# Glacial to Holocene development of Baffin Bay sedimentary systems: processes, provenances, and patterns

## Summary

Ongoing climate warming puts the Arctic in a perilous condition, as it now warms at least twice as fast as other regions in a process called Arctic Amplification. Rising atmospheric and ocean temperatures have forced the dramatic loss of Arctic ice observed in the last decades, with direct implications also for mid- to low-latitude regions via numerous atmospheric and oceanic connections. Understanding past Arctic ice (sheet)-dynamics related to changing climate and ocean conditions is instrumental in constraining numerical model-based projections of future environmental conditions better.

Baffin Bay, a narrow oceanic basin between Canada and Greenland connecting the Arctic and North Atlantic Oceans, is one of the ideal settings for studying past atmosphere-ice-ocean interactions in the northern high latitudes. Three major Northern Hemisphere ice sheets (the Laurentide, Innuitian, and Greenland ice sheets) partly surrounded Baffin Bay during the Last Glacial Maximum (LGM). These large ice sheets remained marine-based on Baffin Bay shelves until the early Holocene. Several studies reconstructing the sedimentary history of Baffin Bay have provided valuable insights into past ice sheet dynamics and paleoenvironmental changes in the region. However, most of these studies are concentrated on eastern Baffin Bay (i.e., the Greenland side), leaving the past ice-margin dynamics and paleoenvironmental conditions in western Baffin Bay poorly understood. In this thesis, we carried out multi-proxy analyses on five marine sediment cores in three separate studies with the aim of contributing to a better understanding of deglacial to Holocene sediment and ice sheet dynamics in western Baffin Bay.

In the first two studies (Chapters 4 and 5), AMS radiocarbon, sedimentological (computed tomography imaging and grain size analysis), mineralogical, and radiogenic isotope analyses of gravity core GeoB22336-4 raised from the mouth of the Lancaster Sound trough and gravity cores GeoB22346-3 and GeoB22357-3 recovered from the Clyde Inlet fjord and Clyde trough, respectively, allowed the reconstruction of local changes in sediment dynamics and provenances since the last deglaciation. These provided new insights into the retreat pattern of the Laurentide and Innuitian ice sheets from western Baffin Bay and subsequent paleoenvironmental developments. In the deeper Lancaster Sound trough in northern Baffin Bay, our study (Chapter 4) improved the retreat chronology of the Lancaster Sound Ice Stream, draining the confluent Laurentide and Innuitian ice sheets. AMS radiocarbon dating of the basal till (> ~14.5 ka BP) suggests the presence of a grounded ice stream in northern Baffin Bay until the start of the Bølling-Allerød interstadial. The prevailing presence of the Lancaster Sound Ice Stream during the Younger Dryas stadial enabled the rapid deposition of detrital carbonate-rich glaciomarine sediments eroded from proximal sources. Meanwhile, the basal till in the sediment core from the Clyde trough (Chapter 5) in western Baffin Bay most likely indicates a Younger Dryas mid-shelf stillstand (or re-advance) of the Clyde Ice Stream (draining the Laurentide Ice Sheet).

In the following early Holocene warming, ice streams of surrounding ice sheets rapidly retreated from marine-terminating to land-terminating positions. Radiogenic isotope data reveal the final deglaciation of the Lancaster Sound (~10.4 – 9.9 ka BP) and Nares Strait (~8.5 ka BP) and the re-establishment of Baffin Bay as an Arctic-Atlantic throughflow, also documenting the impacts of the Arctic gateways opening on sediment routing and deposition. The Clyde Inlet fjord core data show that the Laurentide Ice Sheet was already land-based in this region by ~9.5 ka BP, where the continuous decrease in meltwater discharge to the core site (into mid-Holocene) reflects the further collapse of the ice sheet. In northern Baffin Bay, this substantial reduction in meltwater input as ice sheets shrunk toward their minimum extent during the mid-Holocene probably permitted the deeper Atlantic-sourced warmer waters transported by the West Greenland Current to exert a stronger influence on surface waters. This interaction favored the intense melting of sea ice entering northern Baffin Bay, and the consequent release of sea ice-rafted debris most likely enabled the rapid accumulation of fine-grained sediments observed here.

In the late Holocene, the Neoglacial cooling trend observed in the Arctic, possibly in response to the combined decline in summer insolation and northward oceanic heat transport, is evident in the data from the cores from Clyde Inlet fjord and off Lancaster Sound. This cooling is most prominently displayed by the increase in iceberg-rafted large clasts in the last approximately two millennia, indicating the re-advance of regional glaciers.

In light of the new insights into the close coupling of sediment and ice-sheet dynamics in western Baffin Bay, the third study (Chapter 6) was conducted to compare spatial and temporal trends in sedimentation patterns across the entire Baffin Bay since the LGM. This study is based on the compilation of radiocarbon-derived sedimentation rates from the three sediment cores used in the first two studies (and the remaining two cores here), together with those from previously unpublished and published records from Baffin Bay, totaling 79 sediment cores. This Baffin Bay-wide data compilation shows that during the LGM and up until ~15 ka BP, the deep basin and slope were the only active sediment depocenters as ice sheets likely occupied the surrounding shelves. It highlights the transition from relatively low glacial sedimentation in the deep basin and slope to enhanced deglacial sedimentation on the shelves following the landward retreat of ice sheets from Baffin Bay. Furthermore, the data collated for the West Greenland shelf was converted into subglacial erosion rates, providing for the first time sedimentation rate-based erosion rates for the West Greenland Ice Sheet.

Overall, the present study demonstrates the usefulness of marine sedimentary archives from high-latitude glaciated margins for reconstructing paleo-ice sheet(s) dynamics closely linked to changing atmospheric and oceanic temperatures. The findings of this thesis significantly improve our understanding of the depositional history of Baffin Bay through the last major global warming, the last deglaciation, and provide an analogue of the Arctic ecosystem response to present and future global climate change.