Structural Glaciology, Dynamics and Evolution of Te Moeka o Tuawe Fox Glacier, New Zealand

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"Raki, the Sky Father, wedded Papa-tui-nuku, the Earth Mother. After the marriage, the four sons of Raki who were named Ao-raki, Raki-ora, Raki-rua, and Raraki-roa came down to greet their father's new wife in the canoe of the eldest brother Ao-raki, known as Te Waka o Aoraki. They cruised around Papa-tui-nuku, then, keen to explore, the voyagers set out to sea, but no matter how far they travelled, they could not find land. They decided to return to their celestial home, but the karakia which should have lifted the waka back to the heavens failed and the canoe fell back into the sea and turned over onto its side, and settled with the west side much higher out of the water than the east, thus the whole waka formed Te Waka o Aoraki, the South Island. Ao-raki and his brothers clambered on to the high side and were turned to stone, where they remain today, Aoraki being the highest peak, surrounded by his younger brothers. The permanent snows of these peaks were known as whenuahuka and the great snow fields hukapapa. The glaciers that flowed out of them were called huhapo. Nearby in the darkened valleys was kopakanui or ice and in places cut off from the sun was thick ice of waiuka meaning solid water"

-Māori Mythology

"As a glacier of the first class, the Fox will always take a high position, not only for its scenery, which will attract the non-climbing tourist, but for the scientific lessons to be learned by those who take an interest in such matters".

-Charlie "Explorer" Douglas, 1896

Abstract

The aim of this thesis is to investigate and identify relationships between glacier structure, dynamics and debris transport at *Te Moeka o Tuawe* Fox Glacier; a temperate, maritime glacier in South Westland, New Zealand. Structural analyses of steep, exceptionally dynamic alpine glaciers that respond rapidly to changes in mass balance are rare. In particular, an appreciable dearth of New Zealand-focussed investigations into structural glaciology and glacial dynamics is found in the literature.

Structural glaciology of Fox Glacier is determined by field observations, analysis of remotely sensed images, and ground-penetrating radar (GPR). Dynamics are investigated and quantified by the measurement of ice flow velocity and surface deformation. Debris transport processes occurring at Fox Glacier are investigated using field and laboratory analysis of grain size and clast morphology.

The structures identified on Fox Glacier during this study display similar patterns to structural features of temperate valley glaciers reported in other studies. Strain-rates measured on the surface of Fox Glacier are higher than those reported for both cold-based glaciers and warm-based alpine-style glaciers in the European Alps. However, strain rates are lower than values typically reported for surging glaciers during surge phases. Unequivocal relationships between measured strain-rates and structures are not evident from this research. This may be because many structures are undergoing passive transport down-glacier, and do not reflect the prevailing local stress regime. Or, some structures, such as crevasse traces, may be close to crevassing, without crevasses actually forming.

Results and findings from this study are a useful addition to the accumulating body of work that has emerged over the last decade on the South Westland glaciers. The vast majority of that research has typically focused on glacier fluctuations in response to climate, or has attempted to link late-glacial moraine-forming events to glacier dynamics. In contrast, the present study has attempted for the first time in New Zealand, to characterise and explain the spatial pattern of structures within a valley glacier in its entirety from the névé to the snout.

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