Geomorphology 185 (2013) 1–15

Contents lists available at SciVerse ScienceDirect

Geomorphology

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

The reconstruction and climatic implication of an independent palaeo ice cap within the Andean rain shadow east of the former Patagonian ice sheet, Santa Cruz Province, Argentina

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ARTICLE INFO

Article history:
Received 9 May 2012
Received in revised form 11 October 2012
Accepted 16 October 2012
Available online 29 November 2012

Keywords:
ELA-reconstruction
Glacier-reconstruction
GIS
Last Glacial Maximum
Meseta del Lago Buenos Aires
Patagonia
Accumulation-reconstruction
Remote sensing
Degree day modelling

ABSTRACT

This paper describes the reconstruction of the previously undocumented Meseta Cuadrada palaeo ice cap on south-west Meseta del Lago Buenos Aires, Santa Cruz Province, Patagonia. Based on theoretical surface profiles the reconstruction of the Meseta Cuadrada Palaeo Ice Cap indicates an ice mass covering at least 78 km^2 with a total ice volume around 9.2 km^3. The inferred equilibrium line altitude (ELA) of the palaeo ice cap (2031 m asl) represents a drop of 286 m compared to the ELA of the current Meseta Cuadrada glacier (~2317 m asl). We explain this small change in ELA with reference to the flat hypsometry of the palaeo ice cap and an enhanced aridity to the west of the Patagonian Andes caused by the existence of the Last Glacial Maximum (LGM) Patagonian ice sheet. Calculated annual accumulation values of ca. 402 to 957 mm/a at the ELA of the Meseta Cuadrada palaeo ice cap derived by a degree day model (DDM) during the last local glacial maximum extent are low compared with estimations of the current accumulation at the ELA of the remaining glacierized area of around 3789 mm/a. This strongly supports the existence of increased aridity and seasonality east of the Patagonian Andes during the Last Glacial Maximum, provided both maximum extents were synchronous.

1. Introduction

The aim of this paper is to describe and reconstruct a previously unknown palaeo ice cap on Meseta del Lago Buenos Aires, Patagonia, and to infer its associated palaeo climate. While much work has focussed on the moraine and till chronology of the two palaeo ice streams of Lago Buenos Aires and Lago Pueyrredón (Caldenius, 1932; Mercer and Sutter, 1982; Mörner and Sylwan, 1989; Kaplan et al., 2004; Singer et al., 2004; Kaplan et al., 2005; Douglass et al., 2006; Hein et al., 2009, 2010), moraine features on top of the neighbouring mesetas (the high, flat plateaus), such as Meseta del Lago Buenos Aires, have only recently been reported (Lagabrielle et al., 2010). Lagabrielle et al. (2010) focussed primarily on the tectonic implication of a set of moraine arcs located north of Meseta Cuadrada and Monte Zeballos, but they did not comment on the existence of a well-preserved moraine belt around the remaining Meseta Cuadrada glacier. This moraine belt has never been documented, despite its potential palaeo climatic significance. We present the first description of the Meseta Cuadrada Palaeo Ice Cap based on detailed geomorphologic mapping from remotely sensed imagery at a scale of 1:10000. Using the mapping results will constrain the maximum extent of the palaeo ice cap sufficiently to infer the former ELA and compare it with the current ELA, and thus estimate past and present accumulation values in an area where sparse precipitation records exist. The position of the Meseta Cuadrada glacier (47°4'S./71°38'W.) and Meseta Cuadrada palaeo ice cap is the most eastern location of an independent glaciation apart from the Patagonian Andes and the Last Glacial Maximum (LGM) Patagonian ice sheet. Therefore, the Meseta Cuadrada palaeo ice cap provides the opportunity to infer accumulation (and thus deliver palaeo-precipitation approximations) deep within the precipitation shadow of the Last Glacial Maximum Patagonian ice sheet. The lack of absolute age control requires caution in accumulation reconstructions during the maximum extent of the Meseta Cuadrada palaeo ice cap, but its size suggests it dates from the LGM. Not only the size but also the style and grade of moraine preservation found around Meseta Cuadrada suggest the palaeo ice cap had its biggest extent during the LGM. The moraine belt described here has great similarities with clearly LGM dated moraines from Lago Pueyrredón (Hein et al., 2009, 2010).

2. Research area

The Meseta Cuadrada palaeo ice cap (47°4'S./71°38'W.) is located (see Fig. 1) at the foot of Meseta Cuadrada and Monte Zeballos in the south-western part of the volcanic Meseta del Lago Buenos Aires. The meseta, with an area of around 6000 km^2, is one of the largest basaltic plateaus within the Neogene Patagonian plateau lava

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http://dx.doi.org/10.1016/j.geomorph.2012.10.018

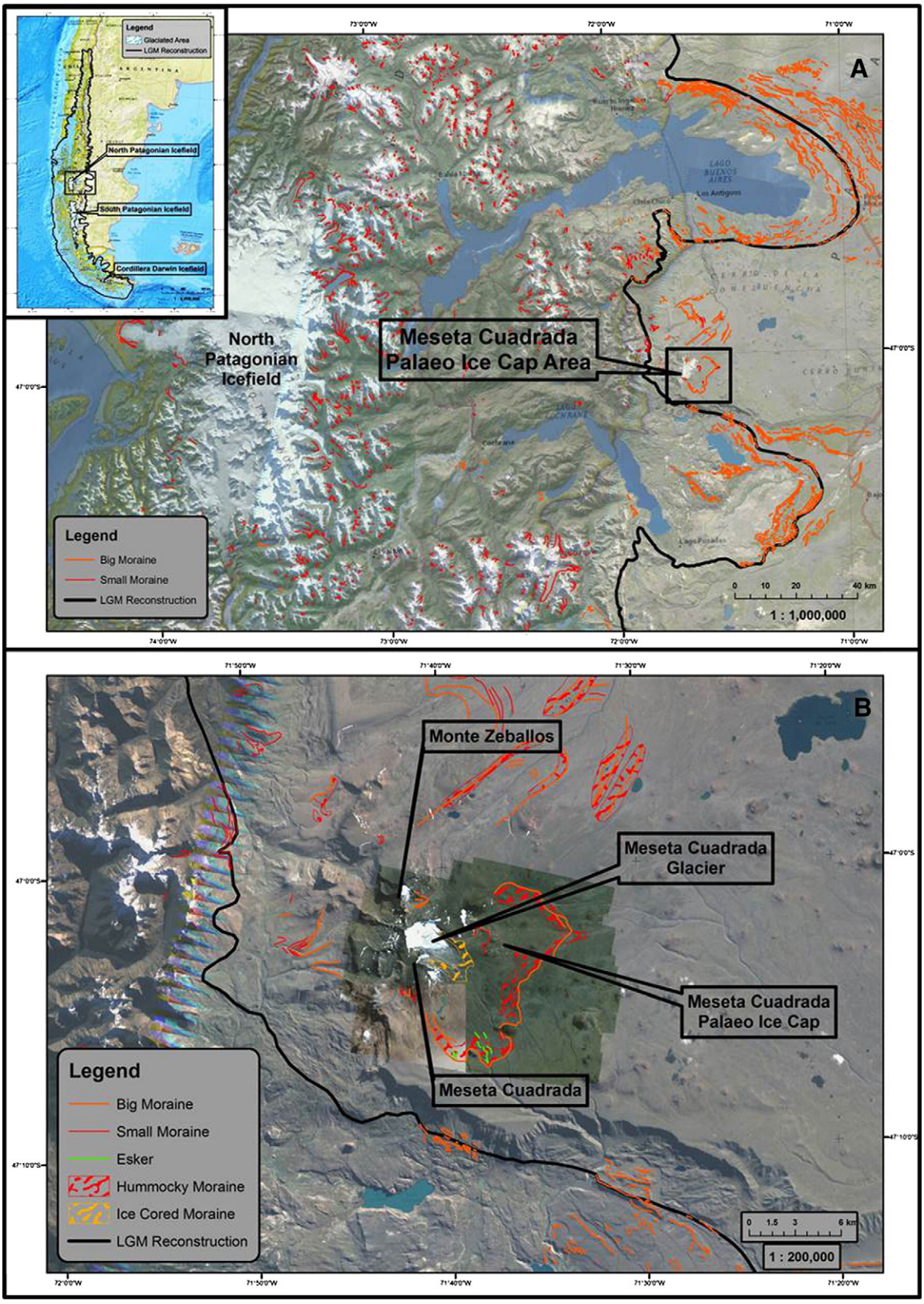

Fig. 1. Location of study area: A general setting; B setting on SW corner of Meseta del Lago Buenos Aires.

province (Boutonnet et al., 2010; Lagabrielle et al., 2010). While the highest point of the Meseta del Lago Buenos Aires is represented by the summit of Monte Zeballos at 2743 m asl in the west, the meseta surface itself dips gently to the east starting with an elevation of ca. 1800 m asl in the western part and falling to an elevation of around 900 m asl in the east. Due to the high altitude of Monte Zeballos and Meseta Cuadrada well above 2500 m asl, two glaciers, some glacierettes and permanent snowfields still exist today despite their arid location east of the Andes (see Fig. 5). The smaller glacier, the Monte Zeballos glacier, is not further investigated in this study. The