Quaternary Science Reviews 99 (2014) 193–202

Contents lists available at ScienceDirect

Quaternary Science Reviews

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

Timing of terminal Pleistocene deglaciation at high elevations in southern and central British Columbia constrained by ^{10}Be exposure dating

Martin Margold [a, *], Arjen P. Stroeven [b, 1], John J. Clague [c, 2], Jakob Heyman [b]

[a] Durham University, Department of Geography, Lower Mountjoy, South Road, Durham DH1 3LE, UK
[b] Stockholm University, Department of Physical Geography and Quaternary Geology, and Bolin Centre for Climate Research, 106 91 Stockholm, Sweden
[c] Simon Fraser University, Department of Earth Sciences, 8888 University Drive, Burnaby, British Columbia V5A 1S6, Canada

ARTICLE INFO

Article history:
Received 29 January 2014
Received in revised form
18 June 2014
Accepted 19 June 2014
Available online

Keywords:
Cordilleran Ice Sheet
Be-10 exposure dating
Deglaciation

ABSTRACT

The Cordilleran Ice Sheet (CIS) covered most of British Columbia and southern Yukon Territory at the local Last Glacial Maximum (lLGM) during Marine Oxygen Isotope Stage 2. However, its subsequent demise is not well understood, particularly at high elevations east of its ocean-terminating margin. We present ^{10}Be exposure ages from two high-elevation sites in southern and central British Columbia that help constrain the time of initial deglaciation at these sites. We sampled granodiorite erratics at elevations of 2126–2230 m a.s.l. in the Marble Range and 1608–1785 m a.s.l. in the Telkwa Range at the western margin of the Interior Plateau. The erratics at both sites are near ice-marginal meltwater channels that delineate the local ice surface slope and thus the configuration of the ice sheet during deglaciation. The locations of the erratics and their relations to meltwater channels ensure that the resulting ^{10}Be ages date CIS deglaciation and not the retreat of local montane glaciers. Our sample sites emerged above the surface of the CIS as its divide migrated westward from the Interior Plateau to the axis of the Coast Mountains. Two of the four samples from the summit area of the Marble Range yielded apparent exposure ages of 14.0 ± 0.7 and 15.2 ± 0.8 ka. These ages are 1.8–3.0 ka younger than the well-established lLGM age of ca 17 ka for the Puget lobe of the CIS in Washington State; they are 1.7 ka younger than the lLGM age for the Puget lobe if a snow-shielding correction to their uncertainty-weighted mean age is applied. The other two samples yielded much older apparent exposure ages (20.6 ± 1.4 and 33.0 ± 1.5 ka), indicating the presence of inherited isotopes. Four samples collected from the summit area of the Telkwa Range in the Hazelton Mountains yielded well clustered apparent exposure ages of 10.1 ± 0.6, 10.2 ± 0.7, 10.4 ± 0.5, and 11.5 ± 1.1 ka. Significant present-day snow cover introduces a large uncertainty in the apparent exposure ages from this site. A snow-shielding correction based on present-day snow cover data increases the uncertainty-weighted mean exposure age of the Telkwa Range erratics to 12.4 ± 0.7 ka, consistent with deglacial ^{14}C ages from areas near sea level to the west. Our exposure ages show a thinning of the southern portion of the CIS shortly after the lLGM and persistence of a remnant mountain ice cap in the central Coast Mountains into the Younger Dryas Chronozone. Our data also show that the summit area of the Marble Range was ice-covered during the lLGM. The presence of an ice body of considerable dimension in north-central British Columbia until, or possibly even after, the Younger Dryas highlights the need for geomorphological and geochronological studies of the ice dispersal centre over the Skeena Mountains in northwest British Columbia and the need for better understanding of the response of the CIS to Lateglacial climate fluctuations.

1. Introduction

The evolution of Earth's climate during the Pleistocene was the result of the interplay between known, hypothesised, and yet undiscovered feedbacks in the climate system and has long been a focus of scientific study. An important aspect of this scientific

* Corresponding author. Tel.: +44 191 33 41829.
E-mail address: martin.margold@durham.ac.uk (M. Margold).
[1] +46 8 16 42 30.
[2] +1 604 291 4924.

http://dx.doi.org/10.1016/j.quascirev.2014.06.027
0277-3791/

Fig. 1. (a) Location of the study area. Outlined are the lLGM extents of the Cordilleran Ice Sheet (CIS) and the Laurentide Ice Sheet (LIS), which includes the Innuitian Ice Sheet (after Dyke et al., 2003; Kleman et al., 2010; generalised). (b) Physiography of the study area and ice geometries at the local Last Glacial Maximum (lLGM; dark blue ice divide after Clague and Ward, 2011) and early during deglaciation (grey ice divide after Margold et al., 2013b). Locations of the sample sites (Figs. 2a and 3a) and the area shown in Fig. 5 are indicated by black rectangles. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

endeavour is the study of receding ice sheets that once covered large areas of the mid-latitudes of the Northern Hemisphere. The Cordilleran Ice Sheet (CIS), which covered British Columbia and southern Yukon Territory and extended into Alaska, Northwest Territories, the conterminous United States, and Alberta, is one of the least understood of the Pleistocene ice sheets, and relatively little is known about the pattern and timing of its demise at the end of the Pleistocene (Clague, 1981; Jackson et al., 1991; Ryder and Maynard, 1991; Ryder et al., 1991; Menounos et al., 2009; Margold et al., 2013a, 2013b). In this paper, we build on our recent efforts to reconstruct and date retreat of the CIS in southern and central British Columbia based on geomorphological evidence and cosmogenic exposure ages from relatively unexplored mountain settings.

The CIS covered all of British Columbia, except for mountain nunataks, at the peak of the last glaciation, termed the Fraser Glaciation in British Columbia (Marine Oxygen Isotope Stage (MIS) 2; Fig. 1; Clague, 1981, 1989; Clague and Ward, 2011). It advanced over the northeast Pacific continental shelf and reached the eastern and northern shores of the Queen Charlotte Islands shortly after 21 ^{14}C ka[3] (Blaise et al., 1990). Its southwest margin reached the shelf edge southwest of Vancouver Island at about 19.5 cal ka (Cosma et al., 2008). The local Last Glacial Maximum (lLGM) has been dated to about 17 ka in Yukon Territory (Stroeven et al., 2010, 2014) and to about 17.0–16.6 cal ka at its limit in southern Puget Lowland, Washington (Porter and Swanson, 1998). The relatively sparse chronological information for the eastern sector of the CIS indicates that it coalesced with the Laurentide Ice Sheet sometime between

[3] ^{14}C ka – non-calibrated radiocarbon age; cal ka – calibrated radiocarbon age; ka – cosmogenic exposure age.