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The vegetation and climate during the Last Glacial Cold Period, northern South Island, New Zealand

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ABSTRACT

Pollen assemblages from Howard Valley, South Island, New Zealand, were used to reconstruct the palaeovegetation and infer past climate during the period ca 38–21 cal. ka, which encompasses the Marine Isotope Stage (MIS) 3/2 transition and Last Glacial Cold Period (LGCP). A glacier occupied the upper Howard Valley during the Last Glacial, whilst extensive glaciofluvial outwash surfaces were constructed in the lower valley. Episodic periods of fluvial aggradation and incision have produced a complex sequence of terraces flanking the main Howard River and its tributaries. Sedimentary sequences from three exposed valley fills, sampled for palynological analysis and radiocarbon dating, consist of a complex vertical and lateral arrangement of coarse textured cobbly sandy gravels interbedded with organic-rich silt deposits. Palynology of these organic-rich horizons was directly compared to an existing beetle record from these same horizons. During late MIS 3 the site was dominated by marshy shrubland vegetation interspersed with mixed beech forest, indicating temperatures ~2–3 °C cooler than present. Climate cooling began as early as 35.7 cal. ka and coincides with evidence of cooling from other sites in New Zealand, South America and with an Antarctic cooling signature. A three phase vegetation and inferred climate pattern occurs at the site during the LGCP beginning with a transition to an alpine/sub-alpine grassland comparable to communities growing near treeline today marking the change to glacial conditions before 31 cal. ka. A small increase in tree abundance between ca 25.8 and 22.7 cal. ka suggests minor climate amelioration during the mid-LGCP. During this phase, a possible volcanically induced vegetation disruption caused by the deposition of the Kawakawa Tephra at 25 cal. ka is evident in the pollen record. This is followed by a further decline in tree pollen and increase in alpine grassland and herb pollen indicating further deterioration of conditions and a period of maximum cooling (~4.5 °C) ca 22.5–20.9 cal. ka. This corresponds with the timing of greatest ice advance based on the geomorphic evidence in the region. Contrary to previous studies in New Zealand, the pollen and beetle records are in close agreement. Both indicate the site was forested during late MIS 3, with progressive reduction of trees during the LGCP. The consistent presence of beech pollen nevertheless confirms small refugia of trees persisted in the region.

1. Introduction

The northern South Island has been a focus of recent discussion concerning forest refugia in New Zealand during the Last Glacial Coldest Period (LGCP) defined here as the period spanning 28–18 cal. ka (Alloway et al., 2007). This is particularly the case towards the end of the LGCP (Marra and Leschen, 2004; Burge and Shulmeister, 2007; McGlone et al., 2010; Newnham et al., 2013). Central to this discussion are the composition and extent of forest survival in the region inferred from beetle and pollen records. Wider interest in this discussion stems from alternative views of glacial forest refugia in regions such as northwest Europe, where the traditional assumption of complete forest elimination from middle and high latitudes during glacials has recently come under challenge from the 'cryptic-' or 'micro-' refugia hypothesis (Stewart and Lister, 2001; Provan and Bennett, 2008; Kelly et al., 2010). In New Zealand, pollen and plant macrofossil evidence have favoured the concept of cryptic glacial forest refugia (McGlone, 1985; Newnham et al., 2013), but beetle evidence has

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recently been used to argue for more extensive forest survival during the LGCP, and for milder climates than previously elucidated from pollen records (Burge and Shulmeister, 2007).

The Howard Valley site in the Nelson Lakes District of northern South Island is critical to this discussion. A fragmentary beetle and plant macrofossil record from this site provided evidence of vegetation during late Marine Isotope Stage (MIS) 3 and 2 (Marra and Thackray, 2010), a period containing few palaeovegetation records. These proxies indicated that the site was forested during late MIS 3 and that forest refugia may have persisted during the LGCP. In this paper we present new pollen records from the same three sections at Howard Valley sampled by Marra and Thackray (2010) to provide further evidence of vegetation and climate change for MIS 3 and 2. We have extended the stratigraphic descriptions and sampling both vertically and laterally and have undertaken further radiocarbon dating to provide a higher resolution palaeovegetation record. The pollen record builds upon, and allows comparison with, the existing palaeoenvironmental evidence at the site. Estimates of temperature depression before and during the LGCP are also provided.

2. Regional description

Howard Valley is located in southeast Nelson, within the Nelson Lakes district, at the northern limit of the Southern Alps (Fig. 1). The Howard River is a tributary of the Buller River, which drains Lake Rotoiti and flows westwards to the Tasman Sea at Westport. Nelson Lakes District is an upland region where mountain ranges reach 2000 m above sea level (a.s.l) with valleys typically between 1200 and 500 m a.s.l. The region experiences a cool-temperate climate with mean annual temperature of 9 °C and mean summer and winter temperatures of 14 °C and 4 °C, respectively (recorded at Lake Rotoiti weather station; New Zealand National Climate Centre, 2010). The prevailing wind is from the northwest, bringing

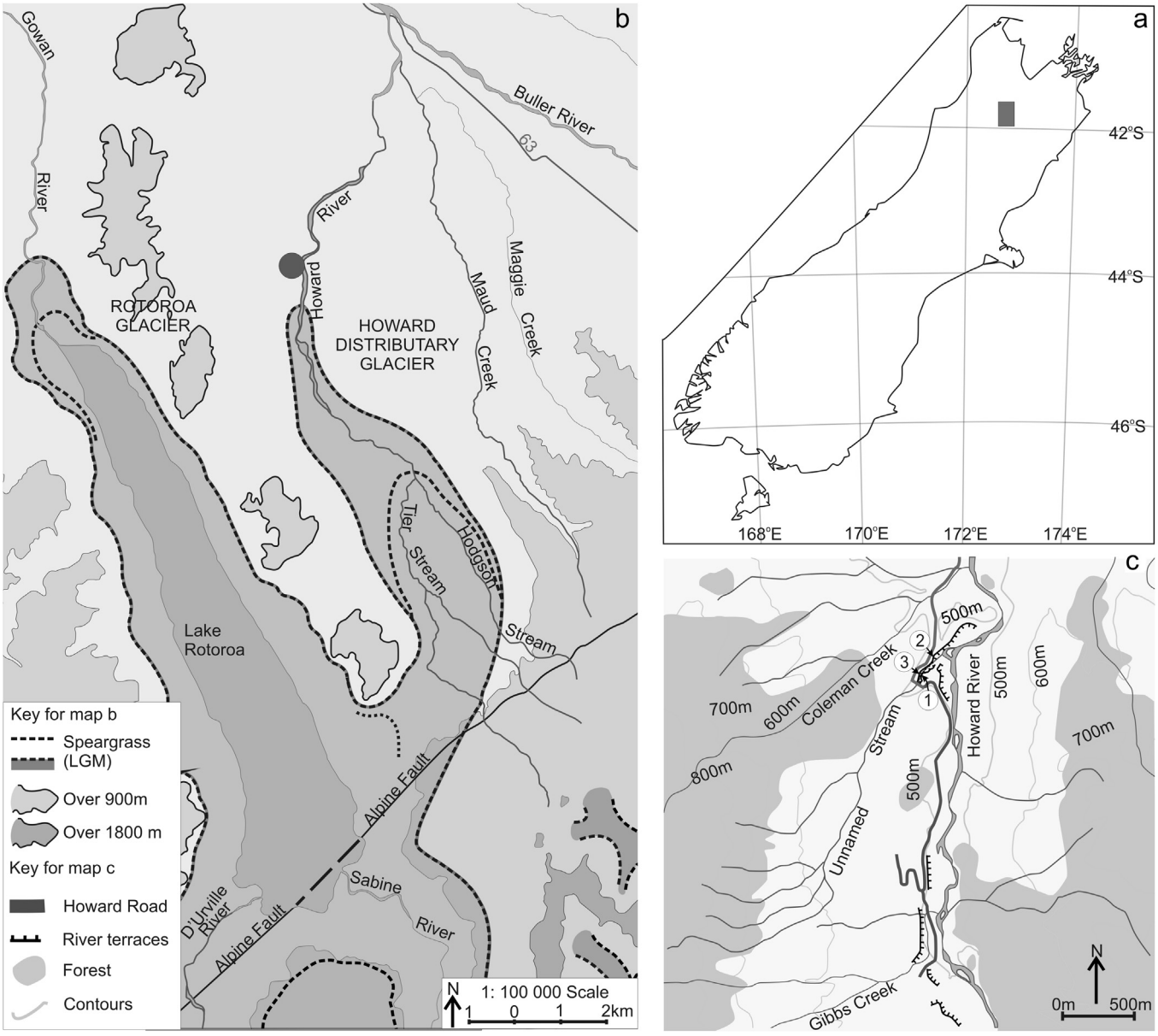

Fig. 1. Location map with a, the South Island with a grey box marking the area covered in map b; b, a map of LGM ice extent in the Rotoroa and Howard Valley (adapted from Challis et al., 1994) and grey circle marking the sample sites; c, a detailed map of the study sites in Howard River and tributary stream.