Lost World of Rēkohu

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Ancient 'Zealandian' Animals and Plants of the Remote Chatham Islands

By

Jeffrey D. Stilwell and Chris Mays

Cambridge Scholars Publishing

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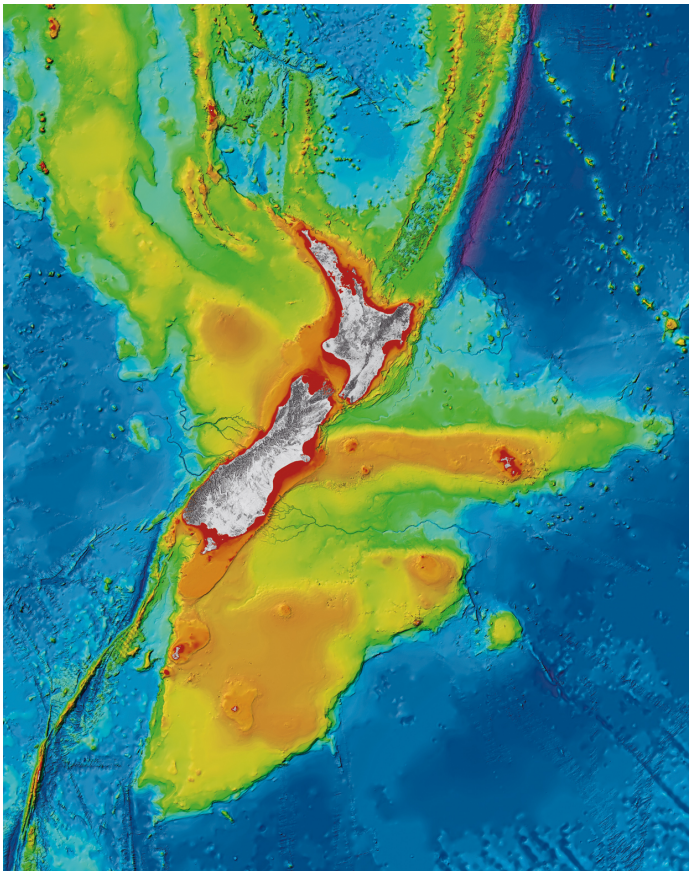
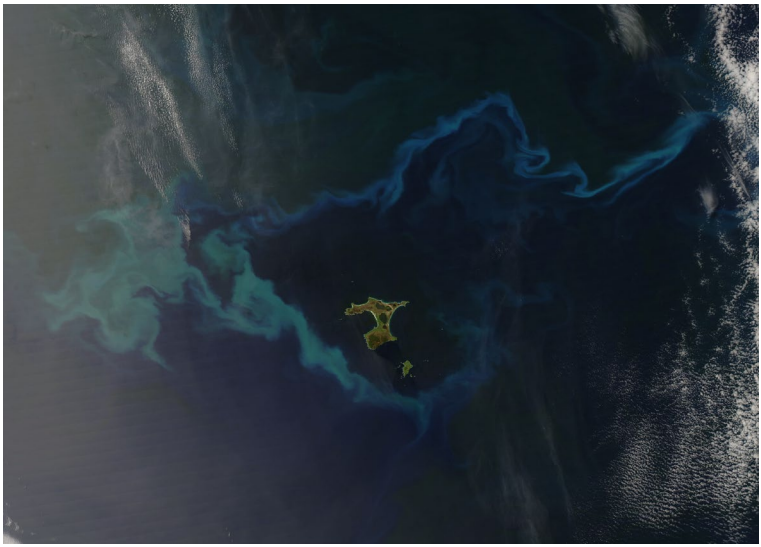


NIWA map of the Zealandian microcontinent. A shallow-water, finger-like extension of the Zealandian landmass is seen to the east, which is called the Chatham Rise. At its eastern edge some 865 km east of Christchurch, emergent islands called the Chathams (Rēkohu) have been inhabited by humans for at least 500 or more years, but probably much longer. The Moriori lived in peace here until 1791, when the British arrived and bloodshed shook the foundations of Moriori society, and they never recovered. 142 years later, the last Moriori, Tommy Solomon, died at the young age of 49—marking the end of a long and great line of eastern Zealandian peoples.



Beautiful blue hues and swirls of indigo to turquoise surrounding the Chatham Islands, which reflect a large plankton bloom occurring on the Chatham Rise. As in prehistoric times, the marine shelf waters around the isles teem with life of diverse vertebrates, invertebrates and microorganisms. The upwelling centre of highly productive waters supports massive phytoplankton blooms that sustain valuable stocks of fish during the year. This image, taken by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite on December 5, 2010, depicts the large annual spring-time bloom.

CONTENTS

The first glimpses of the Chathams, taken from a Convair in March 1995. The anticipation of a first visit to these special isles is palpable! What fossil treasures await us?!

A glorious sunset from Waihere Bay on Pitt Island, looking north to the jagged silhouette of Mangere Island and a peak of Little Mangere and 'The Castle' behind. Evenings such as this take one's breath away with the sheer beauty of the landscape.

Pitt Island and nearby isles from Pitt Strait. Photo taken from a fishing boat looking south to the tip of the Taruwhenua Peninsula of Pitt Island (left), Mangere Island (behind), Little Mangere, Rabbit Island, and The Castle. The topography of these islands reflects the violently volcanic nature of its geologic past, coupled with quiescent intervals of limestone deposition and associated richly fossiliferous beds.

Full moon over Waitangi Bay beach. There is nothing like an evening stroll on Chatham's beaches to close a productive day of geology and palaeontology.

PREFACE

The Chatham Islands in far eastern Zealandia hold many fascinating and unexpected secrets of the natural science kind. Unlocking those geologic and palaeontologic secrets has taken more than two centuries, ever since the islands were rediscovered in 1791 during the British George Vancouver expedition to explore and conquer new lands for the expanding empire. Little did these seafaring Englishmen know upon their chance arrival there that there was already a rich human history of the Moriori peoples on the islands that they called Rēkohu (relating this name to the isles' misty skies), dating back many hundreds of years prior to their landing. Clandestine sealing and whaling by several nations during the late 18th and early 19th centuries effectively stalled scientific progress for many decades to come. Unsurprisingly, it would take a further 50 years into the mid-19th century before scientists would even begin to fathom just how significant this small island chain in the middle of the Southwest Pacific really is in terms of its natural resources, and the evolutionary history of the New Zealand region.

The Chathams rock record tells of prehistoric relict Gondwanan supercontinent connections, and the fossil organisms preserved in these sedimentary deposits provide an exciting new understanding of previously unknown animals and plants that existed in this far eastern outpost, many of which are found nowhere else on Earth. The dynamic nature of the Chathams region in terms of geography and climate can be readily discerned by reading the rocks spanning millions of years of Earth history, which conveys a startling story of a violent past with immense volcanic eruptions during the break-off from the Gondwana motherland at a critical time in our globe's past. Over this interval during an extreme global warming event during the mid-Cretaceous Period from ~100 to 84 million years ago, the Chathams region was positioned very closely to the ancient South Pole and separated from what is now Marie Byrd Land, Antarctica, today. The long-term greenhouse phase meant that terrestrial and marine organisms could spread across the globe, and what today represents the frigid north and south polar latitudes, was, during the Cretaceous and Paleogene periods, quite equitable and balmy by relative standards, even in the polar regions. What has been discovered in the Chathams record in terms of ancient life is no less than remarkable and is the subject of this synthesis of the entire fossil

record of these special islands. Their mystique, raw beauty and splendour have captivated the authors into returning to this remote outpost some 12 times between them with constant daydreams of going back! The 12 chapters in this book highlight the diverse and rich fossil record of the Chathams, which was first recognised by the newly-formed New Zealand Company naturalist and German scientist, Ernst Dieffenbach, in 1840, who collected the first fossils from what is now the Tutuiri Greensand of the early Paleogene age, exposed in the north-western part of Chatham Island. The first four chapters provide the background on the discovery, history and geology of the Chathams and its Moriori peoples, along with the key scientists researching these isles for nearly 180 years of history, to place the palaeontologic discoveries of Chapters 5 to 12 into a regional and global context in terms of their significance. It has been our desire to reconstruct the Chathams' geologic and palaeontologic history and heritage in terms of the diverse nature of plants, animals and microorganisms, as much as the data accurately allow to the present day. Research is ongoing with many researchers continuing to dig deeply into eastern Zealandian rocky and fossil puzzles. The major discoveries of dinosaur remains, including both large and small meat-eating predators and several species of the oldest recorded, penguin-like birds in the world, along with exceptionally-preserved fossil forests and their inhabitants then living at 70–80° south latitudes near the Cretaceous South Pole, render these fossils amongst the most important ever found in the Zealandian region and particularly so since they have been found in the dawn of the new millennium. Technological innovations, such as advanced imaging systems and scanning techniques (e.g., synchrotron, neutron tomography and micro-CT tomography, among others) breathe fresh new life into early organisms millions of years old, so much so that, in 2019, we have the tools to recreate these animals and plants in perfect 3-D, just as if they were alive today. Standard palaeontologic techniques, used over the last two centuries, along with these new ones, create a perfect, and thereby, much-refined scientific recipe to appreciate and understand the evolutionary lineages of the recovered fossils and their relationship to other organisms in Zealandia and across the globe.

The father of evolution, Sir Charles Darwin, upon hearing about the new discoveries being made on the Chatham Islands by Ernst Dieffenbach, wrote a letter congratulating him on being the first to delve into the secrets of a new part of the globe, which was previously unexplored. It is our wish that this book will inspire all generations, young and old, to delve more deeply into the scientific treasures and stories of the Chathams, which deserve to be told. However, be warned, once you catch the 'Chathams bug'—which has taken hold of the authors and many other

colleagues in the past and present—you will find any way possible to get back to this *Lord of the Rings* landscape of volcanoes and steeply-cliffed edifices to unlock more of its secrets…

Associate Professor Jeffrey D. Stilwell
Dr Chris Mays

ACKNOWLEDGEMENTS

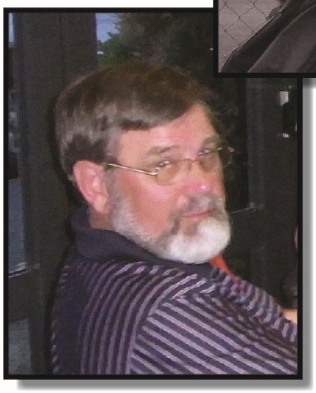
This book summarises the monumental efforts of scores of individuals over a period of almost 180 years, all of whom have been keen on learning as much as possible about a remote archipelago in the Southwest Pacific and its natural wonders. Research on the Chathams is not for the faint-hearted, as its isolated nature and often unrelenting, inclement weather create challenges in all aspects of conducting natural science. Nevertheless, since 1840, one scientist after another has been so very captivated by what these special isles hold in terms of understanding the evolutionary history of animals, plants and microorganisms in the Zealandian region. Most catch the 'Chathams bug' and return as often as possible to delve further into the secrets the rocks hold. The authors are indebted to those intrepid explorers and boffins who have hiked many kilometres over the most rugged landscape long before us and have published exciting accounts of new organisms since the mid-19th century, many of which are quite distinct from the western parts of Zealandia. Many institutions and granting bodies have been graciously supportive of diverse projects on the Chathams, including the New Zealand Grants Committee Postgraduate Bridging Grants, the University of Otago, GNS Science (Lower Hutt), the National Museum of New Zealand 'Te Papa', Canterbury Museum, the Auckland Institute and Museum, the University of Texas (Austin), the National Geographic Society Committee for Research and Exploration, the Australian Research Council (Australian Post-doctoral Award, Australian Research Fellow, Small Grant, and Discovery Grant schemes), the Australian Nuclear Science and Technology Organisation, Monash University, and many others.

The exciting new information in this book would not have been possible without the passionate support of the Chatham Islands peoples, especially the Terry and Donna Tuanui family, who dedicated many days of their lives over the last 25 years to help the authors have the best chances possible to make Zealandian and globally significant palaeontologic discoveries. Donna and Terry—we value so highly your unwavering support and friendship over these many years and admire your humanity and keen curiosity about the Chathams' ancient fossil treasures that provide new clues on the islands' evolutionary history. We are indebted to the following people, who have enhanced the writing of this book by assisting

us in diverse ways throughout two decades of research and field work: Steve Morton (Monash University) for his superb photography skills, Chris Consoli (Global CCS Institute, Melbourne) for his ground-breaking geology and palaeontology studies of the Chathams during his Honours and PhD work; field assistance by the late David Pickering (Museums Victoria), Stephen Poropat (Swinburne University), Jesse Vitacca (University of Western Australia), Bill Zinsmeister (Purdue University), Tom Rich (Museums Victoria), Aidan McMahon (CDM Smith, Melbourne), Lucas Buchanan (ExxonMobil), Sarah Jones (ex-University of Otago), Cameron McKenzie (Deakin University), Julia Clarke, Matt Brown and Sebastian Egberts (University of Texas-Austin), Alan Tennyson (Te Papa Museum), Daniel Ksepka (Bruce Museum, Connecticut), late Andrew Grebneff (University of Otago), Ray Cas (Monash University), the late Leonor Sorrentino-Mariconda (Monash University), David Cantrill (Royal Botanic Gardens Victoria), Sylvia Hope (California Academy of Sciences), the late Bob Carter (James Cook University), John Simes, Chris Hollis and Hamish Campbell (GNS Science, Lower Hutt), John Buckeridge (RMIT University), Jenny Kain (Monash University), Lynette Russell (Monash University), Paul Scofield and Jacob Blokland (Canterbury Museum and ex-Canterbury University [now Flinders University, Adelaide]), Mike Hall (Monash University), Pat Vickers-Rich (Monash University), Pedro Viegas (ex-Monash University), Hannah Carle (Australian National University), Tim Ziegler (Museums Victoria), Steven Salisbury (University of Queensland), Stephen Cox (ex-Monash University), Lucas Buchanan (ex-Monash University), Andrew Coward (Monash University) and Chava Rodriguez (Monash Tech School). We wish to thank Helen Edwards and team of Cambridge Scholars Publishing for their support throughout the entire publication process and also Elisabeth Salverda (UK) for her thorough job of proofreading this book to make it sparkle and shine.

Leonor Sorrentino-Mariconda

David Pickering

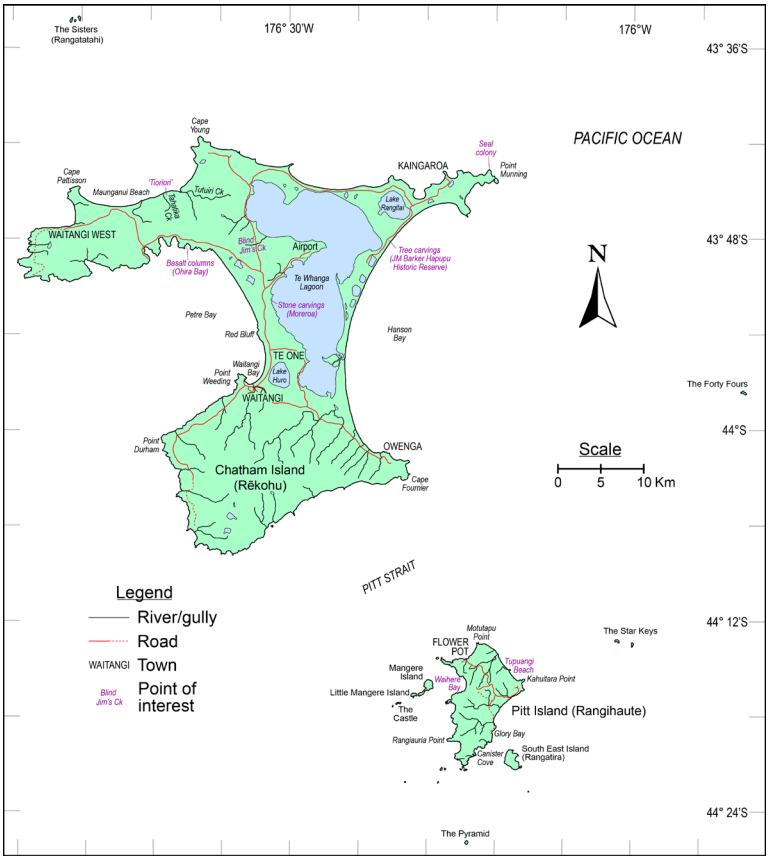


Bob Carter

DEDICATION

This book is dedicated to passionate researchers of the Chathams' natural history, who have passed on only recently and are sorely missed by all—

Ms Leonor Sorrentino-Mariconda, Mr David Pickering
and Professor Bob Carter.


The Sisters
(Rangatatahi)
176° 30'W
176°W
43° 36'S
43° 48'S
44°S
44° 12'S
44° 24'S
PACIFIC OCEAN
Cape Young
Cape Pattisson
Maunganui Beach
'Tiorioni'
Tiriuiri Ck
Gulliver Ck
WAITANGI WEST
Basalt columns (Ohira Bay)
Blind Jim's Ck
Airport
Te Whanga Lagoon
Stone carvings (Moreroa)
Tree carvings (JM Barker Hapupu Historic Reserve)
Lake Rangitai
KAINGAROA
Seal colony
Point Munning
Petre Bay
Red Bluff
Hanson Bay
TE ONE
Lake Huro
Waitangi Bay
Point Weeding
WAITANGI
Point Durham
Chatham Island (Rēkohu)
OWENGA
Cape Fournier
N
Scale
0
5
10 Km
The Forty Fours
PITT STRAIT
Legend
River/gully
Road
WAITANGI Town
Blind Jim's Ck Point of interest
Motutapu Point
FLOWER POT
Mangere Island
Little Mangere Island
The Castle
Waihere Bay
Tupuangi Beach
Kahuitara Point
Pitt Island (Rangihaute)
Glory Bay
Rangiauria Point
Canister Cove
South East Island (Rangatira)
The Star Keys
The Pyramid

CHAPTER 1

THE CHATHAM ISLANDS—EMERGENCE OF A GEOGRAPHIC AND GEOLOGIC WINDOW INTO EASTERN 'ZEALANDIA'

At the dawn of the new millennium, many expeditioners travelled to one of the most remote (and picturesque) regions of the planet—not on a whim—but for what they perceived to be a very good reason, that being one of the few first places on global *terra firma* to bring in the year 2000. The Chatham Islands, located approximately 856 kilometres east of Banks Peninsula, South Island, New Zealand, are 45 minutes ahead in the current time zone, and people living or visiting there are privileged to be the first to bring in the sunshine around the globe, if they are so lucky, given that it rains there about 300 or so days of the year. Most New Zealand mainlanders are none the wiser about the weather on the Chathams, as it scarcely receives a mention in the daily forecasts, but if you are staying in the Chathams, a 'sou..easter' forecast can bring on a fierce shiver of stormy, cold weather and huge seas (although the spectacular rainbows frequently seen on the islands ease the 'pain' to some degree!). The seas can be so ferocious that table-sized pieces of rock can be flipped over and pushed landward to reveal ocean-dwelling, bottom feeders, such as molluscs and sea anemones that live and feed under rocks in nooks and crevasses. This unforgiving power of the sea in the Chatham Islands is no less than remarkable and can be frightening if you are on a boat in swells of several metres; on balance, the *Lord of the Rings*-mystique of this special, wonderful place has driven the authors to return to the Chathams time and time again—in fact, some 12 times between us, but there are current discussions of returning for more exploration! Weather forecasters consider the Chathams to be cool, cloudy

Sun setting on Pitt Island after a long day of fieldwork and hunting for fossils in the Tupuangi Formation. The sunsets on the Chathams can literally take one's breath away!

Walking on the beach at Tioriori between rock outcrops of the Takatika Grit in search of ancient avian (bird) remains, which represent the oldest penguin ancestral bones in the world.

Hiking around Pitt Island reveals some spectacular views, like this panorama from Rangiauria Point, a volcanic edifice on the southwestern coast of Pitt Island.

A perfect representation of why the Moriori called the Chathams the land of the 'misty skies' — the view to Mangere Island from Pitt Island.

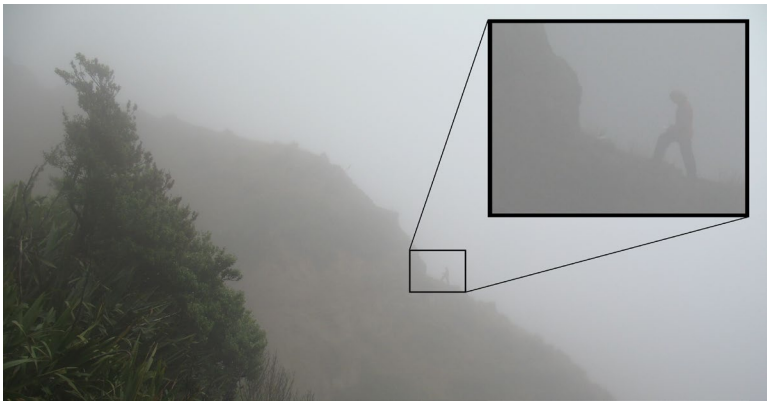
Fieldwork in the fog on Pitt Island in 2008. Jeff Stilwell making his way across Waihere Bay, while studying the Tupuangi Formation.

and windy, and in the main settlement, Waitangi, the average monthly temperatures rise from 7.5°C in July to 14.3°C in January, with an average annual rainfall of 500–1000 mm, elevating to 1,250 mm in the higher country to the south. The prevailing winds are the southwesterlies that can be unforgiving, as reflected in the strangled, stressed, bent nature of many trees on the islands. Mean spring tide is 0.9 metres at Waitangi with the southern and western coasts being constantly hammered by strong southwesterly swells, while somewhat more gentle ocean waves bathe the east coast. Fossickers and fishermen can be caught off guard with many unfortunate deaths over the years. The senior author remembers fossil collecting in Waitangi Creek in the centre of the main settlement in early 2003, only to be startled by a tidal bore with water rushing swiftly up the creek and barely enough time to move onto higher ground. And, sadly, some folks are not as lucky and can get taken to sea by freak waves along the coast, which happens occasionally on the islands. Moreover, there are records of tsunamis in recorded human history from 1868, 1934 and 1964, and legends from pre-historical accounts, that reflect major (but rare) earthquakes along the Chatham Rise. Not only have Chatham Islanders through time relished the natural resources on land and in the sea, but keen nature lovers and serious scientists have also delved deeply into the natural history of the islands to unlock as many secrets as possible of this unique piece of eastern Zealandia, which is ongoing with no signs of abating. Today, Moriori and Māori descendants, along with Pākehā (white folks), live side by side in mostly harmony with a renewed vigour to protect the precious Chathams environment; in fact, some people living on the Chathams are descended from all three groups. On a daily basis, fossickers look for ancient remains of rocks, fossils and artefacts, which range from exotic rock types, such as obsidian and greenstone from the mainland Māori, to very out-of-place rocks called 'erratics', which have been dropped by Antarctic icebergs, once they melted in warmer waters of the Chathams. Incidentally, a few icebergs have been sighted since 1950, and, given the current accelerated rate of Antarctic ice sheet contraction and break-off, it would not be too surprising if more icebergs were to show up in the vicinity of the islands in the future. Even English flint and Welsh slate turn up from ships' ballasts, having been washed ashore attached to kelp holdfasts. And, the secrets being unleashed from the land and sea in just the last decade are changing the way we view the evolutionary history of scores of plants and animals in Zealandia and the greater Southern Hemisphere biotic record. And, it gets better…at the time of this writing, surprising new results from palaeontological research on fossils from the Chathams will mean that all textbooks on fossils need to be updated. The most current state-of-play on

the rich fossil history of these glorious islands is to be found in these pages, incorporating published data, dating back 180 years, and new information 'hot off the press'. Geographical attributes of the Chathams have changed dramatically, as has the climate over many millions of years, since they were attached to Marie Byrd Land, West Antarctica.

The Chatham Islands (970 km²) are positioned on the far eastern edge of the Chatham Rise, a mostly submerged (up to 600 m depth), finger-like continental extension or platform varying from 90 to 150 km wide of New Zealand at 44°S, 176° 30'. The reasons for their elevation above the sea today relate to both long-term volcanism and tectonic or mountain-building activity in the Southwest Pacific. These emergent islands of the Chatham Rise are positioned strictly speaking in the Western Hemisphere, but the International Date Line has been moved east to avoid some confusion. In terms of size, Chatham Island is the biggest at 90,000 ha, followed by Pitt Island at 6,190 ha and Southeast Island at 218 ha. There are six other smaller isles, and lots of steeply cliffed islets and tall rocky stacks. The next closest emergent pieces of land are called the Forty Fours (Motuhara) positioned at 43° 58'S, 175° 30'W, and then a very long 8,000 km journey of open water to the southern coasts of Chile and thousands of kilometres south of rough seas to Antarctica. Significantly, these islands preserve much of the geologic history of the Chatham Rise, which was formally part of the Gondwana landmass in the proto-Pacific. The 30+ islands and islets of the archipelago vary in size from <1 to over 800 km^2, with two main islands—'Chatham' (named after the brig H.M.S. *Chatham* commissioned in 1788 and the Earl of Chatham; also known as *Rēkohu* in the local Moriori language meaning 'islands in the mist' or 'misty skies') and 'Pitt' (named after William Pitt, 1st Earl of Chatham; also known as *Rangiaotea* and *Rangihaute* by the Moriori and *Rangiauria* by the invading Taranaki Māori, who all but exterminated the inhabitants during the 1830s, except for those who were imprisoned as slaves). What is unusual about these islands is that they expose ancient continental crust rocks that are virtually identical to those found on the mainland.

Flying into the islands one notices straight away from the air that the northern part of Chatham Island is relatively low and very gently undulating, with a surprising suite of crystalline basement rocks cropping out on the northwest and north-eastern peninsulas that comprise metamorphic rocks, characterised by very hard, grey, quartz-rich rocks called 'schist' that have been called the Chatham Schist. The Otago Schist on the mainland is made up of the same metamorphic rocks, originally sedimentary rocks heated and buried deeply in the Earth's crust, subsequently deformed and eventually brought to the surface, where they either stand proud or low to the



Hark, who goes there? Misty skies of Rēkoku, indeed. Chris Mays conducting fieldwork on the Tupuangi Formation of Pitt Island.

Gleeful cheers of Monash University geologists while searching and finding great fossils in the Takatika Grit at Tioriori. The exposures here are rich in all types of fossil remains and also large phosphorate nodules. Large bones of marine reptiles and dinosaurs are found associated with these nodules and are extremely difficult to collect for study. However, that has not dampened our spirits at all!

Red Bluff Tuff sequence preserved on Chatham Island, as being studied here by Dr Chris Consoli (ex-Monash University), Prof. Emer. Ray Cas (Monash University) and the late Leonor Sorrentino, who was conducting her MSc research on the volcanic rocks of the Red Bluff Tuff. Note the large lava bombs preserved in the outcrop.

Hiking along the narrow, sheep-worn ridge on Waihere Head Peninsula, Pitt Island, looking out to Mangere Island, Little Mangere Island and The Castle.

ground, and where they are being eroded today around Chatham Island and also far east in the Forty Fours. Encountering deep crustal rocks in the middle of the Pacific is unusual and a relatively rare geological sight. Sitting on top of these basement schists are thick stratigraphic sequences of Cretaceous to Cenozoic-aged limestones and volcanic sandstones, which are capped here and there around the islands by much younger Quaternary-aged sand dune deposits and dune calcarenite present in the north and centre of the main island.

In addition, there are conspicuous conical cones dotting the landscape of Chatham Island, which caught the attention straight away of Ernst Dieffenbach, the original surveyor of the islands. The small, conical hills are usually no more than 150 m high, and date back to the late Eocene Epoch, and extend to the Oligocene and even perhaps the Miocene to Pliocene epochs. A further conspicuous aspect is that the volcanoes reveal a pattern, running in a line from Mount Dieffenbach (*Hewocama*) to *Hokopoi*, *Motuporoporo* and *Korako*. Sediments derived from massive, multi-kilometre volcanoes span the Cretaceous to Paleogene periods, which comprise tuffs (mostly consolidated ash layers) and agglomerates that were deposited in the ocean, and are either sparsely or richly fossiliferous that have both similarities and differences to the mainland, the reasons for which are explored later in this book. Coastal embayments are characterised by yellow and white calcareous sand with a barrier of grassy dunes. Venturing further into the central part of the island one encounters an isthmus of sandy dunes and dune calcarenites being deposited over Cenozoic-aged, fossiliferous limestones, bordered by the impressive Te Whanga Lagoon on its eastern side which is estimated to be about 16,190 ha. The entrance to the lagoon is ephemeral in nature through a dune-capped barrier on the east coast north of Owenga and limestone on its western shorelines. Travelling around Chatham Island, it is common to see many other shallow lakes and lagoons, inhabited by diverse birdlife. The southern part of Chatham is in stark geographic contrast with its much higher topography, comprising Upper Cretaceous volcanic rocks, marking the timing of separation of the ancient Chatham Islands region from West Antarctica very close to 83 million years ago. By air, you can see the steep, southern coast up to some 250 m high, exposing basalt lavas, tuffs and agglomerates that dip to the north, and crop out in dissected remnants of a huge stratovolcano on Pitt Island approximately 23 km to the southeast. This major volcano was originally positioned centrally from what is now Pitt Strait. Pitt and the surrounding islands and islets represent astounding surreal scenery that surprises most visitors and is arguably one of the most spectacular vistas on the globe with steeply cliffed small islands, cut by tachyte dykes, that shoot

straight out of the water akin to the mysterious island and its precipitous cliffs restraining *King Kong* from escaping. The authors admit that their respective first impressions of Pitt Island reflected a firm sense of wonderment about what geologic treasures might await in such a faraway land.

More recently (at least in terms of geologic history), during the late Pleistocene Epoch, peat deposits began to accumulate around 40,000 to 30,000 years ago on the southern 'highlands' of both Chatham and Pitt islands, especially in areas where rushes and tarahinu scrub. Sandwiched between the layers of peat is volcanic ash from the Lake Taupo eruptions, with a major layer some 16 cm thick, which reflects an eruption from 23,000 years ago. Fluctuating sea levels over time have also meant that benches have been cut by marine processes by varying sea levels up to 200 m, especially significant on South East Island, which has a thin coating of sand and cap of peat. These volcanic rocks have also been buckled by enormous tectonic forces, causing fold and faults. The geology of the Chatham Islands and Chatham Rise has been systematically studied predominantly by New Zealand geologists since Ernst Dieffenbach's first observations in 1840, discussed in detail below. The outcrop on the Chathams exposes a rather patchy, but nevertheless important, geological record from the Permian until Recent, providing the only onshore sequences of, and an important window into, the geology of the Chatham Rise. Since 1840, the Chathams have been the subject of many geological expeditions expanding the knowledge of Gondwana, New Zealand and the Pacific, but astoundingly it took 130 years before the first detailed geologic map of the Chatham Islands was produced by Hay et al. (1970); see the latest published map here. It is worth noting that Dieffenbach (1840, 1841) provided the initial details of the stratigraphy of the islands by describing fossiliferous strata along the northern coast of Chatham Island. The account identified thick peat deposits, overlain by greensands and limestone referred to as the Tioriori Group, but the first geologic sketch map of the islands was published 27 years later by geologist Julius von Haast in 1868. The stratigraphy and descriptions of Robert Findlay Hay and his colleagues in 1970 were modified by George Grindley and others in 1977, to include radiometric dating and palaeomagnetic correlation of volcanic rocks and incorporating information derived from petroleum exploration data. Subsequently, several major New Zealand geological survey studies have been completed, such as Herzer and Wood in 1988 and Hamish Campbell and his geology colleagues in 1988 and 1993, who redescribed much of the geology of the Chatham Islands, while also updating geological maps and stratigraphic work on the islands. Concerted efforts by international teams of geologists and palaeontologists over the

Massive volcanic vents being studied by Prof. Emer. Ray Cas (Monash University), as part of a MSc research project completed by the late Leonor Sorrentino.

A land of many volcanoes, the Chathams have had a violent geologic past with punctuated episodes of volcanisms over many millions of years. Some of these volcanoes, such as Mount Dieffenbach (named after early explorer Ernst Dieffenbach), as shown here, along with other volcanic cones, persist through time, but will eventually be worn down from erosion.

Rocky puzzles do, indeed, confound… Jeff Stilwell pondering a large volcanic dyke cutting across the Takatika Grit at Tioriori. This dyke has not been recorded before on the Chathams, so has probably been covered in sand for many years before being exhumed.

A spectacular geologic puzzle at Waihere Bay, Pitt Island, characterised by strongly convolute bedding in volcaniclastic rocks of the Red Bluff Tuff, which sit disconformably on top of the Tupuangi Formation, which is the small, grey exposed unit at the base of the picture. Co-author (CM) for scale.

last 20 years to better understand the Chathams' role in the final break-up of Gondwana and the extraordinary biotic composition of its Cretaceous and Cenozoic assemblages (including the only known, recently discovered non-avian and avian dinosaurs in this part of the Pacific) and how they are related to coeval groups in the southern circum-Pacific, have greatly refined our knowledge of this poorly known region of the planet.