# THE WHAKAPAPANUI GLACIER:
# HYDROLOGICAL BUDGET STUDIES AND ASSOCIATED ASPECTS OF ITS GLACIOMETEOROLOGY

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
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## PREFACE

This thesis represents an attempt to analyse some of the causes and effects of climate/glacier interaction on the Whakapapanui Glacier. Climate/glacier studies encompass a wide range of relationships all of which are interrelated. Meier has developed a system which expresses the manner in which the various aspects of this interrelationship are linked.

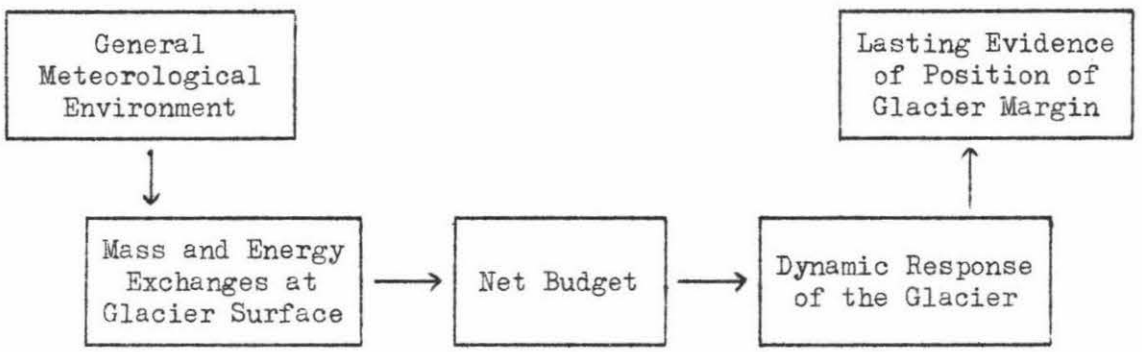


FIG.1

From "Glaciers and Climate", M.F. Meier. In The Quaternary of the United States, 1965, 795.

The writer was concerned principally with the first three stages of this system, those which dealt with "the size to which a glacier grows, its state of health, its degree of activity, its life span and its history" (Sharp, 1960). All these aspects are controlled by meteorological factors and the discipline of glaciometeorology has grown up to deal with them.

Part I introduces the background, setting, instrumentation, methodology and problems encountered in the technique of hydrological budget studies. Part II is essentially a study of the 1968/9 budget year using the methodology described in Part I, together with an indication of the state of health of the glacier. Part III examines the normality of the 1968/9 climatic year, suggests future trends in the state of health of

the glacier, and postulates its length of survival. Finally, Part IV is a comparison with selected glaciers and contains the general conclusions.

The thesis is not intended as a complete exposé of climate/glacier relationships on the Whakapapanui Glacier, it represents rather a method for showing how a simplified glaciometeorological technique can contribute to an understanding of this general problem. There are two prominent and readily observable avenues which are known to reflect the character of climate/glacier relationships. First, there is the budget approach which is concerned with the alteration in balance or imbalance between annual accumulation and annual ablation. Second, there is the approach which examines the response of the glacier to these alterations. "Whereas the former approach registers the finite adjustments of glaciers in the year-to-year fluctuations in weather conditions, the latter because the response is less immediate registers long term climatic trends." (Komb, 1964) This latter technique is an expansion of glacier dynamics while the former aspect is a problem of meteorology.

Aims and Objectives

The principal aim was to develop a simple and relatively inexpensive method for measuring the hydrological budget. The second aim was to analyse the causes and effects of easily measured meteorological parameters on the fluctuations in glacier behaviour. Consequently the research has been conducted using, principally, the meso- and macroscopic scales to examine the relationship between synchronous meteorological parameters and the regime of the glacier. Emphasis was placed on the meteorology of the glacier budget, but it was lack of essential hydrological equipment that prevented the use of the true hydrological approach (i.e. calculating the water potential of a glacier through catchment and runoff measurements) as a complementary technique.

ACKNOWLEDGEMENTS

For the emergence of this thesis I am greatly indebted to my supervisor, Mr R.D. Thompson, for introducing me to this field of research. Through his active interest in the field of glaciometeorology, his patience and dedication to this cause, what was originally just an idea and a hope has culminated in a documented piece of research and a continuing interest in the subject. Second, for the typing of the thesis in its various stages, for unfailing assistance in proof reading and for the typing of the final copy, I am eternally grateful to my wife, Geraldine.

From the inception of the project to its final production in bound form there are a number of people to whom I owe my thanks. For their enthusiasm and assistance I am grateful to Messrs W.A. Buckman, R.B. LeHeron, B. Stafford-Bush and P.J. Liddell, and Miss R.A. Hunt. Special thanks are due to Warwick for acting as guide on several occasions, to Pat for his technical assistance and to Royce for acting as camp dietician on several occasions. For making certain items of equipment available on loan from the Zoology Department at Massey University and for his technical assistance, my grateful thanks to Mr M. Mannering. I am also indebted to various staff members and other student geographers at Massey University for their assistance during field excursions.

Throughout the project close cooperation was maintained with the Tongariro National Park Board Rangers, who assisted in every way possible. Records were readily made available, rangers visited the meteorological station and changed charts whenever they were in the vicinity of the glacier, and Park Board accommodation was made available at our request. Many thanks to Messrs J. Mazey (Chief Ranger), W. Cooper and B. Jeffries for their support.

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# P A R T  I

## INTRODUCTION

Location and Regional Characteristics

Systems of Glacier Classification

Problems

Field Procedure

Instrumentation

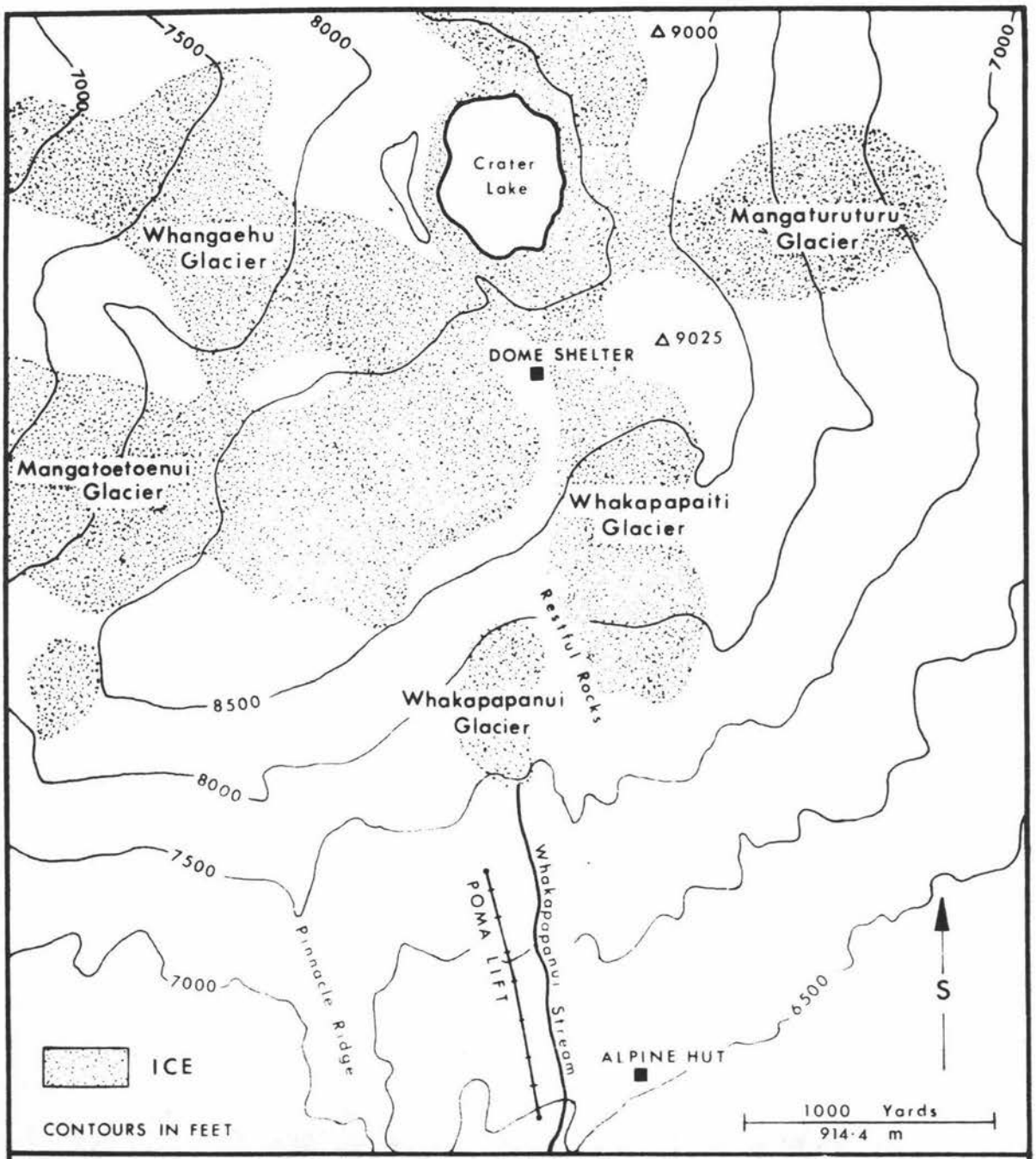
Methodology

Terms and Techniques

## LOCATION AND REGIONAL CHARACTERISTICS

In the centre of the North Island of New Zealand, almost equidistant from the Tasman Sea and Pacific Ocean, is situated a volcanic plateau which is dominated by a complex of three mountains aligned in a south-easterly/north-westerly direction. To the east of this complex, forming the eastern periphery of the plateau, is a cordillera consisting of the Hauhangaroa, Kaimanawa and Kaweka Ranges, while to the south aligned along an almost north/south axis is the Ruahine Range. The only barrier impeding the advance of the prevailing westerly and south-westerly weather is the now extinct volcanic cone of Mt Egmont (2,517 m) on the west coast of the North Island. Of the expanse ringed by these mountainous barriers a 170,000-acre area has been claimed as the Tongariro National Park. This extensive native reserve—the original 6,500 acres of which was bequeathed to the New Zealand Government in 1887 by the Maori chief Te Heuheu Tukino—takes its name from the extinct and northernmost member of the central volcanic complex, Mt Tongariro (1,969 m). Immediately south-east of Mt Tongariro is Mt Ngauruhoe (2,291 m), a young and still very active peak forming an almost perfect cone. South of this again is Mt Ruapehu which, at 2,797 m, is the highest peak in the North Island.

The Whakapapanui is one of seven glaciers on the upper slopes of very extensive Mt Ruapehu. At latitude 39°16'S and longitude 175°33'E it faces almost due north. The Whakapapanui and the north-westerly facing Whakapapaiti are the only two of the seven glaciers which are no longer connected to the summit ice plateau (see Fig.2). Moving around the mountain in an anti-clockwise direction, the other five glaciers are: Mangaturuturu, Mangaehuehu, Wahianoa, Whangaehuehu and Mangatoetoenui. This unusual situation of glacier ice on an active volcano underlines the




**DISTRIBUTION OF GLACIER ICE**
**NORTHERN SLOPES MOUNT RUAPEHU**

**FIG. 2**

exceptional nature of their location (especially since Mt Egmont is completely devoid of glacier ice), while at the same time it accentuates the precarious nature of their existence. They appear to exist, however, not because of the tabu which Te Heuheu, chief of the Taupo tribes, is said to have put on the area, but more likely as a result of the combined effects of topography, altitude, climate and regional setting.

Setting

The Whakapapanui is a small glacier, nestled under a protective rock buttress in the upper reaches of an asymmetrical valley. This rock buttress, rising more than 15 m vertically above the western periphery of the glacier, is the uppermost extremity of Restful Rocks (see Plate 1), a ridge forming the western bank of the Whakapapanui Valley. The slopes to the east of the glacier are much more gentle and form part of the cuesta-like slope which drops down into Te Heu Heu Valley on the steep scarp side. These debris-strewn slopes show strong evidence of glacio-fluvial erosion. Large boulders strewn indeterminately over the lower slopes are testimony of glacial activity while the smaller rounded material and fine debris indicate the extent of erosion caused by meltwater and runoff.

The scene on the upper portion of Mt Ruapehu (see Plate 2) is one of sharp peaks, precipitous ridges, hard volcanic rock and strongly eroded, deglaciated slopes covered with debris and boulders. All in all it is a rather inhospitable landscape, devoid of all vegetation (except mosses and lichens), and exposed to whatever ravages nature can muster. The once U-shaped valley leading into "The Gut" (see Plate 3) is now strewn with large boulders up to 2 m high on which exfoliation and nivation have been at work, giving rise to slated surfaces. Despoliation characterises the valley sides and everywhere there is the look of utter uselessness and

Plate 1. The northern slopes of Mt Ruapehu showing Pinnacle Ridge in the left foreground and the highest peak, Tahurangi (2,797 m), in the right background. In the lower middle and lower right foregrounds are three crescent-like depressions believed to have been occupied by cirque glaciers. The one in the lower right foreground is "The Amphitheatre", while the uppermost one is "The Cirque" and the other "The Staircase".

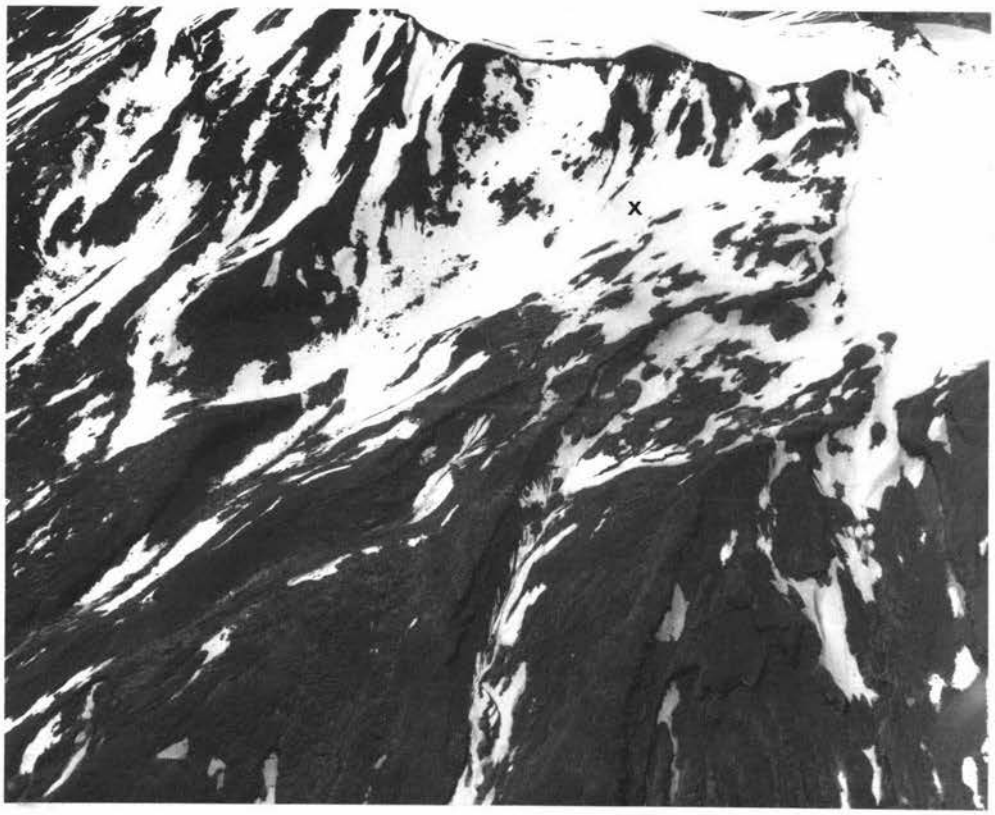



Plate 2. A close-up of the region of the northern slopes above 2,100 m. Knoll Ridge is distinguishable in the middle left foreground with the Whakapapanui Stream barely visible in the valley immediately below. It issues from the snow-covered region in the centre foreground, which is the site of the Whakapapanui Glacier (marked with an "X"). On the extreme right is a large snow-covered depression which is partially occupied by the Whakapapaiti Glacier.

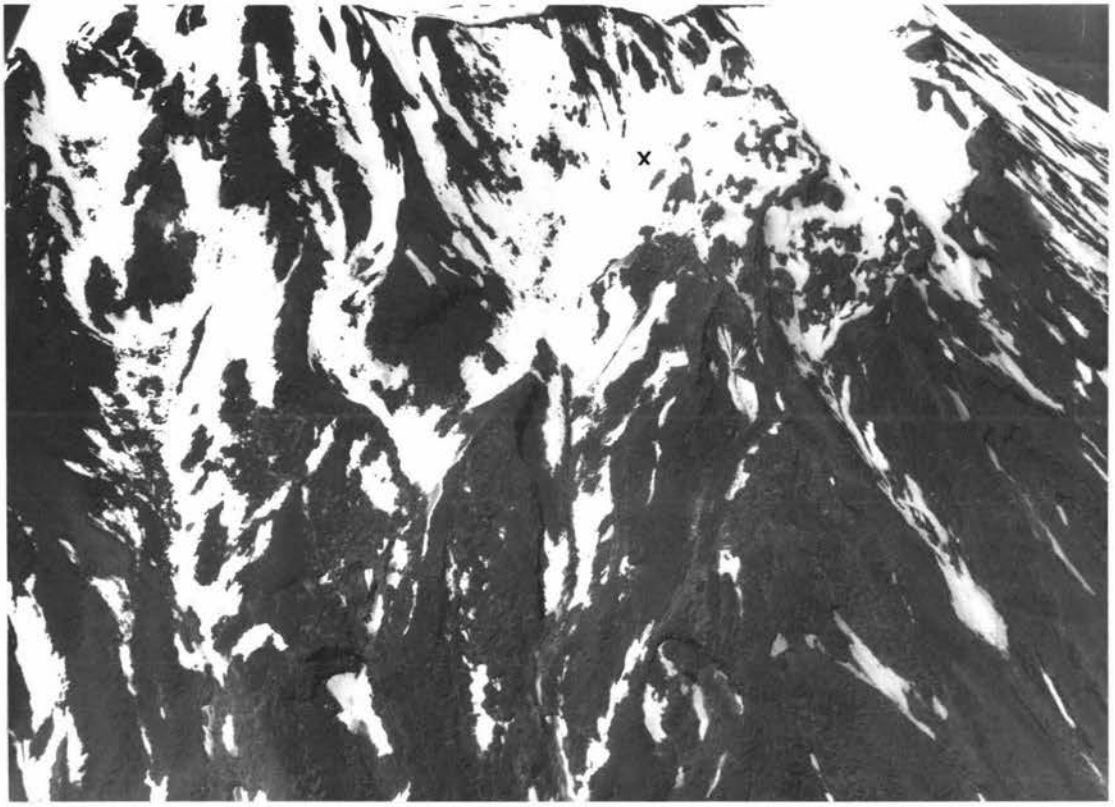



Plate 3. View directly up the Whakapapanui Stream in the centre foreground. "The Cirque" and "The Staircase" are again visible in the lower middle foreground. The area immediately between these two features is known as "The Gut". In the upper middle foreground an "X" marks the position of the Whakapapanui Glacier.

barren infertility (see Plates 4 and 5). Despite its raw and uninviting appearance, in winter when snow covers the landscape down to about 1,500 m it sports tantalisingly superb ski slopes and the mountain becomes alive with ski enthusiasts.

Climate

Two aspects of Mt Ruapehu's climate, which are universal to the whole of New Zealand, are (i) its changeability and (ii) the importance of wind systems in determining the type of weather. The direction of the airflows is fairly predictable: generally speaking, south-westerlies follow cold fronts, north-westerlies follow anticyclones and precede cold fronts, and easterlies are associated with the southern sector of depressions moving along the west coast of New Zealand. Of these airflows the southerly is the most common and its characteristics are readily discernible: cold and often snowy weather is a common feature with the precipitation often falling in the wake of cold fronts. The northerly, on the contrary, usually gives rise to less vigorous winds and mild, but somewhat muggy, weather.

Despite its changeability there is a certain amount of predictability in the weather. This results from the regular weather cycle over New Zealand taking from 6 to 10 days, during which time winds from almost every corner of the compass are experienced to a greater or lesser extent and, likewise, weather of almost every nature. Seldom is the same weather experienced for more than two consecutive days so that variability is the keynote (Garnier, 1957).

Its maritime position means that rainfall is substantial but not outstandingly high, while the fairly clear skies result in abundant sunshine and considerable solar radiation. All in all it has a temperate

Plate 4. The Upper Whakapapanui Valley. In the left foreground is The Knoll, marking the point where the left arm of the original Whakapapa Glacier bifurcated. The Whakapapanui Glacier is demarcated by the dotted line.

Plate 5. View looking north-east across the Whakapapanui Glacier, with the outline of Pinnacle Ridge just visible in the upper left foreground. The Glacier is demarcated by the dotted line.

maritime climate bordering on the region of the "roaring forties".

Systems of Glacier Classification

Due to its location the Whakapapanui is a thermally temperate glacier in that the pressure melting temperature of the ice is attained throughout the glacier during the ablation season. Geophysically it is also classed as temperate in that "it consists of crystalline ice formed by fairly rapid recrystallisation of the annual surplus of solid precipitation due to great quantities of fluid water" (Ahlmann, 1949). Morphologically it is a "cut-off" lobe of ice for it is now separated from the ice plateau from which it originally extended as an outlet glacier. Finally, in terms of both climatic and dynamic classifications it is known as dead ice. In the first place it is dead because it is no longer connected to a year-round source of ice and snow, while the lack of movement within the ice, resulting from a complete lack of transfer of materials from a regular source, has accounted for its dynamically dead state.