufort Sea and changes in Arctic Ocean circulation (Stein 2008). Increased dolomite abundances in Younger Dryas aged sediments from the Mendeleev and Lomonosov Ridges have also been argued as evidence for an outburst of proglacial Lake Agassiz into the Arctic via the Mackenzie Valley (Not and Hillaire-Marcel 2012).

The Mackenzie River is a prominent transport system of weathered bedrock, and of all the Arctic rivers, delivers the largest amount of suspended sediment to the Arctic Ocean (Carson et al. 1998). However, no detailed and proximal study of dolomite content of suspended material carried by the Mackenzie River exists. Here we investigate the mineralogy of the fine fraction (<38 µm) material in Late Pleistocene to Holocene sediments from an 81.5 m long borehole (MTW01) drilled in the landward part (45 mwd) of the Mackenzie Trough by the Geological Survey of Canada in 1984 (Fig. 1). The borehole penetrated a 52 m progradational facies deposited during deglacial sea-level rise, and an overlying 30 m unit of marine silts and clays deposited after marine inundation at this site (Fig. 2). This study aims to (i) quantify the abundance of dolomites in sediments delivered to the Arctic Ocean by the Mackenzie River and (ii) investigate deglacial and Holocene variations in the dolomite content.

Mineralogical analysis (XRD) of 23 samples reveals the presence of dolomite throughout the core (0-81.5 mbsf) while calcite is present mainly below 22 mbsf. The content of <38 µm dolomites varies between 5-11 wt % with an average of 8.5 wt %. We conclude that Mackenzie Trough has been a source of dolomites for the last ca. 14 ka, and provides a significant and sustained input of fine-grained dolomite to the Arctic Ocean.

Settings

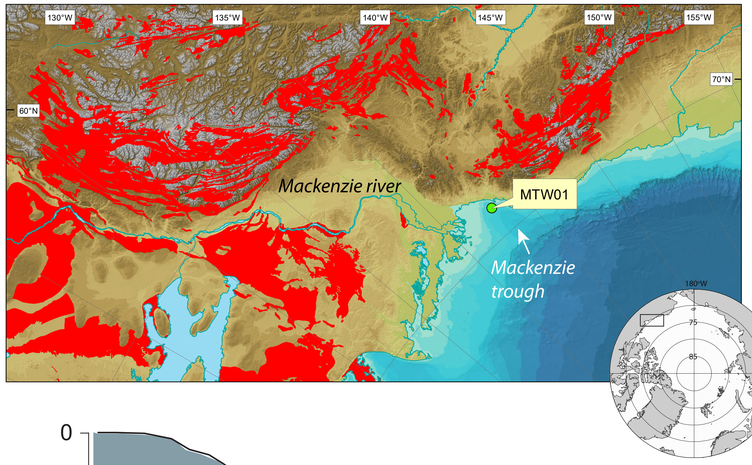


Figure 1
The Mackenzie River Valley in Northern Canada and the adjacent Mackenzie Trough. MTW01 = location of the 81.5 m long borehole. Red areas = carbonate bedrock.

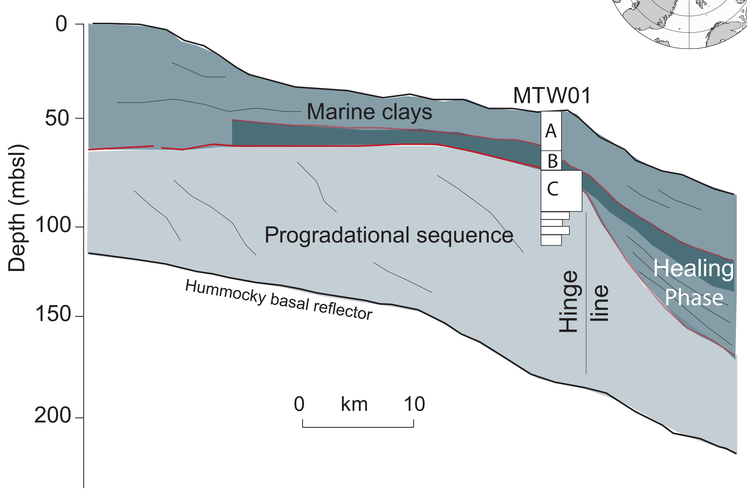
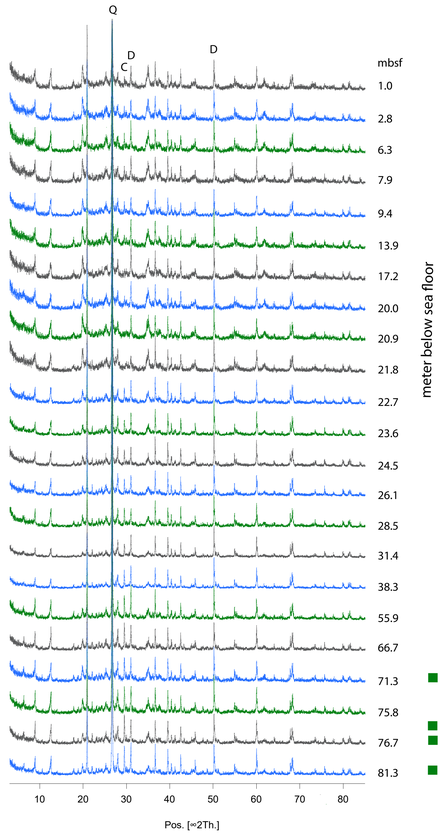


Figure 2
Interpreted seismic stratigraphy of the Mackenzie Trough with the extension of MTW01 adapted from Moran et al., 1989; Hill, 1996 and Blasco et al.,1990 . Progradational sequence is overlain by foram-bearing marine clays deposited after transgression of the site 9-10 ka.

Figure 3
Diffractograms of all 23 samples stacked together to show the degree of uniformity of the mineralogy between the samples. Numbers of the y-axis refer to meter below sea floor. Letters above distinct peaks show major peaks of selected minerals. Q = quartz, C = calcite and D= dolomite. Note that the major quartz peak (Q) has been shortened considerably. HighScore 3.0e together with ICSD database was used to identify peaks and a complete mineralogical suite for each sample. .

Results



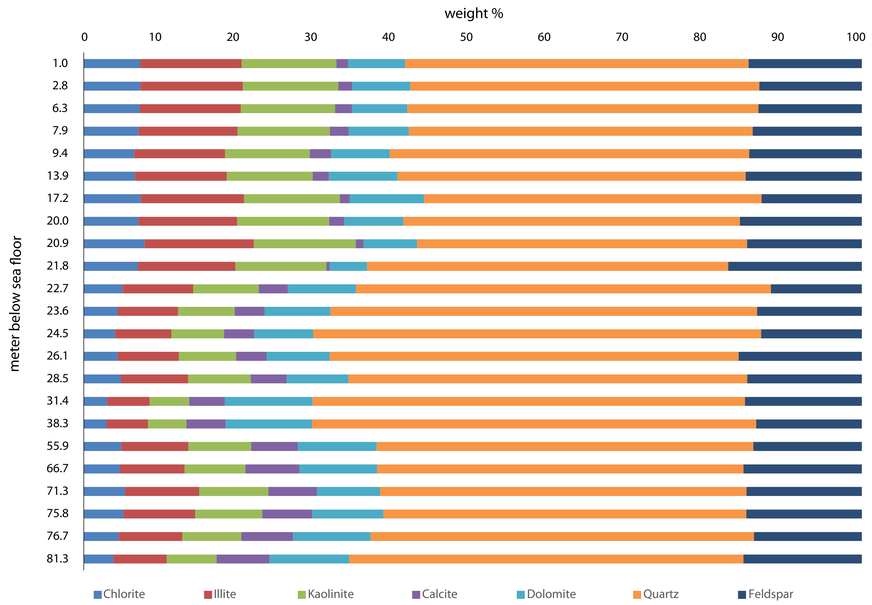


Figure 4
Mineral content (wt %) of the MTW01 with respect to depth. The values are derived through Rietveld refinement using MAUD software (Lutterotti et al. 2007). The dolomite content is fairly stable throughout the core. Notable is the decrease in calcite and quartz at ~22 mbsf accompanied by an increase in clay minerals (chlorite, illite and kaolinite).

Conclusions

A. Mackenzie river has been a source of dolomite (<38 µm) to the Arctic Ocean during deglaciation and the Holocene.

B.The average dolomite content of MTW01 sediments in the <38 µm fraction is 8.5 wt %

C. A slight reduction in dolomite content, and increase in chlorite, illite and kaolinite is seen after transgression of the site

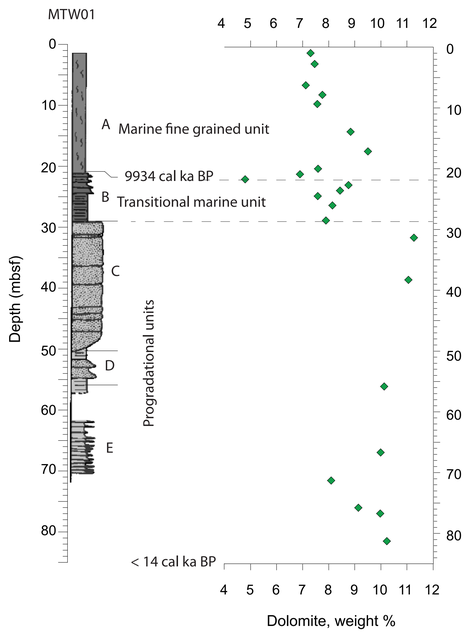


Figure 5
Lithology and chronology of MTW01 along with the dolomite content (weight %) showing a stable dolomite input (5-11%) to the Arctic Ocean during the last 14 yrs. A slight decrease in the dolomite input at the transition towards a marine environment is reflected in the data. Chronology adapted from O'Regan et al. (in prep)

References

Carson, M. A., Jasper, J. N., & Conly, F.M. 1998: Magnitude and sources 455 of sediment 456 input to the Mackenzie Delta, Northwest Territories, 1974–94. Arctic 51, 116–457 124..

Hill, P.R., 1996. Late Quaternary sequence stratigraphy of the Mackenzie Delta. Canadian Journal of Earth Sciences 33, 1064-1074.

Blasco, S.M., Fortin, G., Hill, P.R., O'Connor, M.J., & Brigham-Grette, J. 1990: The late Neogene and Quaternary stratigraphy of the Canadian Beaufort continental shelf. In: Grantz, A., Johnson, L., Sweeney, J.F. (Eds.), The Geology of North America. The Arctic Ocean Region, vol. L. Geological Society of America, Boulder, Colorado, pp. 491-502.

Lutterotti, L., Bortolotti, M., Ischia, G., Lonardelli, I. and Wenk, H.-R. 2007: Rietveld texture analysis from diffraction images, Z. Kristallogr., Suppl. 26, 125-130

Moran, K., Hill. P.R., & Blasco, S.M. 1989: Interpretation of piezocone penetrometer profiles in sediment from the Mackenzie Trough, Canadian Beaufort Sea. Journal of Sedimentary Petrology 59, 88 - 97.

Not, C. and Hillaire-Marcel, C. 2012: Enhanced sea-ice export from the Arctic during the Younger Dryas, Nature Communications 3:647

O'Regan, M., Blasco, S. M., Coxall, H., Hill, P. and Hilton, R. Radiocarbon constraints on the deglacial and Holocene stratigraphy of the upper Mackenzie Trough, Canadian Beaufort Sea. *in prep.*

Stein, R., 2008: Proxies Used for Palaeoenvironmental Reconstructions in the Arctic Ocean. In: Stein, R., (Ed.), Developments in Marine Geology Volume 2, Arctic Ocean Sediments: Processes, Proxies, and Paleoenvironment. Elsevier, Amsterdam, p. 133–243