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The glacial sedimentology and geomorphological evolution of an outwash head/moraine-dammed lake, South Island, New Zealand

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ABSTRACT

Extensive exposures through the glacial landforms around southern Lake Pukaki, New Zealand, comprise seven lithofacies (LFs 1–7). LFs 1–3 are grouped together as LFA 1 (Pukaki Member) and record pulsed subaqueous grounding line fan progradation, cohesionless debris flows, underflow activity and rhythmite deposition by suspension settling, iceberg rafting of dropstones, and pulsed traction current activity. Localized disturbance of these deposits by glacitectonic deformation and multi-generational hydrofracture fills records minor readvances by the glacier snout and the emplacement of a glacitectonite (LF 4) derived from cannibalization of glacilacustrine sediments. LFs 4–6 are grouped together as LFA 2 (Twizel Member) and record direct glacigenic deposition of glacitectonite (LF 4), subglacial traction till (LF 5) and supraglacially dumped boulder rubble (LF 6). Stratigraphic relationships between LFA 1 with LFA 2 record the oscillatory behaviour of the former Tasman Glacier snout when it formed a calving margin in a proglacial and locally supraglacial lake dammed by a glacitectonically disturbed outwash head and lateral moraine ridges. This is entirely consistent with the landform–sediment record of its coeval terrestrial margins, where flutings and push moraines are diagnostic of active temperate glacier recession from a glacially overridden outwash head, the latter being recorded by the vertically stacked sub-horizontally bedded and coarse-grained gravels of LF 7 (Waitaki Member). Previous proposals that late Pleistocene lake damming was initiated by an ice-cored moraine arc appear unfounded, because the glacilacustrine deposits only lie above the altitude of the outwash head/lateral moraine arc in locations where they have been glacitectonically compressed. Alternatively, it is proposed that the overdeepened subglacial topography was produced by the construction of an outwash head, leading to a glacilacustrine sediment sink which operates at times when the expanded Tasman Glacier actively retreats from the outwash head apex. The changing landsystem imprint related to the shrinkage of the Tasman Glacier records spatio-temporal landsystem change, involving evolution from a coupled landsystem to a moraine-dammed to an uncoupled landsystem.

1. Introduction and rationale

The widespread recession of debris-charged mountain glaciers in response to recent climate warming has resulted in the development of numerous moraine-dammed and supraglacial lakes, which pose a serious potential threat of catastrophic glacial lake outburst floods (Watanabe et al., 1995; Benn et al., 2000; Clague and Evans, 2000; Nakawo et al., 2000; Richardson and Reynolds, 2000; McKillip and Clague, 2006; Benn et al., 2012). The landform–sediment assemblages that have developed in association with glacier snout recession and lake growth have been the subject of ongoing monitoring projects, facilitating the compilation of modern analogues for glacial depositional models (Kirkbride, 1993; Benn et al., 2003; Hambrey et al., 2008; Bennett et al., 2010). Such models are critical to the development of accurate palaeoglaciological reconstructions based on Pleistocene glacial landsystems in active mountain terrains characterized by debris-charged glaciers. The employment of modern process-form observations in deciphering ancient glacial sedimentary systems in the same topographic setting is well illustrated by the study of Mager and Fitzsimons (2007), who used the evolving moraines and proglacial lake of the modern Tasman Glacier in New Zealand as a direct analogue for the evolution of the landform–sediment associations of the south shores of Lake Pukaki, located only 60 km to the south; they invoked the damming of lake water by a former latero-frontal moraine arc characterized by a thick ice core, thereby explaining why lake sediments presently locally lie altitudinally higher than the older moraine arcs that could have acted as a dam. The extensive sedimentary exposures along the shore of Lake Pukaki warrant further examination in light of their importance to the

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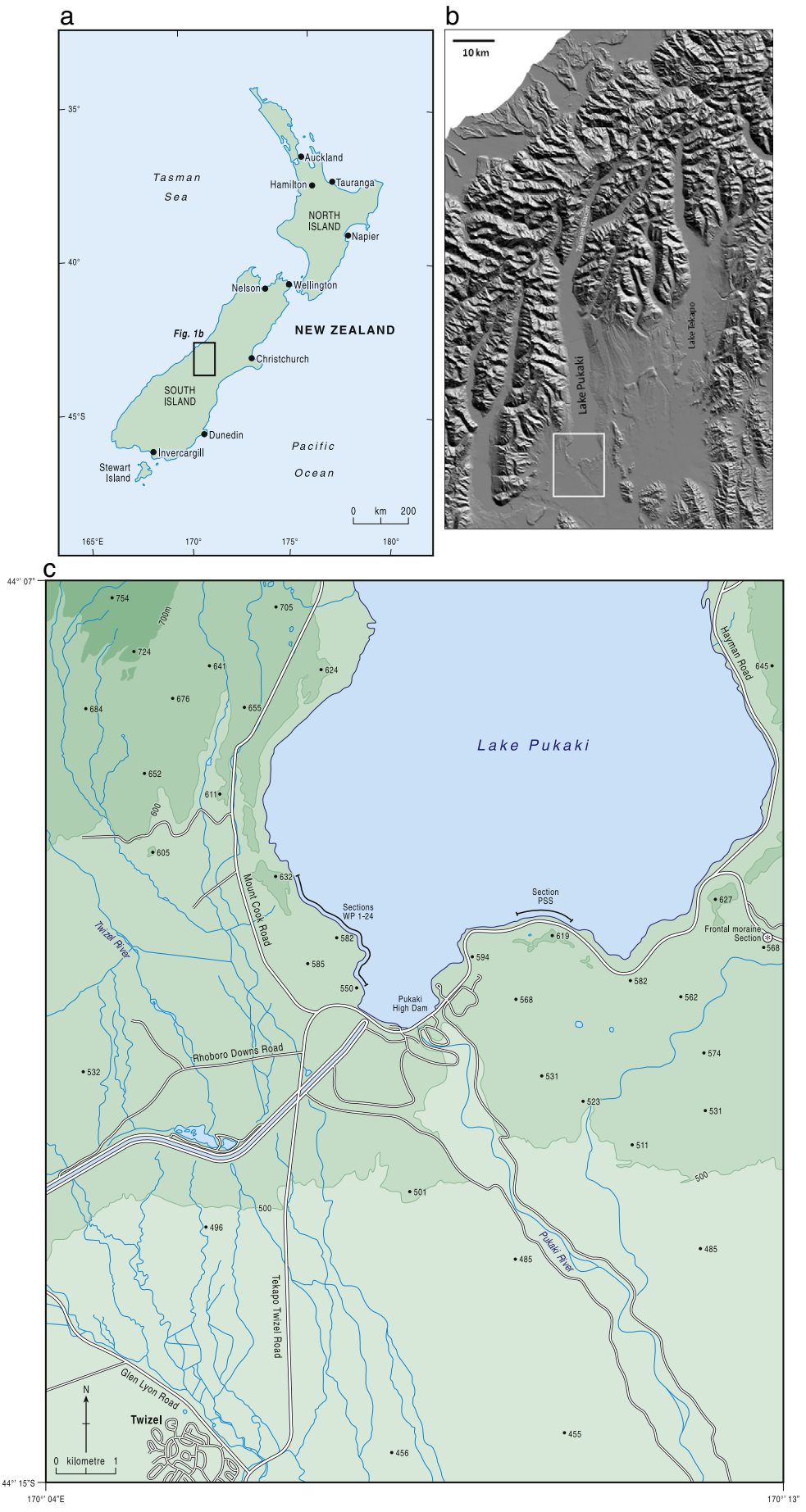
a
35°
40°
45°S
165°E
170°
175°
180°
Tasman
Sea
Pacific
Ocean
Auckland
Hamilton
Tauranga
NORTH
ISLAND
Napier
Nelson
Wellington
Fig. 1b
NEW ZEALAND
Christchurch
SOUTH
ISLAND
Dunedin
Invercargill
Stewart
Island
0 km 200
b
10 km
Lake Pukaki
Lake Tekapo
c
44°° 07°
44°° 15°S
170°° 04°E
170°° 13°
Lake Pukaki
Hayman Road
Mount Cook Road
Twizel River
Sections
WP 1-24
Section
PSS
Frontal moraine
Section
Pukaki
High Dam
Rhoboro Downs Road
Tekapo Twizel Road
Pukaki River
Glen Lyon Road
Twizel
N
0 kilometre 1
700m
600
500