

Rock meets sea: geology at the cutting edge



Hawkdun Range, Otago

Hamish Campbell





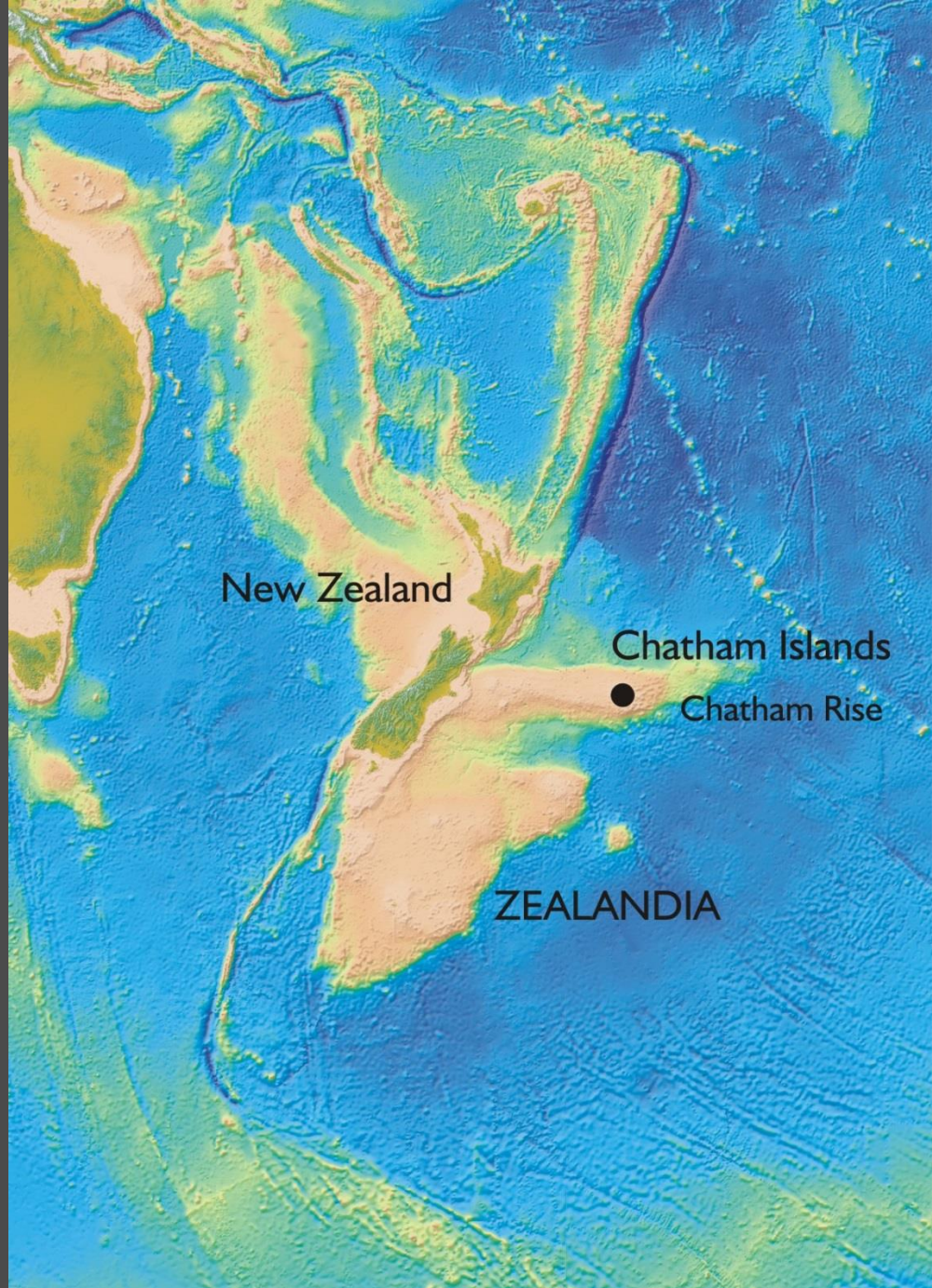
Central Chatham Island, looking to the south

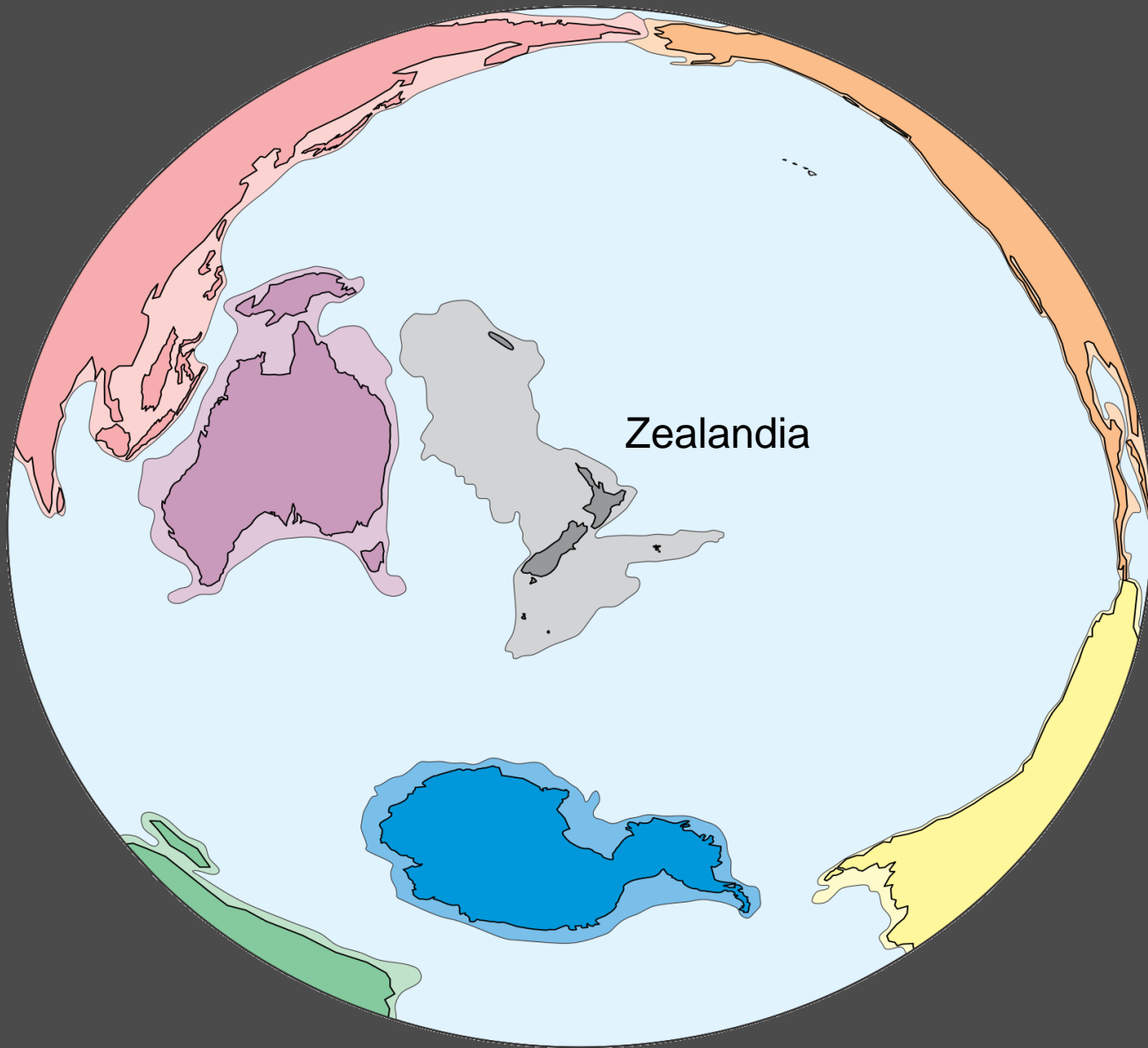
TALK OUTLINE

- Zealandia
- Sea level
- Tectonism

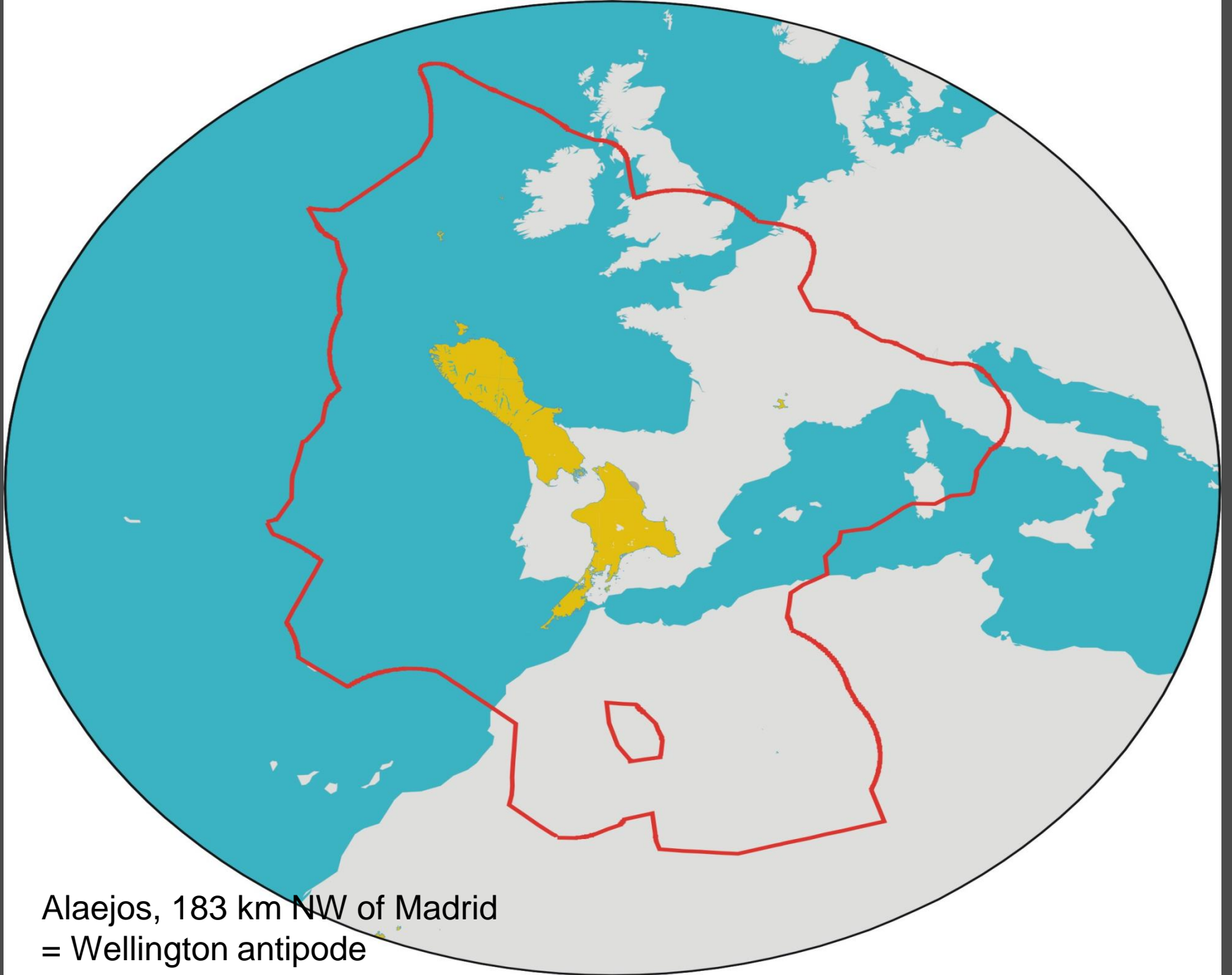
Bathymetric map
based on gravity

Vaughan Stagpoole
GNS Science
2002





Zealandia



Alaejos, 183 km NW of Madrid
= Wellington antipode

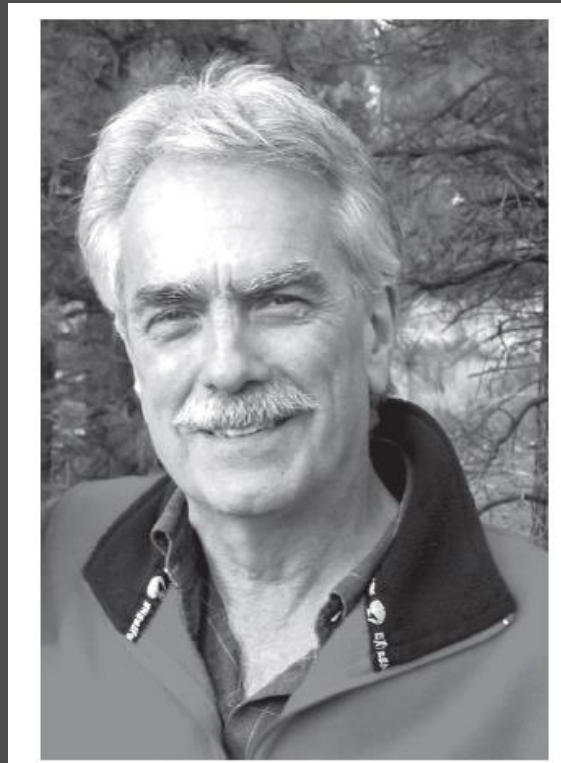
New Zealand

named after Zeeland Province, Netherlands
by Dutch cartography Johannes Blaeu (1648)

Australia to the Dutch was New Holland

Zealandia

named after New Zealand by
Bruce Luyendyk (1995)
University of California, Santa Barbara



Lector et emergo =
I struggle and I emerge

Mortimer et al. (2017) Zealandia: Earth's hidden continent. *GSA Today* 27: doi: 10.1130/GSATG321A.1

- Eight page open access paper in journal *GSA Today*; GSA press release 13 Feb
- in week after release, 16,000 news articles
- Potential audience of >900 million
- The most accessed GSA paper of all time (84,950 views to 22/3/17)

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Zealandia: Earth's Hidden Continent

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ABSTRACT

A 4.9 Mkm² region of the southwest Pacific Ocean is made up of continental crust. The region has elevated bathymetry relative to surrounding oceanic crust, diverse and silica-rich rocks, and relatively thick and low-velocity crustal structure. Its isolation from Australia and large area support its definition as a continent—Zealandia. Zealandia was formerly part of Gondwana. Today it is 94% submerged, mainly as a result of widespread Late Cretaceous crustal thinning preceding supercontinent breakup and consequent isostatic balance. The identification of Zealandia as a geological continent, rather than a collection of continental islands, fragments, and slices, more correctly represents the geology of this part of Earth. Zealandia provides a fresh context

in which to investigate processes of continental rifting, thinning, and breakup.

INTRODUCTION

Earth's surface is divided into two types of crust, continental and oceanic, and into 14 major tectonic plates (Fig. 1; Holmes, 1965; Bird, 2003). In combination, these divisions provide a powerful descriptive framework in which to understand and investigate Earth's history and processes. In the past 50 years there has been great emphasis and progress in measuring and modeling aspects of plate tectonics at various scales (e.g., Kearey et al., 2009). Simultaneously, there have been advances in our understanding of continental rifting, continent-ocean boundaries (COBs), and the discovery of a number of micro-

continental fragments that were stranded in the ocean basins during supercontinent breakups (e.g., Back, 1991; Lister et al., 1991; Gattin et al., 2003; Franke, 2013; Eagles et al., 2015). But what about the major continents (Fig. 1)? Continents are Earth's largest surficial solid objects, and it seems unlikely that a new one could ever be proposed.

The *Glossary of Geology* defines a continent as "one of the Earth's major land masses, including both dry land and continental shelves" (Neuendorf et al., 2005). It is generally agreed that continents have all the following attributes: (1) high elevation relative to regions floored by oceanic crust; (2) a broad range of siliceous igneous, metamorphic, and sedimentary rocks; (3) thicker crust and lower seismic velocity

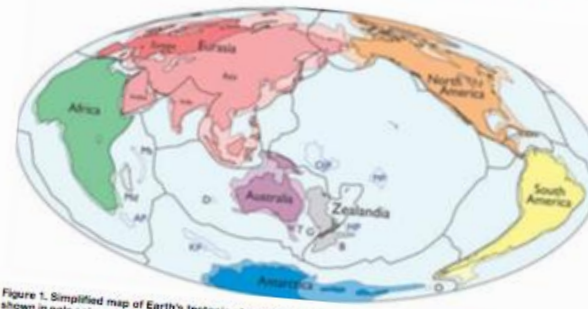


Figure 1. Simplified map of Earth's tectonic plates and continents, including Zealandia. Continental shelf areas shown in pale colors. Large igneous province (LIP) submarine plateaus shown by blue dashed lines: AP—Agulhas Plateau; KP—Kerguelen Plateau; OJP—Ontong Java Plateau; MP—Manihiki Plateau; HP—Hikurangi Plateau. Selected microcontinents and continental fragments shown by black dotted lines: Md—Madagascar; Mi—Mauritia; D—Guilford Drak; T—East Tasman; G—Gibbert; B—Bollons; O—South Orkney. Hammer equal area projection.

GSA Today, v. 27, doi: 10.1130/GSATG321A.1

February 2017

Zealandia

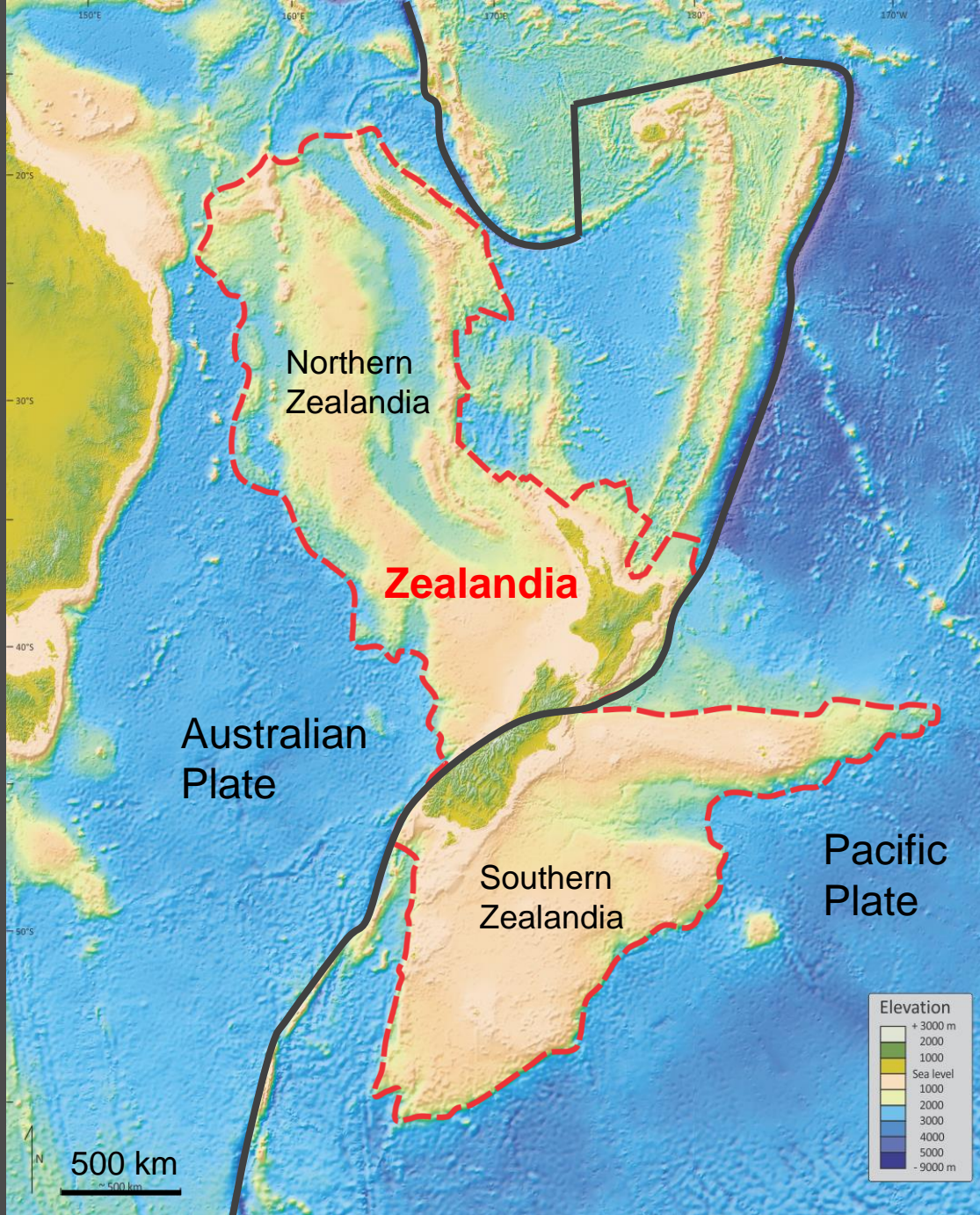
*Earth's
most submerged,
thinnest,
smallest,
freshest
7th continent*

*But not the
youngest...
Australia and
Antarctica are*



Zealandia

and the modern
plate boundary



ZEALANDIA

- high but 94% submerged
- continental geology
- 20-35 km thick crust
- 4.9 M km² in area
- surrounded by oceanic crust

Mortimer & Campbell 2014
Zealandia: our continent revealed.
Penguin, Auckland. 271 pp.

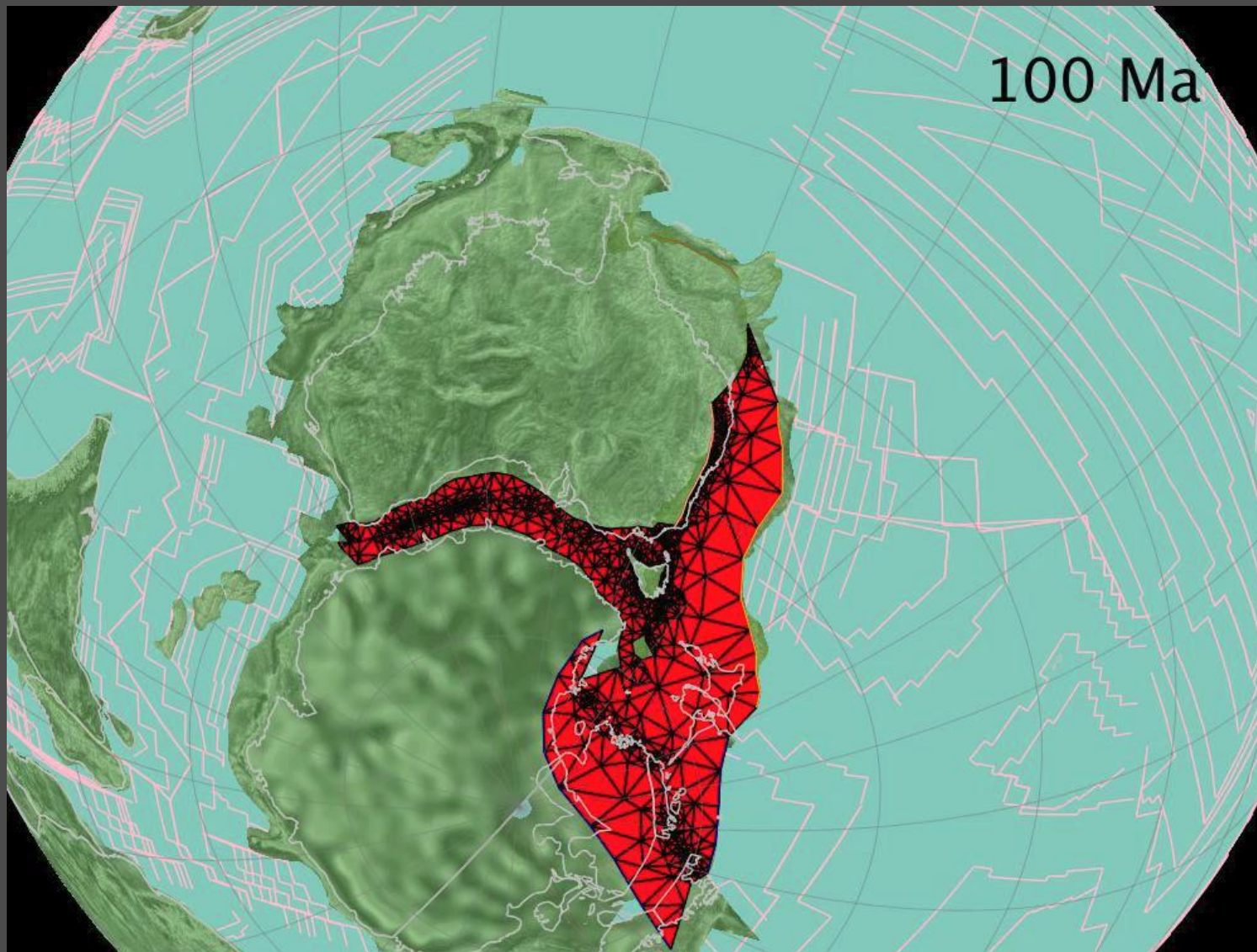
Mortimer et al. *GSA Today* 2017





- Continental crust
- Oceanic crust
- Plate boundaries



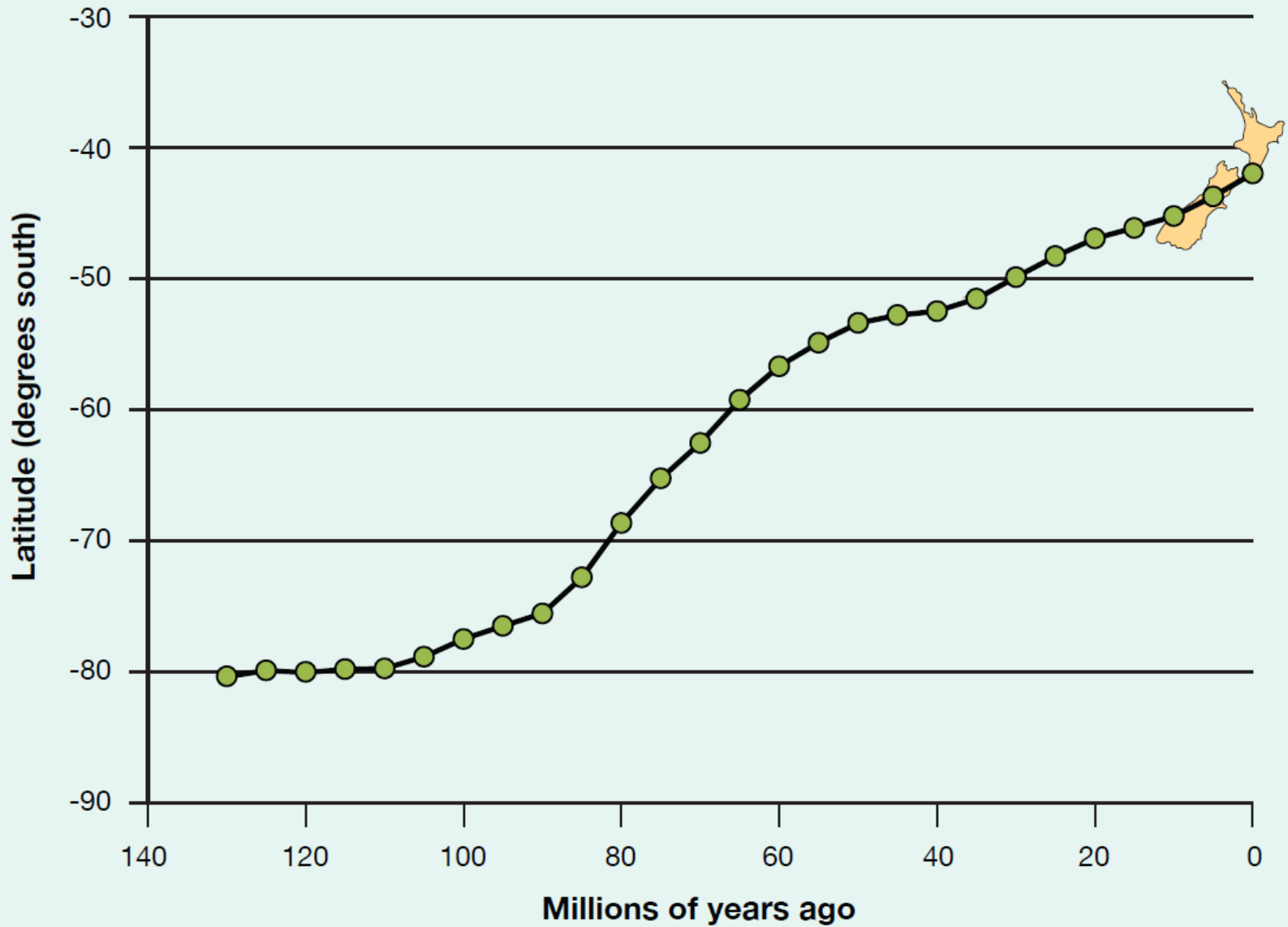


100 Ma

Rigid continent

Plastically deforming continent

Oceanic crust



The northward travel of Zealandia and New Zealand through time

20,000 years ago

Last glaciation

Sea level:
125 m lower

Average surface
temperature:
5° C below




Wanganui Basin

Cook Strait


Marlborough Sounds

'lithospheric sag'



An aerial photograph of the Marlborough Sounds in New Zealand's South Island. The image shows a vast expanse of turquoise water filled with numerous islands and fjord-like inlets. The land is covered in dense green forest, with some areas appearing more rugged and brownish. The perspective is from an elevated position, looking down and across the water towards the horizon.

Marlborough Sounds, South Island



Wairarapa Fault

Cape Turakirae
Cook Strait

looking NW

Wairarapa Fault

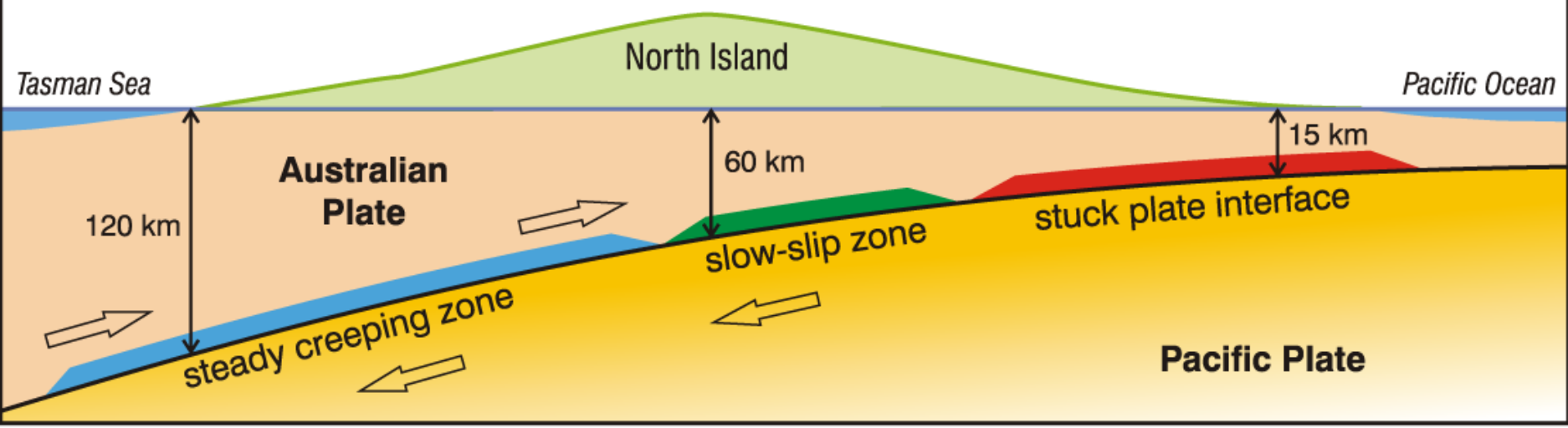
Turakirae Head: a record of four earthquakes

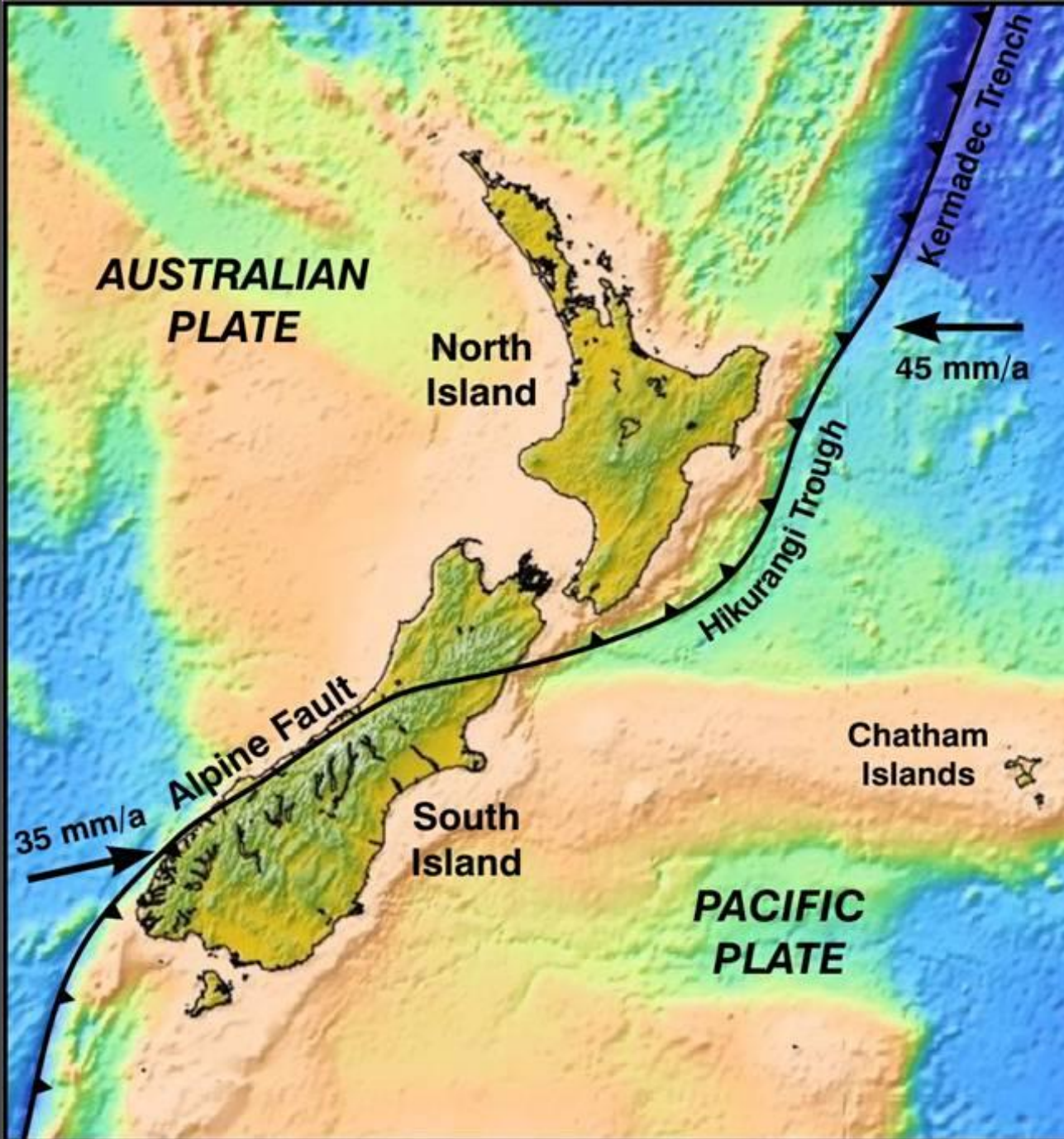
- Events:
 - 1855
 - 2110 – 2300 years BP
 - 4840 – 5210 years BP
 - 6610 – 6920 years BP
- Recurrence:
c. 2,200 years BP
- Plus, older uplifted marine benches (e.g. 125 ka bench)



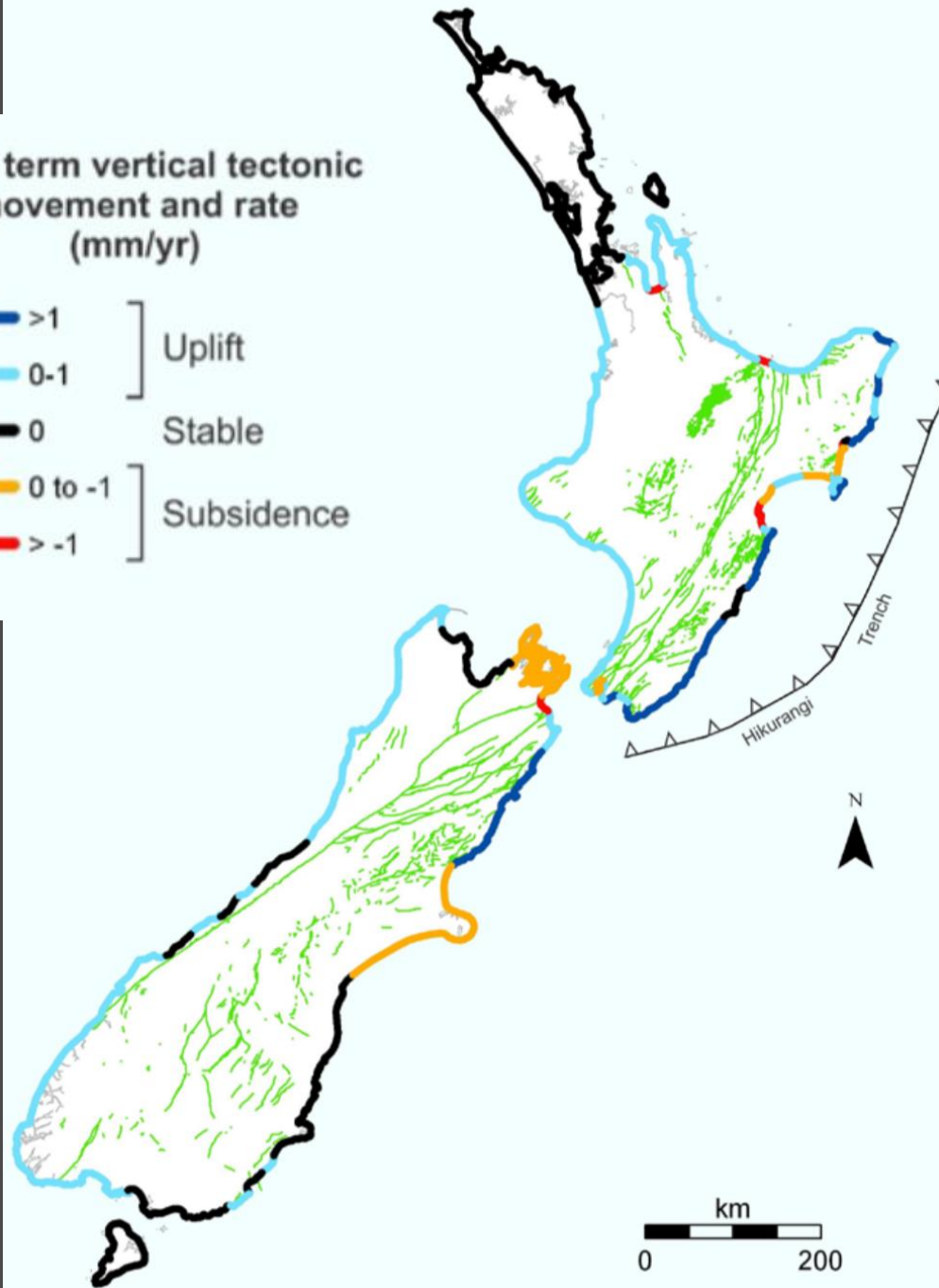
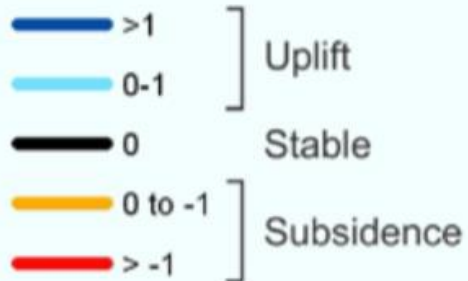


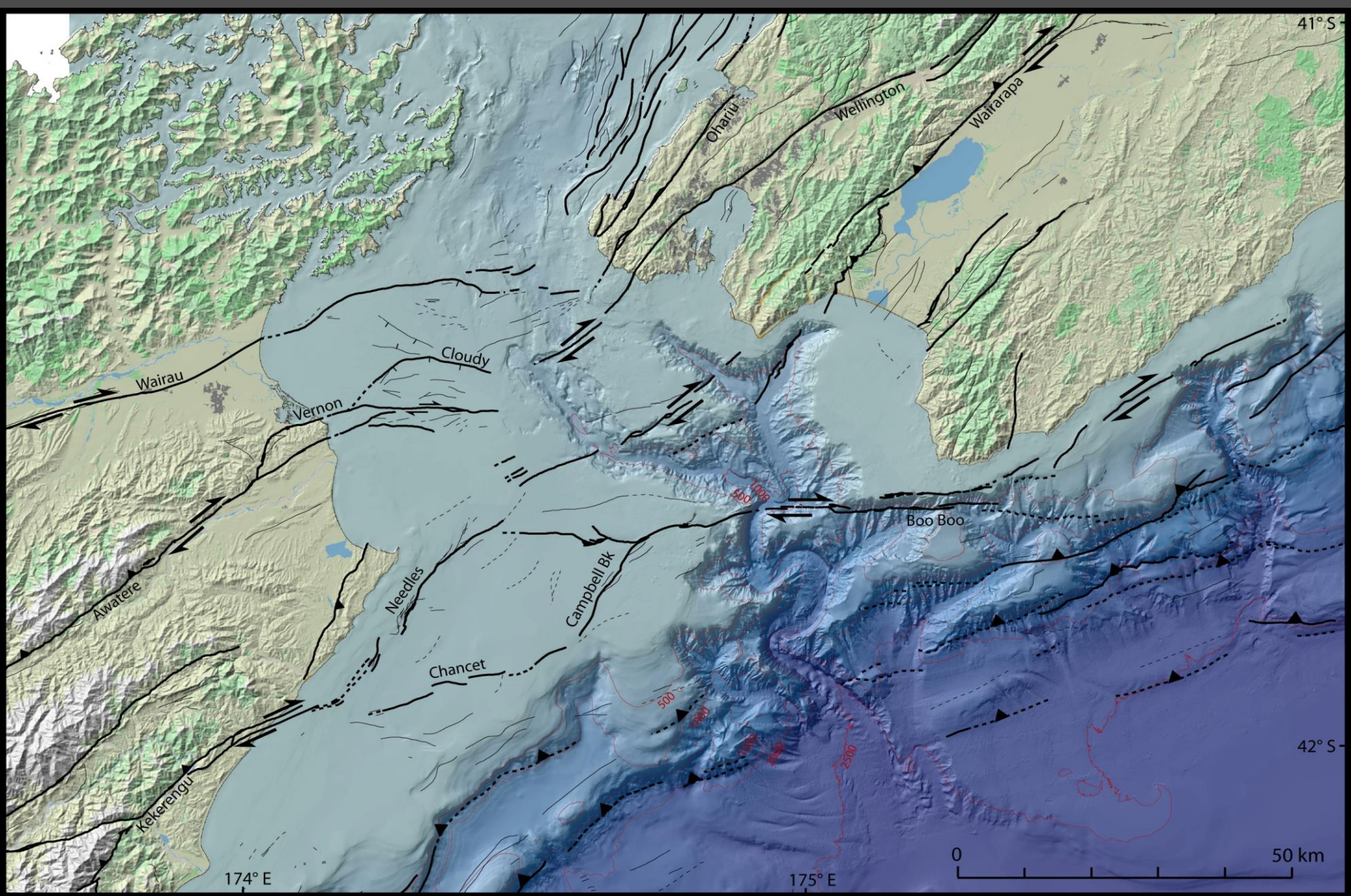
Schematic of North Island and plate interface viewed from Cook Strait





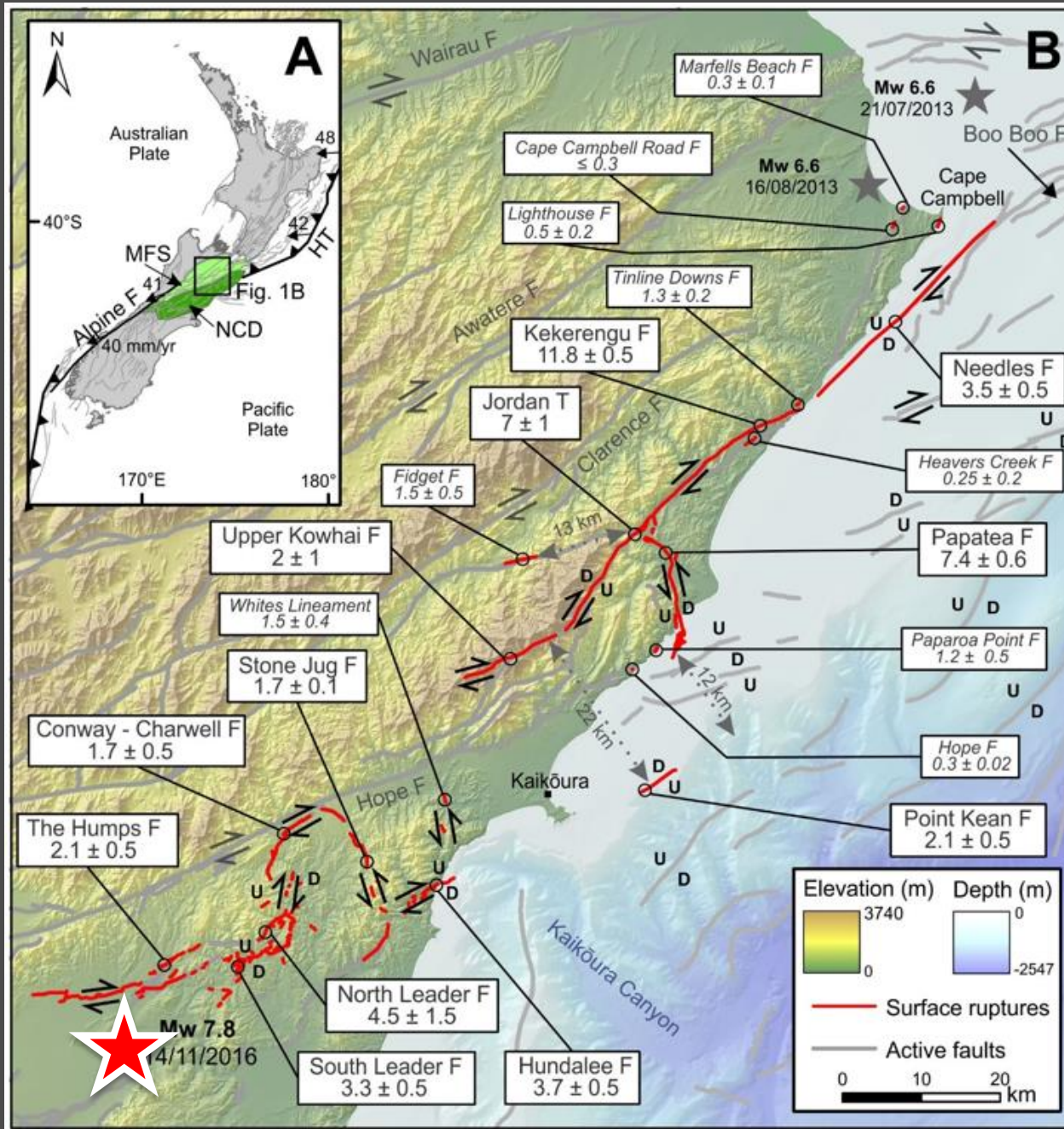
Long term vertical tectonic
movement and rate
(mm/yr)





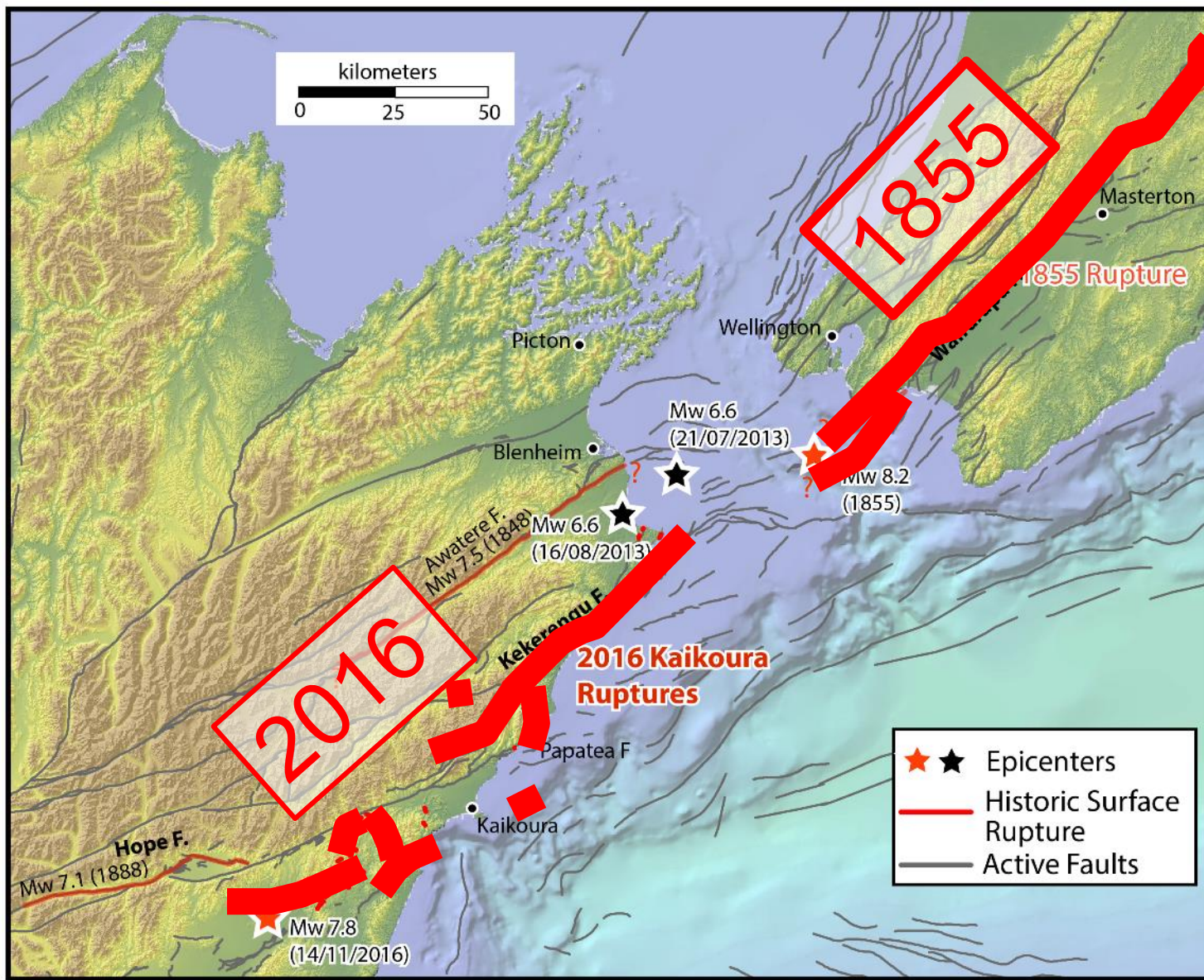
Pondard and Barnes, JGR, 2010

Kaikōura Earthquake Surface Fault Rupture



- About two-dozen major and minor faults ruptured the ground surface
- With differing
 - orientations
 - senses of slip
 - slip rates
 - recurrence intervals

The 1855 and 2016 ruptures share some characteristics



1. Both face each other along strike on opposite sides of Cook Strait
2. Both have unusually large slips (two of the top 4 or 5 known single event displacements globally)
3. Both also have large slip/length ratios
4. Both are non-vertical, dipping, dextral-reverse fault planes

Papatea Fault



South to North...

*From Langridge et al, (GeoSciences
2016)*

Papatea Fault: At the coast



Photo: Tim Little



Photo: Will Ries

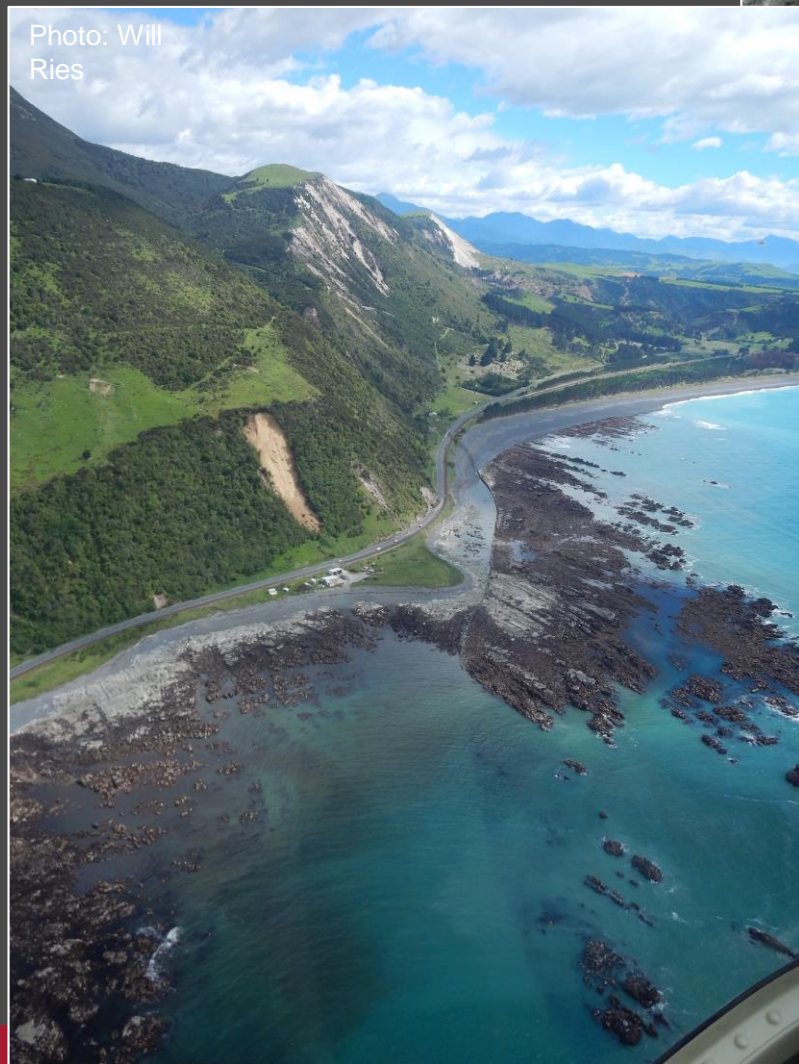


Photo: Will Ries

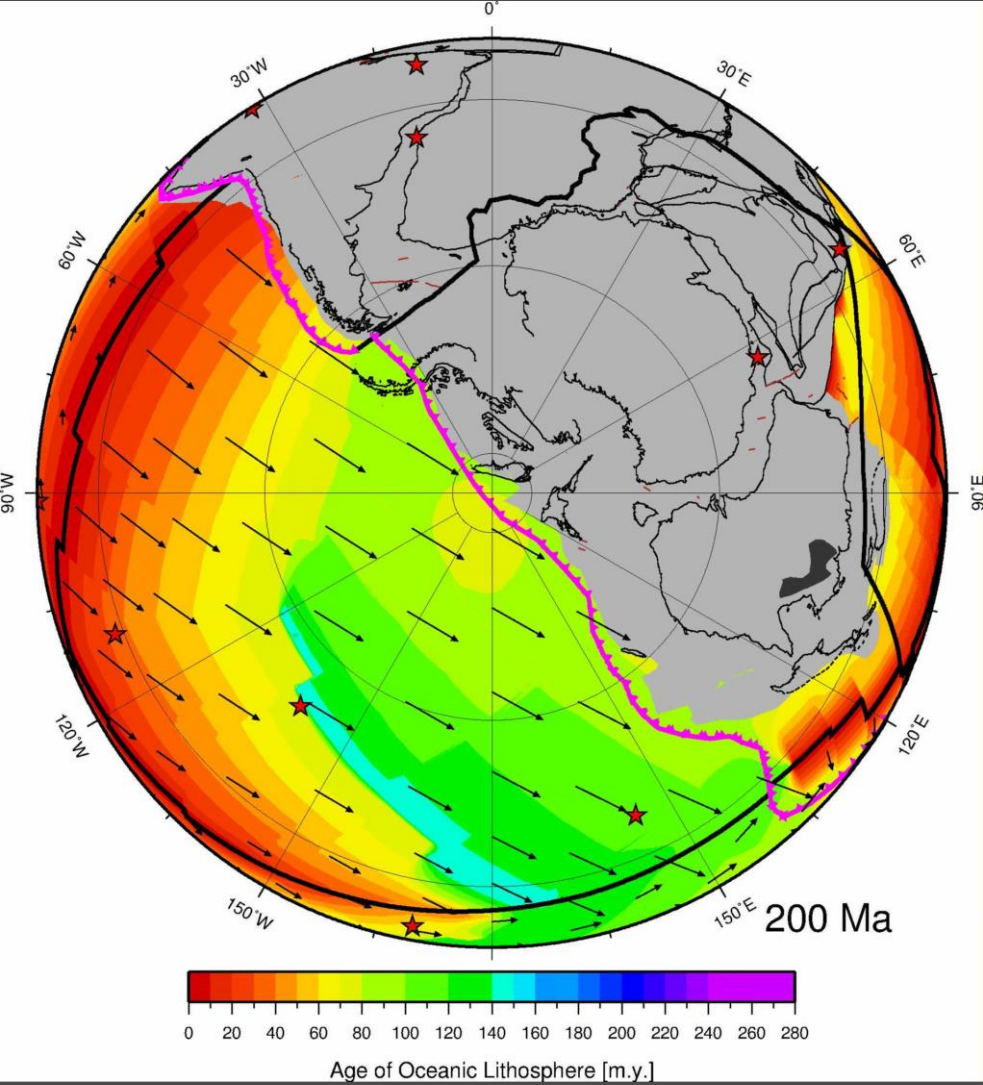


Papatea Fault









Continental geology

- Granite, diorite, gabbro
- Greywacke, schist

Zealandia

