Earth and Planetary Science Letters 272 (2008) 8–18

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl

Late Weichselian relative sea-level changes and ice sheet history in southeast Greenland

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ARTICLE INFO

Article history:
Received 30 November 2007
Received in revised form 8 March 2008
Accepted 17 March 2008
Available online 9 April 2008

Editor: H. Elderfield

Keywords:
Greenland Ice Sheet
relative sea-level
isolation basin
ice sheet model
isostatic rebound

ABSTRACT

Relative sea-level (RSL) observations from the margins of the Greenland Ice Sheet (GIS) provide information regarding the timing and rate of deglaciation and constraints on geophysical models of ice sheet evolution. In this paper we present the first RSL record for the southeast sector of the GIS based on field observations completed close to Ammassalik. The local marine limit is c. 69 m above sea-level (asl) and is dated to c. 11 k cal. yrs BP (thousand calibrated years before present) and is a minimum date for ice free conditions at the study site. RSL fell to c. 24 m asl by 9.5 k cal. yrs BP and continued to fall at a decreasing rate to reach close to present by 6.5 k cal. yrs BP. Our chronology agrees with radiocarbon dates from offshore cores that indicate ice free conditions on the adjacent mid-shelf by 15 k cal. yrs BP. We compare the new RSL data with predictions generated using two recently published glaciological models of the GIS that differ in the amount and timing of ice loading and unloading over our study area. These two GIS models are coupled to the same Earth viscosity model and background (global) ice model to aid in the data-model comparison. Neither model provides a close fit to the RSL observations. Based on a preliminary sensitivity study using a suite of Earth viscosity models, we conclude that the poor data-model fit is most likely due to an underestimate of the local ice unloading. An improved fit could be achieved by delaying the retreat of a thicker ice sheet across the continental shelf. A thick ice sheet extending well onto the continental shelf is in agreement with other recent observations elsewhere in east and south Greenland.

1. Introduction

Relative sea-level (RSL) data provide the most powerful available constraints on the Holocene dimensions of the Greenland Ice Sheet (GIS). Thus, the age and elevation of the marine limit (the highest level attained by RSL since deglaciation), provide information on the timing of ice margin retreat and net uplift since that time (Funder and Hansen, 1996). The rate of early and mid Holocene RSL fall provides information regarding the timing and magnitude of ice unloading, whilst a late Holocene rise in RSL observed in west and south Greenland reflects the combined effects a readvance of the GIS during the neoglacial, the collapse of the Laurentide Ice Sheet forebulge and ice-equivalent 'eustatic' sea-level change (Kelly, 1980). RSL data also constrain geophysical models of ice sheet history during the Late Weichselian that provide insights into the longer-term history of the ice sheet, including its response to climate and its contribution to global sea-level change (Bennike et al., 2002; Tarasov and Peltier, 2002; Huybrechts, 2002; Fleming and Lambeck, 2004).

Relative sea-level observations in west and south Greenland are reasonably abundant, with data points derived from radiocarbon-dated marine molluscs, drift wood or whale bones, originally deposited in beaches or glaciomarine deposits and now uplifted above present sea-level. Archaeological observations yield additional RSL estimates since c. 4 k cal. yrs BP (thousand calibrated years before present) (Rasch and Jensen, 1997; Rasch, 2000). Each of these types of data has age and altitude uncertainties that are typically ±5 to 10 m and ±200 to 400 cal. yrs. Less common are data obtained from isolation basins, natural rock basins that at various times in their history are either connected to or isolated from the sea (Foged, 1973; Bennike, 1995; Long et al., 1999, 2003, 2006; Long and Roberts, 2003; Sparrenbom et al., 2006a,b). These have better resolved age and height relationships to former sea-level, typically ±0.5 m and ±100 cal. yrs. Where these data exist from a relatively small geographical area, they provide particularly useful constraints on ice sheet history and geophysical models of glacial isostatic adjustment (GIA), which include both an Earth and ice component.

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doi:10.1016/j.epsl.2008.03.042

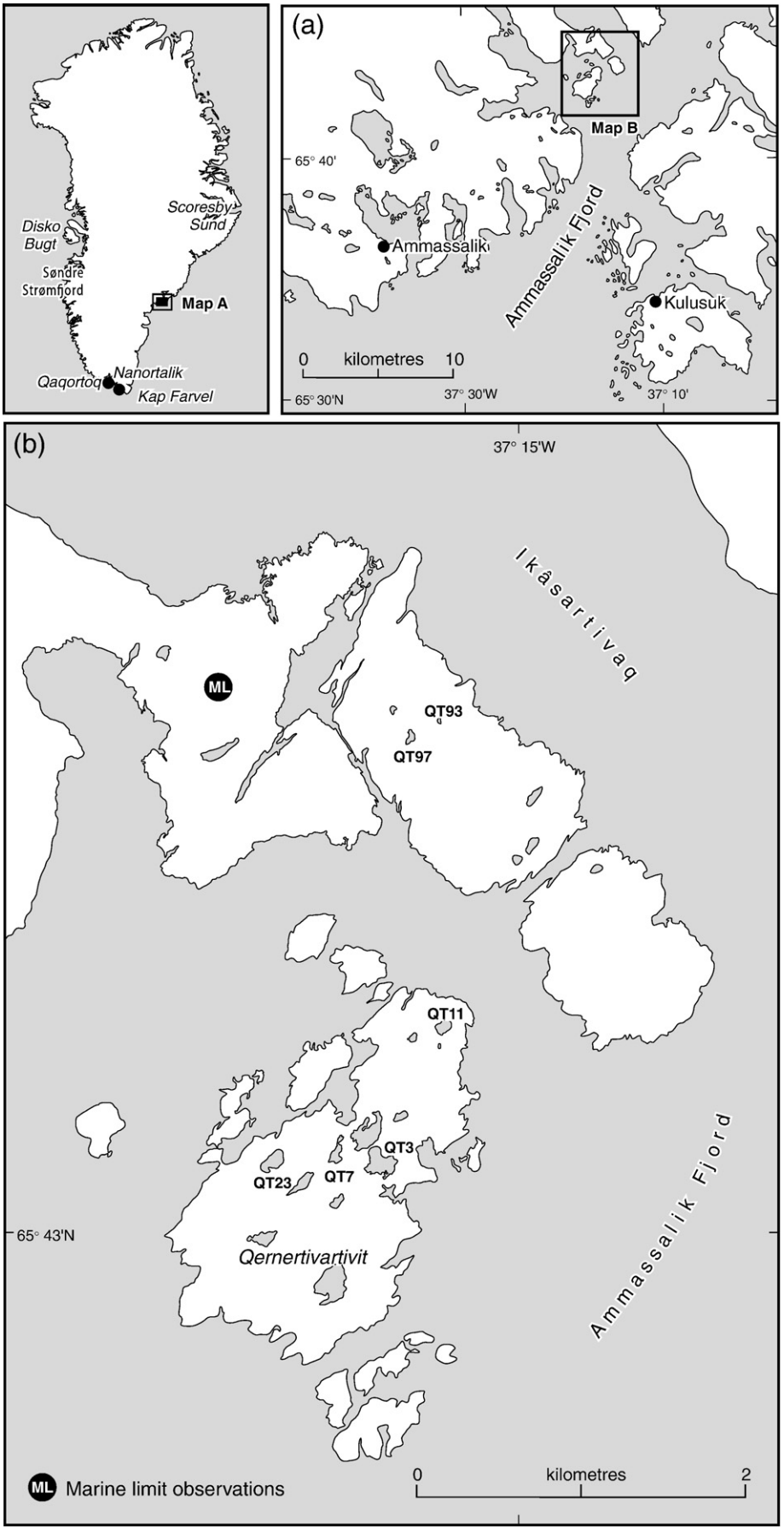

Fig. 1. Location map of the study area showing the location of the lakes sampled, and the survey point for observations relating to the local marine limit (ML).