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Topographic and microclimatic impacts on glaciation of the Denison Range, southwest Tasmania

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ABSTRACT

Morphostratigraphic relationships between landforms and sediments, comparative boulder weathering status, and paired ^{10}Be and ^{26}Al exposure ages indicate the occurrence of at least three separate glaciations that are interpreted as dating from MIS 2, 6 and possibly 8. The Rhona Glacier remained at or close to its greatest LGM extent until ~17.6 ka due to a very favourable micro-climate that resulted from local topography. That these factors were sufficient to over-power relatively subtle zonal temperature shifts that caused significant changes in more exposed Tasmanian glaciers implies a need for caution in correlating between glacier systems in markedly different topographic settings when environmental conditions are only marginally supportive of glaciation. No evidence was detected for any greater ice extent during MIS 3 or MIS 4 than during MIS 2, but much more extensive glaciations occurred during earlier glacial climatic cycles. Reduced local precipitation in parallel with increasing aridity of the Australian continent may account for the progressively diminishing maximum extent of glaciers during the latter part of the Pleistocene, and it would have emphasized the importance of local topography and microclimate for the glaciers of southwest Tasmania.

1. Introduction

In the predominantly oceanic southern temperate latitudes the only mountains within or bordering the circumpolar westerly wind belt are the Patagonian Andes, the Southern Alps of New Zealand and the highlands of southeastern Australia and Tasmania. Present day glaciers are confined to the mountains of South America and New Zealand where their latitudinal position and oceanic setting makes them particularly sensitive to fluctuations in the position and intensity of the westerly wind belt, and thus useful indicators of climatic variability (Fitzharris et al., 2007). Similarly, glaciers that waxed and waned in these southern temperate mountains during the past few Glacial Climatic Cycles were equally influenced by this oceanic setting. Well preserved glacigenic landforms and sediments in Tasmania offer a geomorphological archive of information on past glacier activity and climates. This paper reports new mapping of glacial landforms and sediments from the Lake Rhona Valley in the Denison Range, located in the upper catchment of the Gordon River, the largest of the drainage systems in Tasmania's south-west wilderness area (Fig. 1). It provides an interpretation of former glacier limits based on this mapping, and an interpretation of their age based on cosmogenic radionuclide exposure dating of moraines.

In marked contrast to the altitudes attained by the Southern Alps and Andes, the Tasmanian Mountains are relatively low and tectonically stable. Important pioneering studies of Tasmanian cirque morphology by Peterson (1968, 1969) highlighted the important role of topographically-induced microclimate in conditioning cryogenesis and resulting glacial erosion, but the potential significance of local microclimates on the behaviour of Tasmania's former glaciers has since remained largely unexplored. Tasmania's Southwest is a large and geomorphologically distinct part of the island's glaciated landscape where multiple cirque and short valley palaeo-glaciers formed on a succession of linear mountain ridges that are aligned north-south across the path of the prevailing westerly airstream (Kiernan, 1995, 2005). This largely unresearched terrain differs markedly from the Central Plateau and West Coast Range further north which have provided most of the evidence for our current understanding of Tasmanian glacial history, based on studies of outlet glaciers that drained ice caps (Kiernan, 1983, 1990a, 1991; Colhoun, 1985; Hannan and Colhoun, 1987; Fitzsimmons et al., 1993; Augustinus and Colhoun, 1995;

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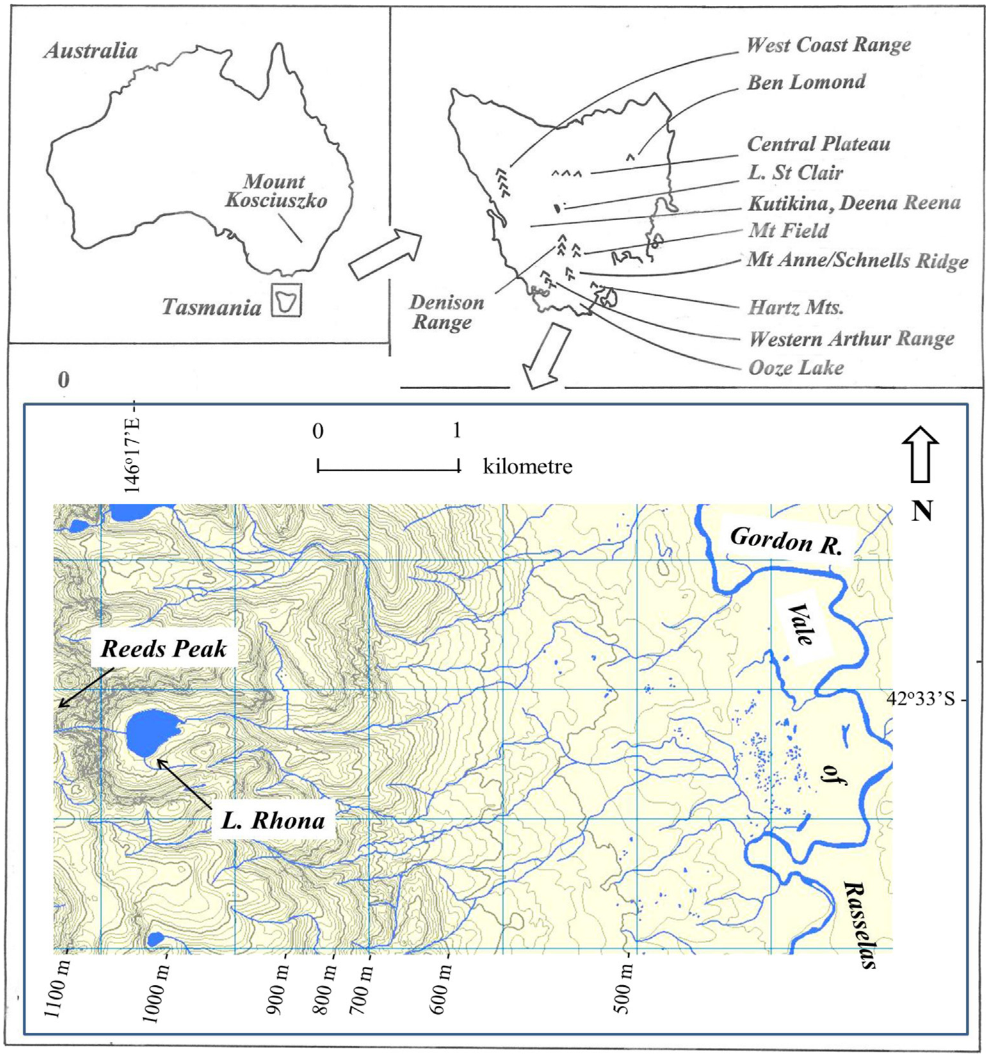

Fig. 1. Location of the study area and other sites mentioned in text.

Augustinus, 1999). Published exposure ages from Tasmanian MIS 2 moraines are generally in the range of ~22–17 ka and suggest that the earliest appearance of maximum ice extent was attained ~21–22 ka (Barrows et al., 2002; Kiernan et al., 2004; Mackintosh et al., 2006). ^{10}Be exposure ages presented prior to 2009, would have necessarily been calculated using SLHL spallation production rates of ~4.5 atoms/yr/gram.quartz (following correction for adjustments of nominal values for AMS Standard reference Materials, see Nishiizumi et al., 2007; Balco et al., 2008). This reduction *does not* alter young ^{10}Be exposure ages as the correction factor applies to both numerator and denominator in the ratio (concentration/production rate), and young ages are independent of the value of the ^{10}Be half-life (Fink and Smith, 2007). However recent trends, both from New Zealand and high northern latitudes present strong arguments for an additional reduction in spallation production rates from ~4.5 to 3.85 (Putnam et al., 2010a, 2010b) or ~4.2 at/yr g-quartz (see for example, Fenton et al., 2011).

In this work we choose to employ the new and lower sea-level, high latitude (SLHL) spallation production rates specific for New Zealand. Thus previously-obtained ^{10}Be exposure ages from Tasmania (Barrows et al., 2002, Kiernan et al., 2004, 2010; Fink et al., 2004,unpublished data; and 2005) will require a 15% increase in quoted age to be compatible to the new ages calculated in this work. In summary, the lower production rate would increase the mean local LGM onset age from ~21 ka to 24 ka. However, irrespective of these uncertainties concerning the precise timing of the MIS 2 advances in Tasmania (Fink et al., 2005), it is clear that they were considerably less extensive than the advances that occurred earlier during major glaciations (Colhoun et al., 2010) including at least one advance during either MIS 3 or MIS 4 (Fink et al., 2000; Kiernan et al., 2004; Mackintosh et al., 2006).

The impact of topography on glaciers is likely to be most marked when conditions are only marginally suitable for glaciers to exist, including during deglaciation. In both South America and New Zealand research has recently focused on the Last Glacial Maximum and Termination 1 (~10–25 ka), with particular attention directed towards determining inter-hemispheric temporal relationships. Debate has arisen regarding the possible impacts of the Antarctic Cold Reversal (ACR) which occurred at ~14–13 ka and the Younger Dryas (YD) at ~13–11.5 ka (eg. Moreno et al., 2001; Kaplan et al., 2004; Sugden et al., 2005; Vandergoes et al., 2007; Carter et al., 2008; Kaplan et al., 2010; Putnam et al., 2010a, 2010b). Exposure ages from recessional moraines at Lake St Clair in west-central Tasmania and further south at Mt Field led Barrows et al. (2002) to conclude that there was no evidence for any advance coincident with either the ACR or YD. However, no exposure ages have been obtained thus far from those Tasmanian palaeo-glacier systems topographically most suited to glacier persistence, and very