Quaternary Science Reviews 189 (2018) 134–148

Contents lists available at ScienceDirect

Quaternary Science Reviews

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

Late Quaternary deglacial history across the Larsen B embayment, Antarctica

Ara Jeong [a], Jae Il Lee [b], Yeong Bae Seong [c, *], Greg Balco [d], Kyu-Cheul Yoo [b], Ho Il Yoon [b], Eugene Domack [e], Hyun Hee Rhee [c], Byung Yong Yu [f]

[a] School of Geographical Sciences and Urban Planning, Arizona State University, Tempe, AZ 85287, USA
[b] Korea Polar Research Institute, Incheon 21990, South Korea
[c] Department of Geography, Korea University, Seoul 02841, South Korea
[d] Berkeley Geochronology Center, 2455 Ridge Road, Berkeley, CA 94709, USA
[e] College of Marine Science, University of South Florida, 140 7th Avenue South, St. Petersburg, FL 33701, USA
[f] AMS Laboratory, Advanced Analysis Center, Korea Institute of Science and Technology, Seoul 02792, South Korea

ARTICLE INFO

Article history:
Received 27 February 2018
Received in revised form
12 April 2018
Accepted 16 April 2018
Available online 24 April 2018

Keywords:
Quaternary
Glaciation
Antarctica
Cosmogenic isotopes
Glacial geomorphology
Larsen ice shelf
Deglaciation
Meteoric ^{10}Be
In-situ ^{14}C

ABSTRACT

We measured meteoric ^{10}Be variation throughout a marine sediment core from the Larsen B embayment (LBE) of the Antarctic Peninsula, and collected in situ ^{10}Be and ^{14}C exposure ages on terrestrial glacial deposits from the northern and southern margins of the LBE. We use these data to reconstruct Last Glacial Maximum (LGM) to present deglaciation and ice shelf change in the LBE. Core sedimentary facies and meteoric ^{10}Be data show a monotonic progression from subglacial deposits to sub-ice-shelf deposits to open-marine conditions, indicating that its collapse in 2002 was unprecedented since the LGM. Exposure-age data from the southern LBE indicate 40 m of ice surface lowering between 14 and 6 ka, then little change between 6 ka and the 2002 collapse. Exposure-age data from the northern LBE show a bimodal distribution in which clusters of apparent exposure ages in the ranges 4.9–5.1 ka and 1.0–2.0 ka coexist near 50 m elevation. Based on these results, other published terrestrial and marine deglaciation ages, and a compilation of sea bed imagery, we suggest a north-to-south progression of deglaciation in the northeast Antarctic Peninsula in response to Holocene atmospheric and oceanic warming. We argue that local topography and ice configuration inherited from the LGM, in addition to climate change, are important in controlling the deglaciation history in this region.

1. Introduction

The Antarctic Peninsula experienced rapid regional warming over the last century, with a rise in temperature six times greater than the global mean (Vaughan et al., 2003). Recent sequential north-to south retreat and collapse of Antarctic Peninsula ice shelves including the Larsen A (LAIS) in 1995, the Larsen B (LBIS) in 2002, and current thinning of Larsen C (LCIS) (Shepherd et al., 2003) (Fig. 1) has led to concern about stability of other Antarctic ice shelves and potential sea-level impacts of ice shelf collapse under future warming (Scambos et al., 2003; Shepherd et al., 2003; Rignot et al., 2004; Glasser and Scambos, 2008; Banwell et al., 2013). For example, accelerated glacial flow promoted by the removal of buttressing by the LBIS (De Rydt et al., 2015) triggered mass loss of 27 km^3 yr^{-1} in glaciers across the Larsen B embayment (LBE), which has significantly contributed to global sea level change (Rignot et al., 2004). Bentley (1999) estimated that changes in the ice volume of the Antarctic Peninsula during the postglacial contributed to a rise in global sea level ~ 1.7 m, compared with 6–13 m for the entire Antarctic Ice Sheet, although Shepherd and Wingham (2007) suggested the sea level contribution of the Antarctic Peninsula (AP) is negligible because snowfall-driven growth of continental ice cap in AP would cancel out the accelerated flow from the Larsen A embayment (LAE) and Larsen B embayment (LBE). Thus, for example, the trillion-ton iceberg which broke off from the LCIS on July 12, 2017 has led to concern about the sea-level impacts of potential future disintegration of the LCIS (MIDAS Project, 2017).

The purpose of this study is to gain information about past ice-shelf changes in the Larsen embayment during LGM-to-Holocene

* Corresponding author.
E-mail address: ybseong@korea.ac.kr (Y.B. Seong).

https://doi.org/10.1016/j.quascirev.2018.04.011
0277-3791/

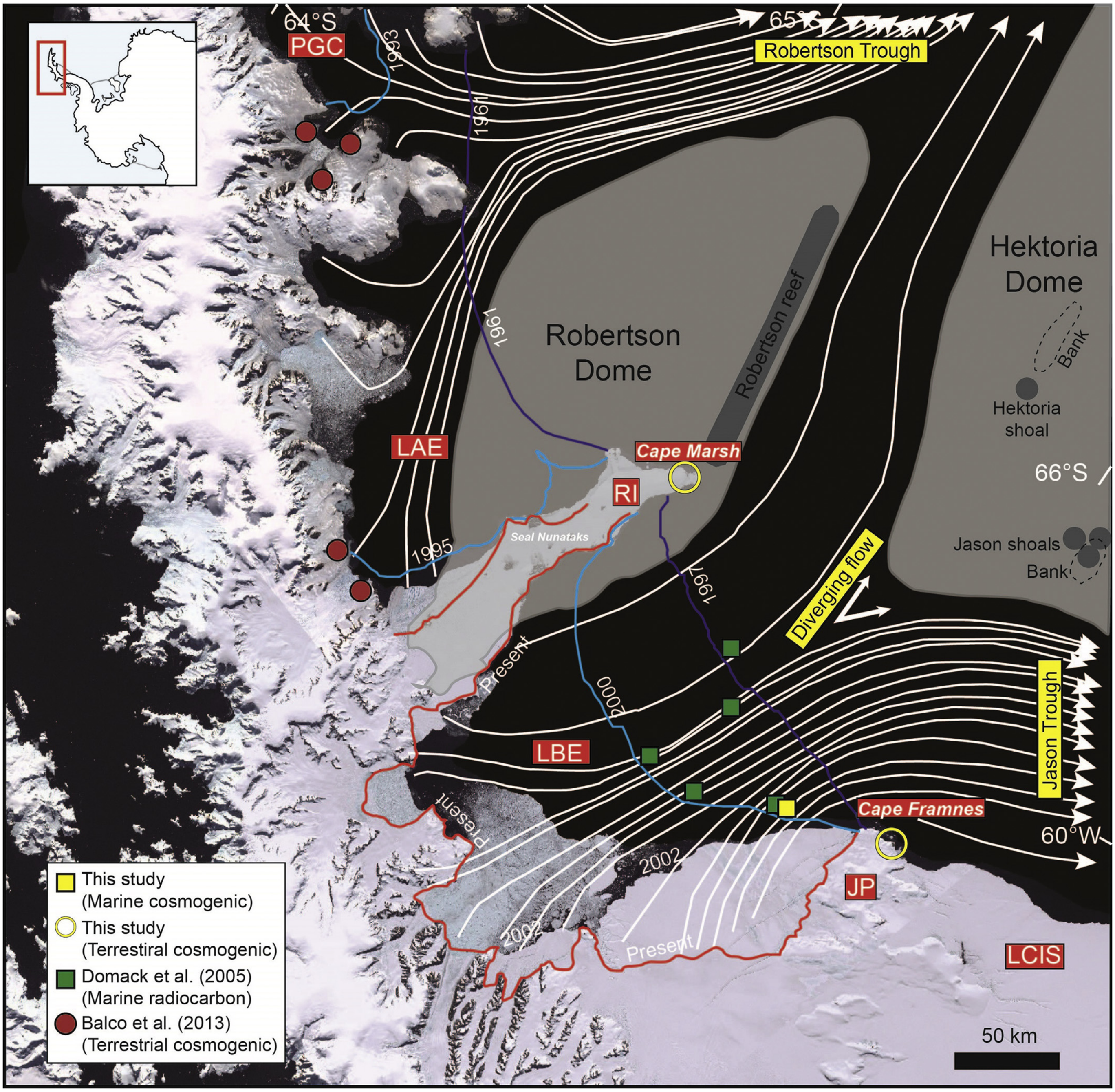

Fig. 1. The Larsen B embayment with coring locations and sampling sites for exposure dating, as well as paleo-ice configurations and flow at the global last glacial maximum (LGM). The background image was obtained from the USGS Landsat Image Mosaic of Antarctica, and the annual coastal line was extracted from the SCAR Antarctic Digital Database. Paleo-ice flow directions and locations of the ice domes are modified from Lavoie et al. (2014). Topographic banks (Sloan et al., 1995) and shoal and reef areas (Lavoie et al., 2014) indicate the shallowest areas of the region which could have worked as centers of glacial nucleation (Lavoie et al., 2014). Abbreviations used: PGC: Prince Gustav Channel; JRI: James Ross Island; LAE: Larsen A embayment; RI: Robertson Island; LBE: Larsen B embayment; JP: Jason Peninsula; LCIS: Larsen C Ice Shelf.

deglaciation that can potentially be valuable in understanding present and future ice shelf change. A complex LGM-to-present history has been reported among the ice shelves of the north-eastern Antarctic Peninsula (NEAP) (Johnson et al., 2011). The LAIS is thought to have collapsed almost completely during the middle to late Holocene, and then re-formed again before the collapse in January 1995 (Brachfeld et al., 2003; Balco et al., 2013), whereas the LBIS is believed to have remained intact throughout the Holocene until its latest collapse (Domack et al., 2005).

In this study we gather geological and geochemical observations that improve our reconstruction of LBIS change and provide some information about the LCIS, including (i) applications of the rare radionuclides ^{10}Be and ^{14}C produced by cosmic-ray interactions both in the atmosphere ("meteoric" ^{10}Be) and in surface rocks and minerals ("in-situ-produced" ^{10}Be or ^{14}C) (Fig. 2); (ii) sedimentological analysis of marine cores, and (iii) a compilation of marine bathymetric data related to ice-flow reconstruction (Lavoie et al., 2014). Meteoric ^{10}Be variations within marine sediment cores reflect the changing extent to which the area is open over time, which, in turn, helps to define the number of ice shelf collapses