

Preface

It is now a decade since Jaap van der Meer initially asked me to consider writing a book on the Quaternary of New Zealand. The offer was flattering but intimidating. It was intimidating because New Zealand is a sub-continental scale region that is exceptionally tectonically active and contains some of the finest Quaternary archives on the planet. Any single writer would be challenged to do it justice. Nevertheless the temptation to accept was high, primarily because there really has not been a book that focusses on the Quaternary history of the New Zealand and the need for such a volume was obvious. The closest existing offering is the book on the 'Landforms of New Zealand' by Soons and Selby which is now over 30 years old and has more of a geomorphological than Quaternary focus. Thus when the offer to contribute a book on New Zealand in the Progress in Quaternary Science series was issued by the series editor (Colm O'Cofaigh) in 2015, I agreed, but on the basis that it was an edited volume rather than a single author text. It is a decision that is clearly vindicated by the individual chapters. No single author could present the debates on topics as diverse as the composition of magma chambers, the mitochondrial DNA of human commensals and the role of fragmentation on rock avalanche processes with the insights of the disciplinary experts who have written the chapters.

Though the volume is an edited one, the book nevertheless reflects some of my own views and biases. Notably, in the selection of authors, I have leaned heavily towards individuals and groups interested in the underlying earth and biological processes rather than simple histories. Hopefully this gives the book a better sense of integration as well as providing deeper insights into how and why New Zealand changed during the Quaternary. In the end, the challenge with a book like this is not what is presented but rather what is omitted. For example, the loess/soil history of New Zealand is covered in several chapters, most notably in the Whanganui Basin chapter, but arguably warrants a chapter in its own right. Even within topics, so much progress has happened over the last 30 years that comprehensive overviews of the entire discipline are infeasible. My own chapter on glaciation in New Zealand focusses on the last glaciation (74,000–11,500 years ago) because that is where the dating breakthroughs, especially in cosmogenic radionuclides, have revolutionised

our understanding of the timing of glacial events and triggered robust debates on the drivers of glaciation. It is hoped that the while the individual chapters will stand as significant reviews and perspectives in their own right, that the book as a whole will be greater than the sum of its parts.

Why New Zealand?

New Zealand lies at the junction of the Australian and Pacific plates and encompasses a wide variety of active tectonic settings including but not limited to a rift zone in the central North Island associated with extensive volcanism, strike-slip faulting along the Alpine Fault, and active subduction zones in the southern South Island and the eastern North Island. It is one of the best natural laboratories in the world to examine neotectonics. For example, strike-slip faulting was first demonstrated in the 1880s in New Zealand through displacement of terraces and fence lines along the Hope Fault in NE South Island. Prior to then, observations had suggested that fault movement involved only vertical motion of the earth's crust.

In examining this history, Nicol and his colleagues (Chap. 1) provide a detailed overview of the different tectonic regimes around New Zealand highlighting the complexity of a plate boundary characterised by a complete reversal of the direction of motion between the westward subducting Hikurangi margin on North Island and the eastward subduction south of South Island. In the first part of the chapter, they undertake a regional survey of the tectonic styles and Quaternary history around New Zealand. The outcome of this survey is to highlight that there are both striking regional differences but also that there appears to have been an increase in tectonic activity over the last 1–2 million years, coincident with the Quaternary. They do not venture a cause, but in the Southern Alps at least, there is a relationship between high topography, rainfall, erosion and uplift. The chapter also sets the context for much of the mountain geomorphology covered by Davies in Chap. 6.

Active volcanism in New Zealand, which encompasses all major types of volcanic activity, from small-scale basaltic flows and maar explosions through to rhyolitic super-eruptions have left a world class record of tephra and other volcanic deposits on the New Zealand landscape. This record is of course related to the tectonic history but is important in its own right. New Zealand Quaternary volcanologists are world leaders in tephra and micro-tephra analyses. The outstanding volcanic record is interesting both because it gives insight into processes in a variety of plate marginal settings but also because the tephra provide critical independent age control for Quaternary events in New Zealand and help make the New Zealand Quaternary a 'Rosetta Stone' for determining the timing and nature of many climate events. This latter theme is explored in many of the chapters in the book, notably the climate and oceanography chapter (Chap. 3) and the Whanganui Basin story (Chap. 4).

In Chap. 2, Shane provides a comprehensive overview of the distribution, style and timing of volcanism in the Quaternary in New Zealand. The chapter emphasises

the role of volcanism in landscape evolution in the Quaternary and the application of tephra as key chronostratigraphic markers in Quaternary sequences. The chapter acts as a stepping-stone into the literature on the processes operating within the magma chambers as well as the surficial consequences. The chapter also highlights how little we know about some aspects of volcanic activity in New Zealand.

The largest single chapter in the book is the climate and oceanography chapter by Lorry and Bostock (Chap. 3). This chapter is a major undertaking. Looking at the oceanography alone, several major fronts (the sub-tropical front, the sub-Antarctic front) and currents (Deep western boundary current, East Australia current) converge in the New Zealand region and the offshore bathymetry ensures a complex and regionally diverse interaction of water masses and currents. Antarctic (e.g. southern annular mode) and tropical Pacific (El Niño Southern Oscillation) systems interact in the region both atmospherically and oceanographically. The authors cover both the processes operating in the atmosphere and the oceans, some of the key paleobiological and geological evidence that underpins our understanding of past climate conditions and a time series of climate reconstructions that yields detailed insights into the climatology and oceanography of the region through the latest part of the Quaternary. Cumulatively, these first three chapters underpin the rest of the book providing the context for the stratigraphically, geomorphologically and biologically focussed sections that follow afterward.

Chapter 4 is unique in this book focussing on a single relatively defined region, the Whanganui Basin. In southern North Island, the late Quaternary uplift of earlier Quaternary marine sediments provides one of the world's best-exposed lower Quaternary sequences. These outcrops in the Whanganui Basin yield unique insights into climate and environmental change in the earlier parts of the Quaternary, at a level of resolution unmatched globally. The records are critical to understanding major changes in the Quaternary including events such as the mid-Quaternary transition when global climate cycles shifted abruptly from 40,000-year dominant cycles to 100,000-year cycles. It might be my New Zealand prejudice, but these records should arguably form the stratotypes for much of the lower Quaternary.

Over the last few decades, there has been a global focus on mountain glaciers as a 'canary in the mine' for global warming. In New Zealand this has been reflected in a plethora of work covering both the scale and causes of modern glacial fluctuations and an upsurge in interest in reconstructing the timing and climatic causes of glacial advances during the last ice age. This latter focus has been underpinned by our relatively new ability to date glacial advances, or more accurately, their recession from advanced positions using cosmogenic radionuclides. In Chap. 5, I have tried to highlight the nature of glaciation in New Zealand, focussing on the Southern Alps. New Zealand glaciers are among the most temperate in the world and are associated with exceptional sediment supply. These characteristics give New Zealand glaciers some definitive response patterns and I have summarised these aspects before reviewing the climatic inferences derived from late Quaternary (specifically the last glacial cycle) advances.

New Zealand is also one of the best places in the world to examine landslides and other processes driven by the tectonic setting. Recent work includes world-leading research on the processes of landsliding that has yet to be summarised and made available to a more general audience. Geohazards associated with seismicity, volcanism and extreme climate events are prevalent throughout New Zealand, and New Zealand provides both outstanding examples of many of these hazards but also case studies in how to respond to them.

In Chap. 6 Davies examines geomorphic systems in New Zealand with a focus on mass movement (especially landsliding) and to a lesser degree rivers. He brings an engineering geomorphological prism to the topic and a very strong focus on physical processes. The chapter concentrates on places where there have been conceptual advances in understanding in the last 30 years. The observations on the role of channel constriction and base-level change in braided rivers affects both the modern management of the rivers and also our conceptual understanding of how these systems may have responded to past climate and environmental change. Many of the ideas presented challenge orthodoxy and having been peripherally involved in some of these debates myself, there is enormous value in doing so, even if orthodoxy sometimes prevails.

Continuing the Southern Ocean theme, New Zealand has been isolated from adjacent continents for the better part of 90 million years and may (unlikely) have been completely submerged at least once during this period. As a result, it had a unique fauna dominated by flightless birds and has a flora with strong Gondwanic affinity. The isolation provides a great laboratory to examine the adaptation of fauna and flora to the rise of the New Zealand mountains in the Pliocene and Pleistocene and the response of biota to climate change and ecosystem fragmentation in the Quaternary.

Wood and colleagues (Chap. 7) take a long term overview of New Zealand biotic history before covering the Quaternary in detail. This chapter contains some really interesting ideas about how plant (and to a lesser extent) animal populations responded to glaciation. It presents a strong argue for abandoning the idea of plant and animal refugia during glacial times in place of a dispersed patchwork of persistence.

New Zealand is also one of the world's great laboratories for human colonisation. New Zealand was first settled only about 800 years ago and as a result it is possible to examine the impact of humans on the environment rather more easily than in other parts of the world. Some of these impacts were devastating including the rapid extinction of the avian megafauna, in a setting where it is easy to distinguish human impact from climate change. DNA analysis has become critical to understanding the colonisation story and there have been dramatic advances in mitochondrial DNA that is allowing us to decipher the colonisation story.

Chapter 8 by Matisoo-Smith on the settlement of Aotearoa has a strong focus on the use of ancient DNA and highlights our ability to track colonisation of the Pacific using both human and commensal animal DNA. The chapter traces the last great human exploration and migration from Near Oceania (constituting islands close to New Guinea) into the remote Pacific (the Polynesian Triangle). It delineates an

earlier and later wave of migration into Near Oceania based on human mitochondrial DNA with the haplotype dominant in Polynesia quite different to those present in Australian and New Guinea populations. The work confirms a roughly 3000-year lineage for people in Polynesia. Using the ‘commensal approach’ so named by Matisoo-Smith herself, the mitochondrial DNA signature of New Zealand’s Polynesian Rat (*Rattus exulans*) confirms central Polynesia as the source of settlement of New Zealand. The wide genetic variability of the rats supports the idea of multiple phases of colonisation or at least long contact between New Zealand and central Polynesia. Looking at human mitochondrial DNA for New Zealand, the conclusion is that the settlement group included a large number of individual females (close to 200). This settlement happened about 800 years ago and started the major alteration of New Zealand’s biota discussed in Chap. 7.

Finally, New Zealand is both one of the most sensitive locations for examining future environmental change and conversely one of the most geologically active landscapes on earth where background processes may swamp anthropogenic change. In the final chapter, ‘Adrift in the Anthropocene’ we re-evaluate the background geological and climatic processes before highlighting possible impacts on everything from glaciers to biota and people. The conclusion is that human impacts on biota are critical but that most other changes from anthropogenic action may be hard to discern. Geomorphic processes in particular will continue to beat to a tectonic rather than anthropogenic drum.

In summary, this book attempts to provide coverage of the last 30 years of progress in Quaternary Science in New Zealand, while acknowledging the baseline of near 150 years of work that preceded this period. The book is targeted at an audience that has some scientific background but expertise of the individual topics is not expected. Rather it is hoped that this book can act as a point of entry into a broad range of research.

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