Quaternary Science Reviews 169 (2017) 114–130

Contents lists available at ScienceDirect

Quaternary Science Reviews

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

Postglacial relative sea-level changes in northwest Iceland: Evidence from isolation basins, coastal lowlands and raised shorelines

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ARTICLE INFO

Article history:
Received 2 December 2016
Received in revised form
19 May 2017
Accepted 24 May 2017
Available online 13 June 2017

Keywords:
Holocene
Sea level changes
Europe
Micropalaeontology
Diatoms
Isolation basin
Iceland

Abstract: Relative sea-level (RSL) data provide constraints on land uplift associated with former ice loading and can be used to differentiate between contrasting ice unloading scenarios. Isolation basin, coastal lowland and geomorphological evidence is employed to reconstruct RSL changes in northwest (NW) Iceland, which may have experienced contrasting uplift patterns. Under local (NW) uplift, highest RSL would be expected in central Vestfirðir, whereas highest RSL would be closest to the main ice-loading centre under regional (central Iceland) uplift. Four new RSL records are presented based on 16 sea-level index points and 4 limiting ages from sites principally focussed along a transect away from central Iceland. The new RSL records highlight spatial variability of Holocene RSL changes and provide constraints on deglaciation. There is an increase in marine limit elevation with proximity to the proposed principal ice loading centre in central Iceland. Highest recorded marine limit shorelines are found in Hrútafjörður-Heggstaðanes (southeast), the lowest in Hlöðuvík and Rekavík bak Látrum (north), and at an intermediate elevation in Reykjanes-Laugardalur (central Vestfirðir). Evidence from Breiðavik-Látrar records early rapid deglaciation in Breiðafjörður or a complex interplay of multiple uplift centres. RSL fell rapidly following deglaciation in several locations as a result of the quick response of the Icelandic lithosphere to unloading. The RSL data along the transect show an uplift pattern consistent with extensive regional glaciation emanating from central Iceland, which could have implications for ice sheet configuration and patterns of deglaciation, glacio-isostatic adjustment modelling and the volume of meltwater input into the North Atlantic.

1. Introduction

A range of evidence has been used to investigate the lateral and vertical extent of the Last Glacial Maximum (LGM) Icelandic Ice Sheet (IIS), including glacial geomorphology, striation mapping (e.g. Thoroddsen, 1905–1906; Hoppe, 1968, 1982), sedimentology (e.g. Syvitski et al., 1999; Andrews et al., 2000), seismic profiling (Egloff and Johnson, 1979), submerged feature mapping (Spagnolo and Clark, 2009), ice sheet modelling (Hubbard et al., 2006; Hubbard, 2006), marine limit mapping (Norðdahl and Pétursson, 2005; Norðdahl et al., 2008), and ocean coring (Andrews et al., 2000; Eiríksson et al., 2000). However, none of these methods have been able to unequivocally determine the most likely LGM ice loading scenario for Iceland. Relative sea-level studies have the potential to produce high-resolution data to identify the location and thickness of former ice loading through constraint of the marine limit, the establishment of deglacial timing and the patterns of Lateglacial to Holocene relative sea-level changes. In turn, these data act as important constraints for glacio-isostatic adjustment (GIA) models, which can further assist in the testing of ice loading hypotheses, lithospheric and mantle viscosity characteristics. This paper provides new relative sea level (RSL) data from northwest (NW) Iceland, which reflect post-(de)glacial loading and unloading of the crust as a result of near-equilibrium glacio-isostatic conditions during deglaciation (Norðdahl and Ingólfsson, 2015). Establishing the lateral and vertical extents of the LGM IIS, associated ice volumes and patterns of deglaciation, is crucial, due to Iceland's location close to sensitive areas of deepwater formation in the

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http://dx.doi.org/10.1016/j.quascirev.2017.05.022

Nordic Seas and northern North Atlantic (Dickson et al., 2002, Fig. 1).

Isolation basins have been used in a number of locations close to present and former ice sheets to develop records of RSL change, including e.g. in Antarctica (Watcham et al., 2011), Canada (Hutchinson et al., 2004; Smith et al., 2005), Finland (Eronen et al., 2001), Greenland (Long et al., 2011), Norway (Balascio et al., 2011), Russia (Corner et al., 1999), the UK (Shennan et al., 1994, 1998) and Iceland (Rundgren et al., 1997; Lloyd et al., 2009). Isolation basins are rock depressions which have been connected to or isolated from the sea due to RSL changes across an impervious rock sill that controls tidal inundation (e.g. Lloyd and Evans, 2002; Long et al., 2011). A series of stages of basin isolation have been identified (e.g. Lloyd and Evans, 2002) and analysis of sediment and microfossil datasets allows the identification of three isolation contacts – diatomological, hydrological and sedimentological - which can subsequently be linked to positions within the tidal frame (Kjemperud, 1986). Radiocarbon dates at these isolation contacts provide constraints on the timing of RSL change and the resulting RSL curves may in turn determine patterns of postglacial land-level

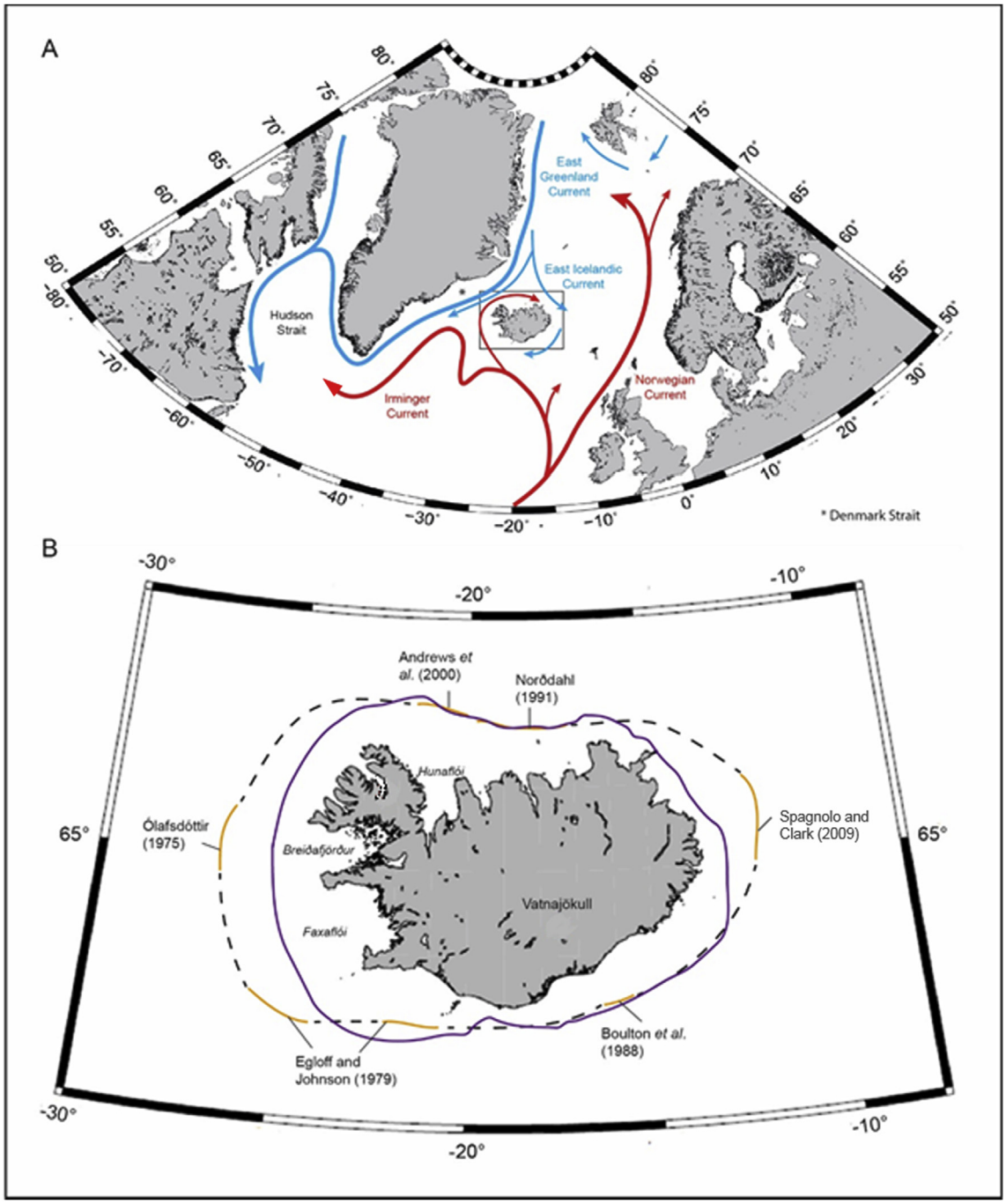

Fig. 1. A: Current oceanic circulation patterns in the North Atlantic, highlighting Iceland's position close to several major currents. B: Field and modelling evidence for the lateral extent of the LGM IIS (e.g. Boulton et al., 1988; Norðdahl, 1991), including undated moraines (solid orange), diverse physical evidence (black dashed, Norðdahl and Pétursson, 2005; Norðdahl and Ingólfsson, 2015) and modelled extent (solid purple, Hubbard et al., 2006). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)