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Coastal Environmental Change
During Sea-Level Highstands:
A Global Synthesis with implications
for management of future coastal change

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Quaternary coastal morphology and sea level changes

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Evidence for late Holocene sea-level rise and Greenland Ice Sheet expansion.

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Abstract

There is widespread geomorphological evidence that the Greenland Ice Sheet has expanded since the onset of the climatic cooling associated with the "Neoglacial" from c. 4000 cal. yr BP (Kelly, 1980; Weidick, 1996). Quantifying the exact timing and magnitude of this readvance is important if we are to better understand: i) the size of the contracted Ice Sheet during the climatic warmth of the mid Holocene; ii) the response of the Ice Sheet to climate cooling in the late Holocene and; iii) the earth's response to renewed ice load during the late Holocene. The latter is especially important to efforts that seek to use satellite data to better comprehend current Ice Sheet mass balance.

In this paper we present the results of a detailed study of the evidence for late Holocene RSL change in Disko Bugt, a large marine embayment in West Greenland (Figure 1). Our approach relies on the use of low-lying and submerged isolation basins, together with coastal saltmarsh sequences, to reconstruct the timing of the switch from early Holocene emergence to late Holocene submergence, the magnitude of late Holocene submergence, and the spatial pattern of this submergence across the study area. We compare our results with geophysical rebound models for the region, as well as recent GPS observations of absolute earth movements.

New RSL data are presented from a site within the Jakobshavns Isbrae icefjord, the closest RSL site yet examined to the Greenland Ice Sheet in Disko Bugt. A contemporary isolation basin, with a sill c. -4m below mean sea-level, records evidence for a tripartite depositional sequence that comprises marine, freshwater and then marine sediments conditions. These sediments record the initial uplift of the basin and its isolation from the sea, followed by its submergence in the late Holocene. Diatoms from the sample core demonstrate these changes in environment particularly clearly, whilst bulk AMS radiocarbon dates provide a core chronology. The basin provides evidence for a rise in mean sea-level at this site of at least 4 m during the late Holocene. The protracted period of freshwater conditions recorded when the basin lay above the marine influence indicates that the magnitude of neoglacial RSL rise is likely to have exceeded this value.

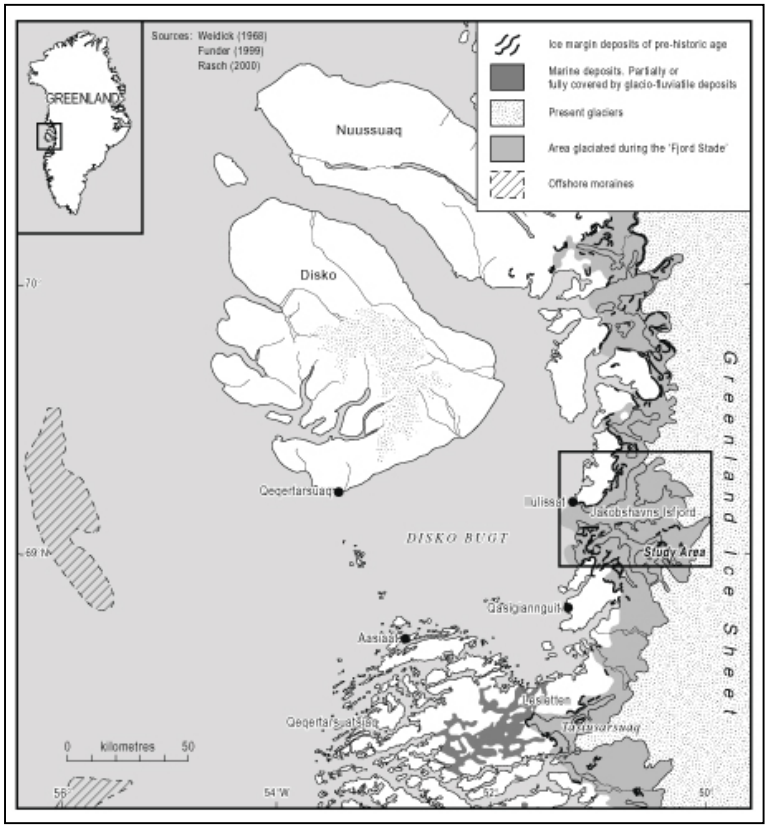

Figure 1. Location map of study area

The new data from Jakobshavns Isbrae are compared with other isolation basin and saltmarsh sequences from elsewhere in Disko Bugt (Long et al., 1999; Long and Roberts, 2002; Long and Roberts, in press; Rasch, 2000). In general, rates of submergence are greatest in sites closest to the Ice Sheet, as is the magnitude of submergence. These trends are compatible with a hypothesis of crustal submergence caused by Ice Sheet readvance during the Neoglacial, and are opposite to those expected by forebulge collapse associated with the Greenland and Laurentide Ice Sheets in the region.

Recent GPS observations and geophysical rebound models associate rapid rates of late Holocene RSL rise in many areas of Greenland with significant neoglacial Ice Sheet expansion. For example, GPS data indicate subsidence of *c.* 5.8 ± 1.0 mm/yr at Kellyville (South Greenland) and 2.1 ± 1.5 mm/yr at Kulusuk (East Greenland). Wahr et al. (2001a, b) interpret these patterns as evidence for crustal redepression associated with Ice Sheet readvance of up to 50 km in the last 4000-3000 years. Moreover, in ice sheet modelling experiments, Kelly (1980) and Tasarov and Peltier (2002) note that significant late Holocene Ice Sheet readvance is needed to explain the observed trend in late Holocene RSL rise, and also why the marine limit is generally higher on the outer coast of West Greenland compared with sites closer to the present Ice Sheet margin.

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