Assessing New Zealand's Petroleum Endowment: The Atlas of Petroleum Prospectivity*

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Search and Discovery Article #30434 (2015)**
Posted December 14, 2015

*Adapted from oral presentation given at AAPG/SEG International Conference & Exhibition, Melbourne, Australia, September 13-16, 2015

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Abstract

Where, in New Zealand's extensive offshore territory (Zealandia), does the geological evidence indicate that new petroleum fields are likely to be discovered, and which of New Zealand's numerous offshore sedimentary basins will host the next commercial discovery? A recently-initiated 4-year Government-funded research programme at GNS Science aims to address these questions by providing readily accessible digital maps in GIS format (with associated metadata) of potential subsurface petroleum habitats to aid conceptual development of exploration targets. The "Atlas of Petroleum Prospectivity" (APP) programme will synthesise the wealth of existing and new data, information, and knowledge within GNS Science and other open-file sources, to produce a nationally-significant baseline reference dataset that summarises in one place, for the first time, the current understanding of our geologically complex offshore petroleum basins. It will provide a consistent template for evaluating petroleum prospectivity within and between basins across Zealandia. It will also provide a basis for promulgation and technical administration of exploration permits and for identifying where new geoscience data and interpretations are required to better demonstrate petroleum potential. The APP will deliver a series of digital maps of all key petroleum systems elements in NZs offshore sedimentary basins. Map layers will include total sediment thickness, paleogeography, basement lithology, source and reservoir rock distribution, source rock maturity, heat flow, structure, trap distribution, and other salient information. We are adopting a "common risk segment" approach to delineate exploration play fairways, evaluate areas of highest prospectivity, and identify areas with poor data control or availability. Petroleum systems in each basin will be evaluated and calibrated with respect to previous exploration drilling successes and failures. The APP will provide a basis for developing new exploration concepts and strategies in the increasingly sophisticated search for new petroleum reserves. Compilation and assessment of the NW basins (Taranaki-Northland-Reinga) is well underway, and compilation and mapping of the SE (Great South-Canterbury) and eastern basins (Pegasus-East Coast-Raukumara) has commenced. Basins of the "far frontiers" will be progressively assessed in coming years. Programme outputs will be released via a web-server (e.g., GNS Science's Petroleum Basin Explorer) and data packs.

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Department of Petroleum Geoscience

GNS SCIENCE TE PŪ AO

150 YEARS of SCIENCE

For a better New Zealand

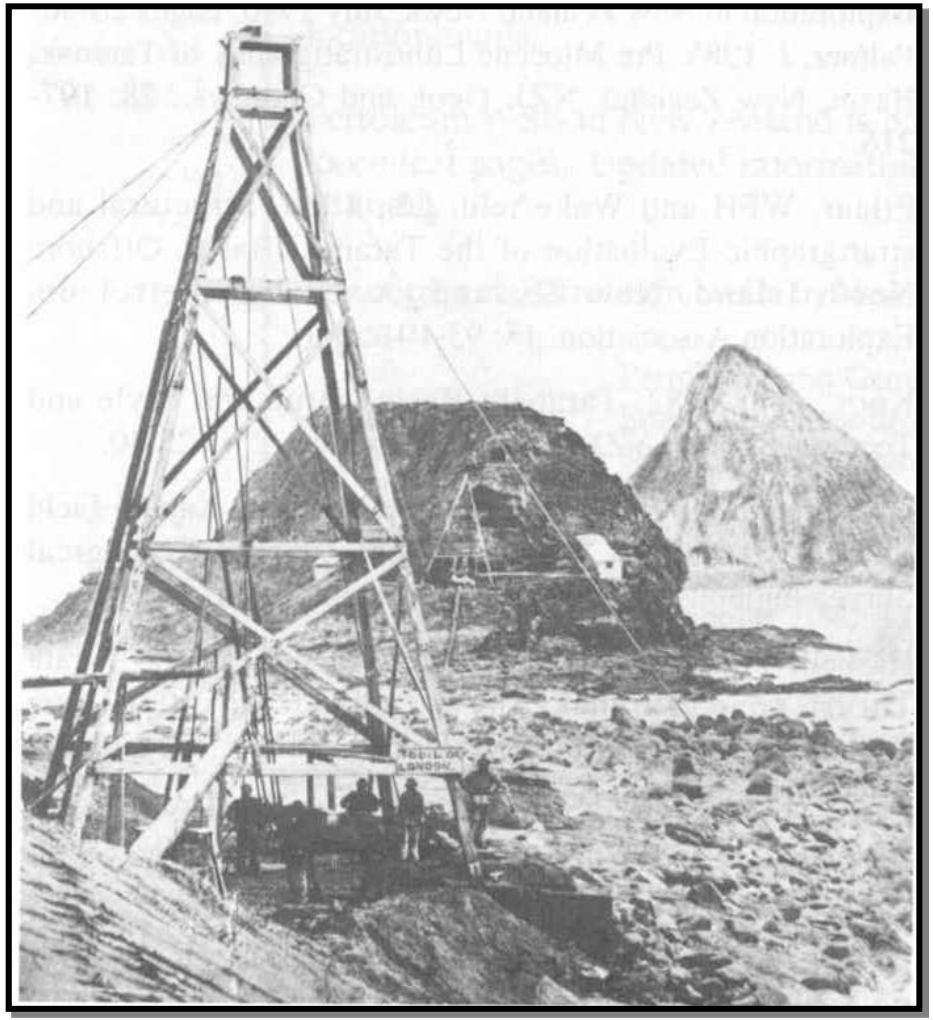
Acknowledgements

This work programme is funded by the New Zealand Government, through the Ministry of Innovation, Business and Employment's (MBIE) Energy and Minerals targeted research fund. Contract C05X1406 to GNS Science.

This work is also supported by the Petroleum Basins Research Programme via Direct Crown Funding from the New Zealand Government (MBIE).

This year marks 150 years of geological discovery in NZ

The NZ Geological Survey was primarily established for mineral exploration (e.g. gold, coal, oil)

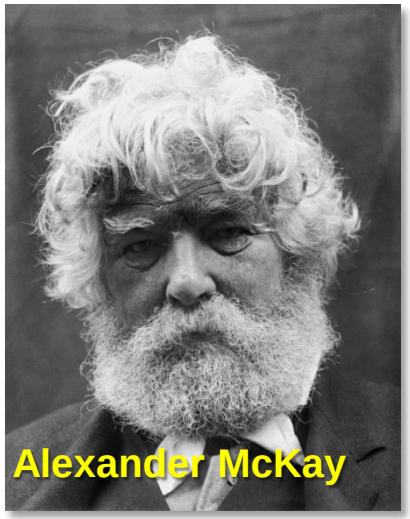


Petroleum exploration in NZ is not new

- Early settlers noted oil seeps on the beach near Moturoa, New Plymouth
- “Alpha” well drilled in 1865
- Total depth was 55 m
- British Empire’s first oil well
- 2 bopd (for a while…)
- Moturoa produced 250,000 barrels oil between 1914–1970

The large-scale onshore mapping of NZ is complete

Many significant discoveries have been made


Alexander McKay


Hartley Ferrar


Sir James Hector


The QMap programme team

We’re on top of New Zealand’s onshore geology…

…now we're looking to map the nation's offshore realm…

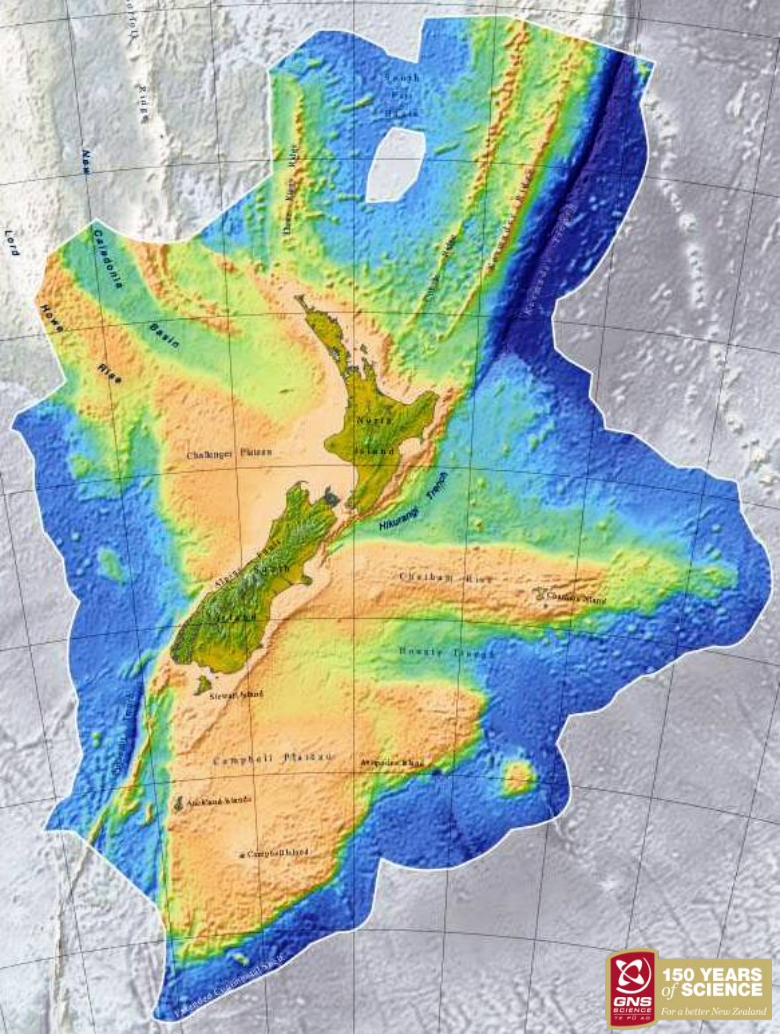
Castle Point, eastern North Island

…beyond Taranaki

We now know that New Zealand is the largest emergent part of "Earth's 8th continent"

"*Zealandia*"

About 96% of NZ lies beneath the waves

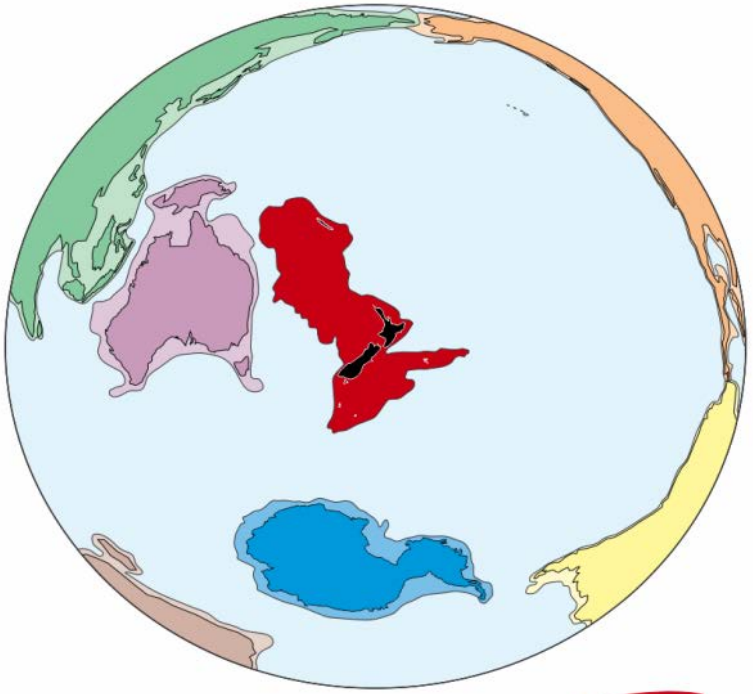


New Zealand's Extended Continental Shelf

UNCLOS: United Nations Convention on the Law of the Sea

NZ has a vast offshore territory, ~5,800,000 km^2

Only 4% of New Zealand is above sea level



Discover

Zealandia

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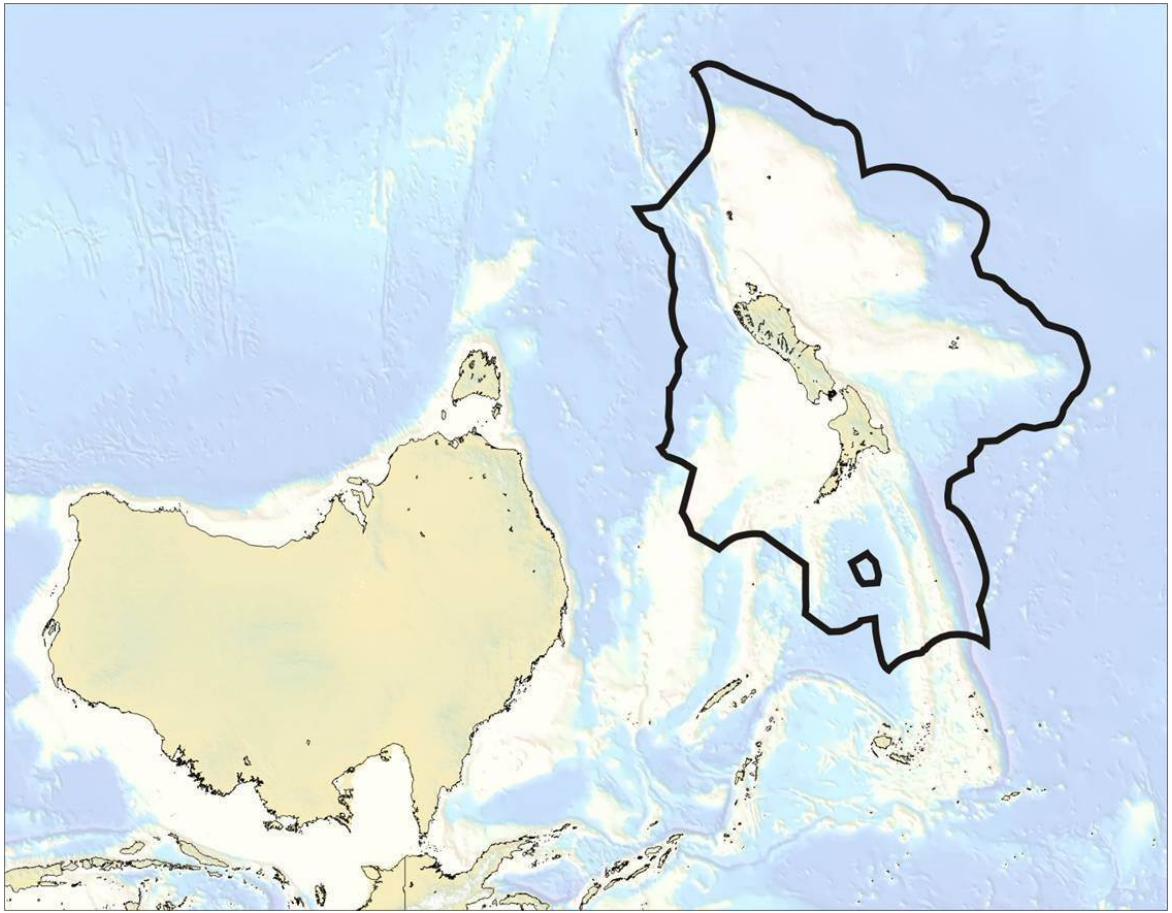
It’s time to Discover Zealandia

Map & understand Earth’s 8th continent

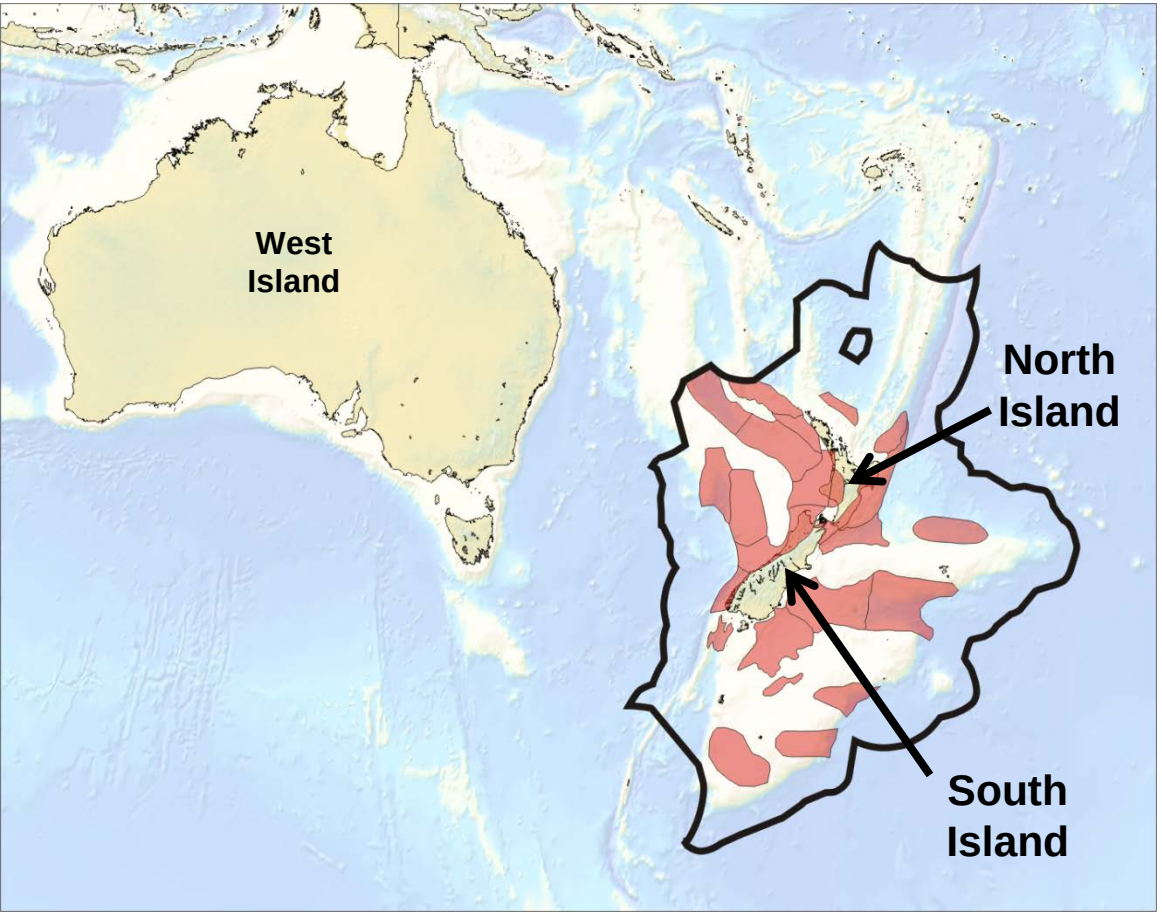
Map & understand NZ’s vast offshore realm

We’re changing the way we think about NZ

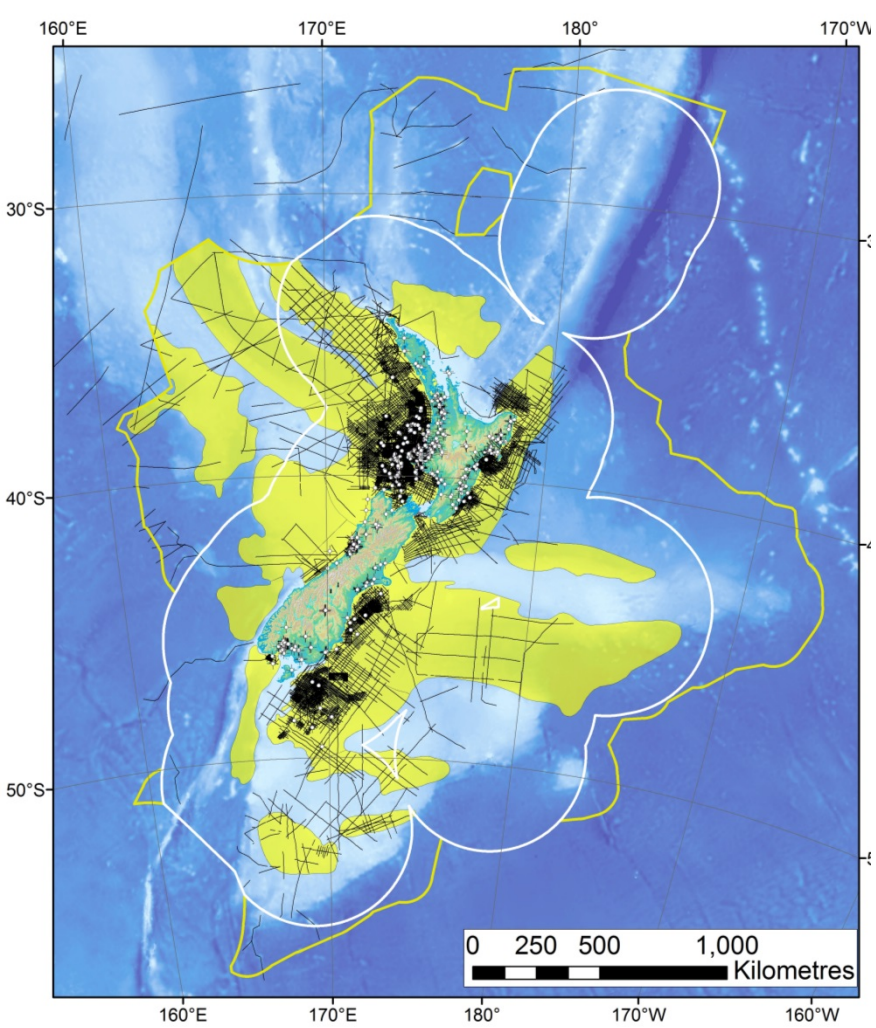


- New Zealand is a large country
- New Zealand covers 79% of the land area of Australia
- Equal to the European Union, the North Sea and some of the Mediterranean

NZ's sedimentary basins cover ~1,700,000 km^2



- The basins are almost all offshore
- Most are well away from the modern plate boundary
- There are likely to be sedimentary basins not yet discovered



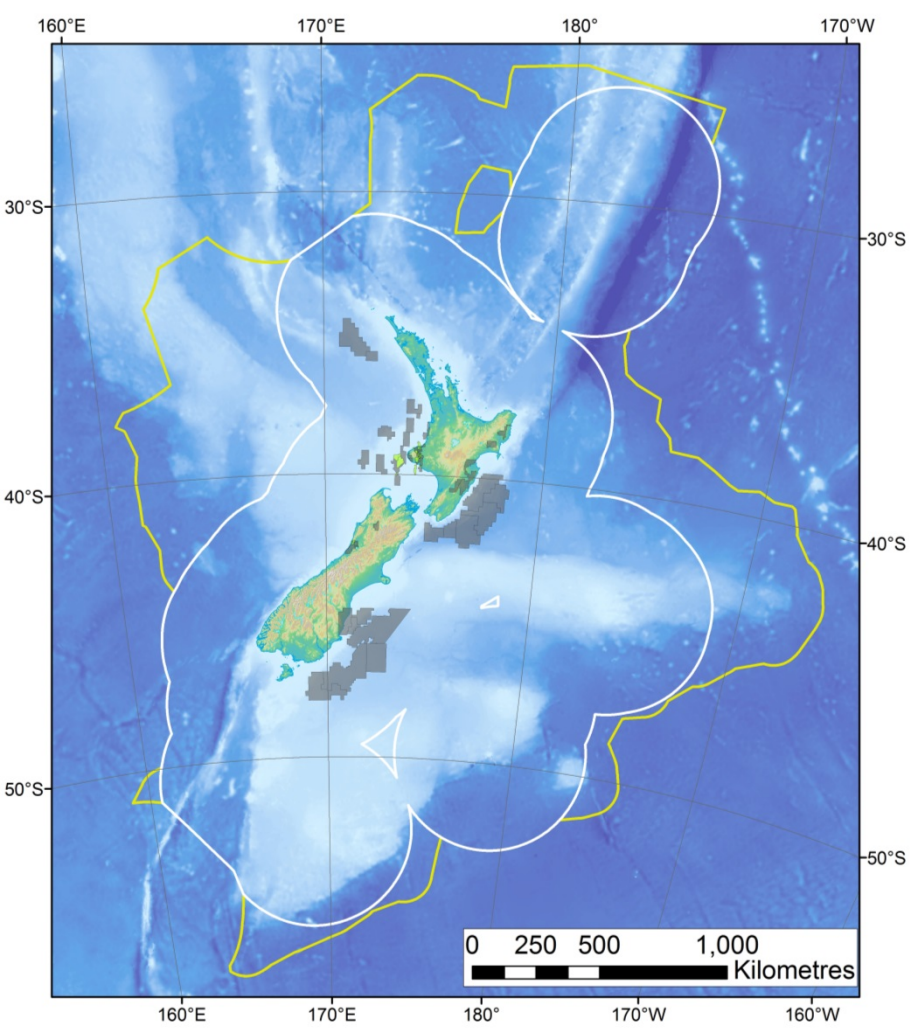
New Zealand's sedimentary basins

Cover a large part of our EEZ and ECS

Mapped from gravity surveys and marine seismic

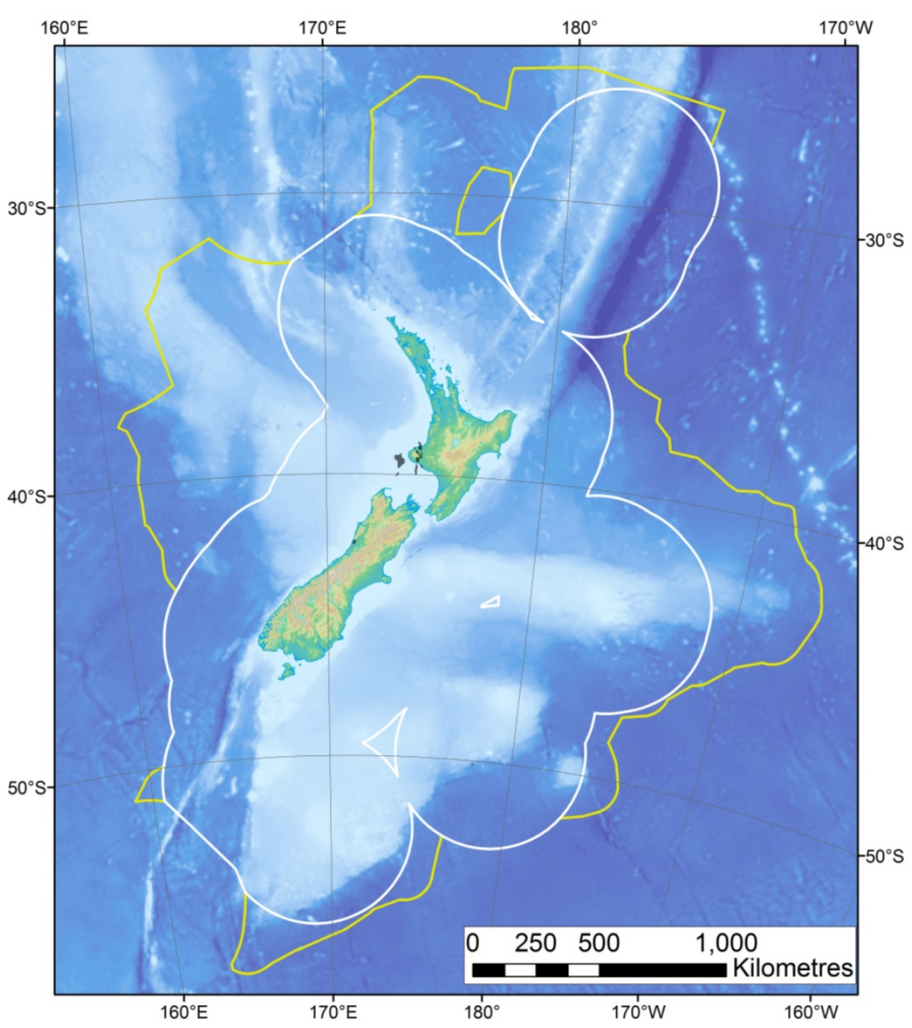
We have a reasonable knowledge base – but it's incomplete

Only parts of these basins have sedimentary fill thick enough to have generated oil and gas



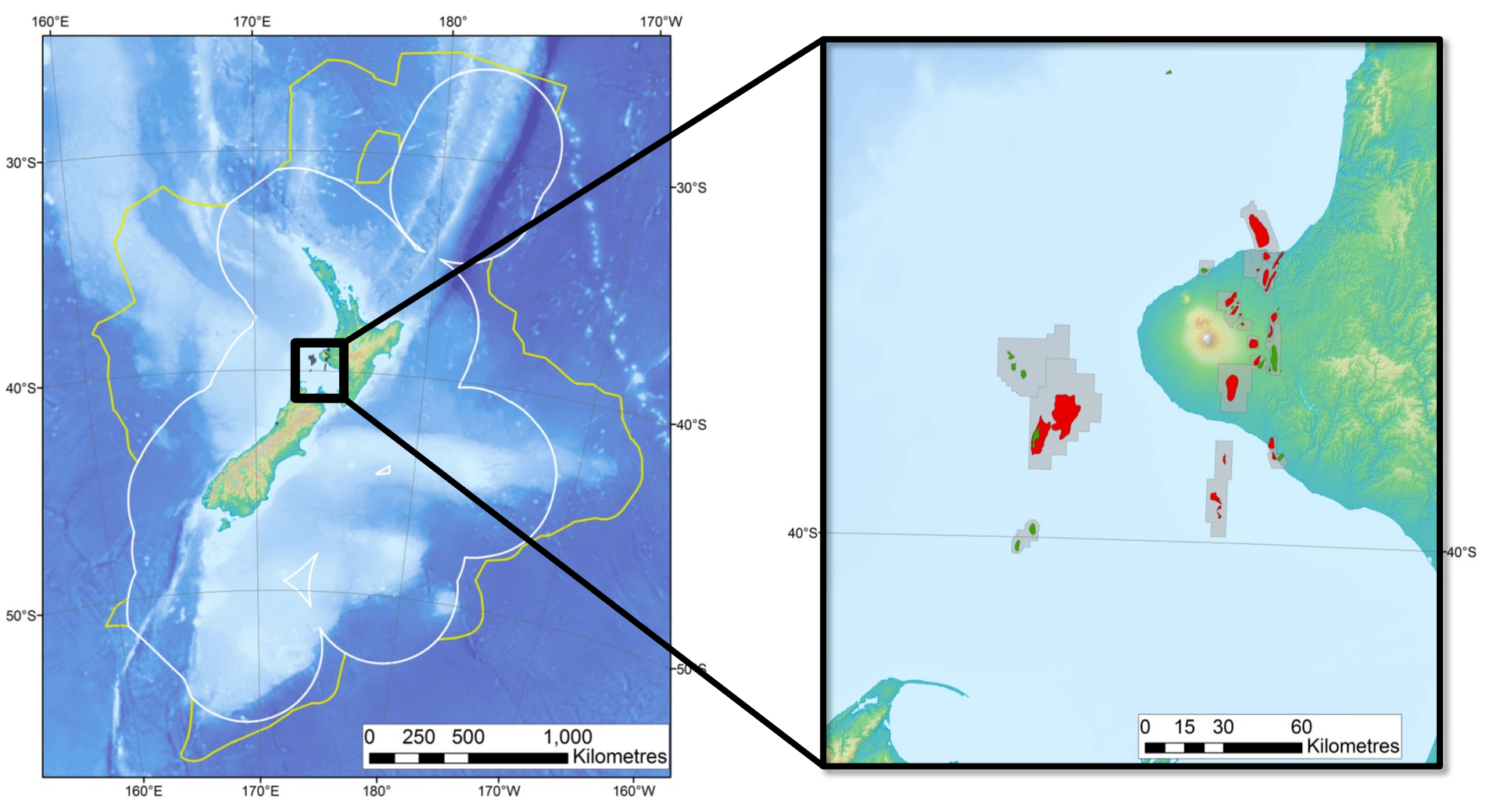
New Zealand petroleum permits

Grey boxes cover all of NZ's current exploration permits



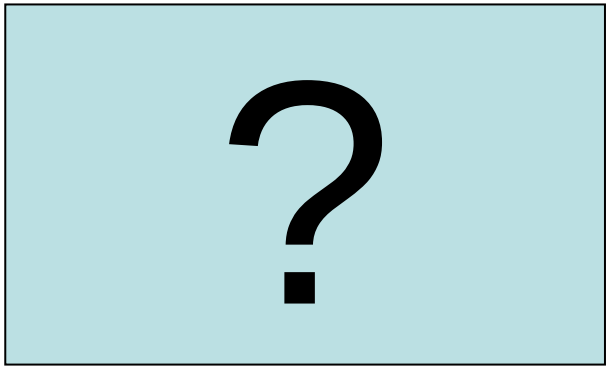
New Zealand petroleum permits

- Grey boxes cover ALL of NZ's production and reserves
- New Zealand's discovered petroleum fields cover ~440 km^2
- *c.f.* NZ's offshore basins cover ~1,700,000 km^2


160°E
170°E
180°
170°W
30°S
40°S
50°S
0 250 500 1,000
Kilometres
0 15 30 60
Kilometres

The big unknown

1. **At least 300,000 km^2 of NZ's territory has Cretaceous–Cenozoic sedimentary rocks buried deeply enough (>4000 m) to have generated oil and gas, e.g.:**
   - **Taranaki > 50,000 km^2**
   - **Reinga/Northland > 40,000 km^2**
   - **East Coast >> 30,000 km^2**
   - **Great South Basin > 40,000 km^2**



2. **Is eastern Taranaki the only area where oil and gas have been generated and trapped in commercial quantities?**
3. **Or are there commercial quantities of oil and gas still to be discovered in other basins?**

Atlas of Petroleum Prospectivity — APP

- Government-funded (MBIE) contestable, targeted research fund
- $0.5M per year
- Four years duration (October 2014–October 2018)
- Will cover all offshore basins in NZ’s EEZ and ECS
- **Working in association with our Direct Crown-Funded Petroleum Basins Research (PBR) & EEZ programmes**

Aims

- To produce a GIS-based digital atlas summarising the prospectivity of NZ's offshore basins

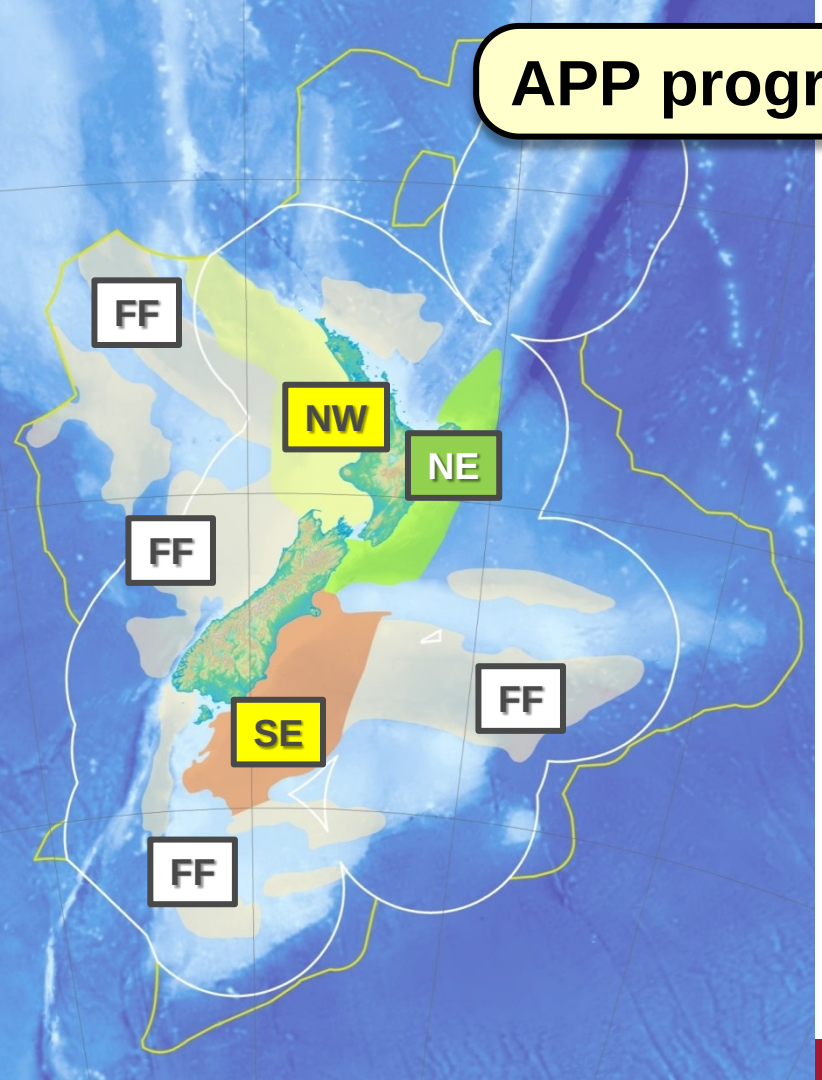
- Assess all elements of a petroleum system, including play concepts **…but at regional scale**

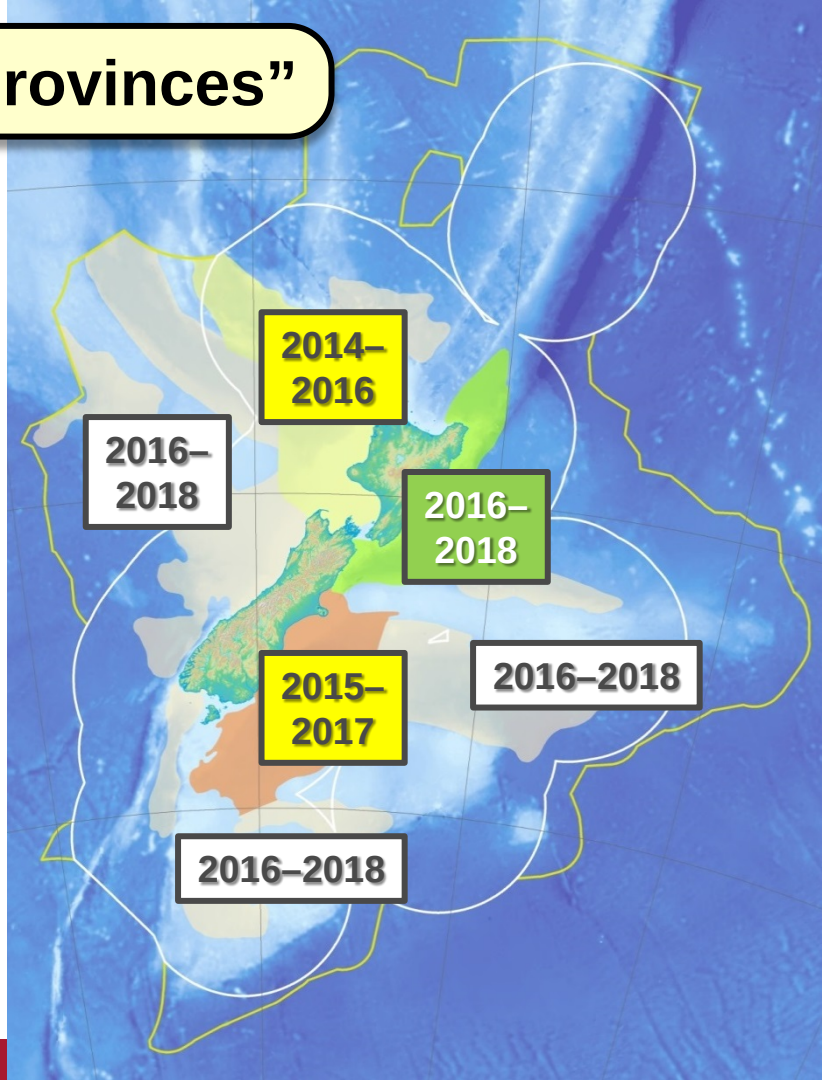
- Bring together many disparate data sets

- Delivery via the web and datapacks

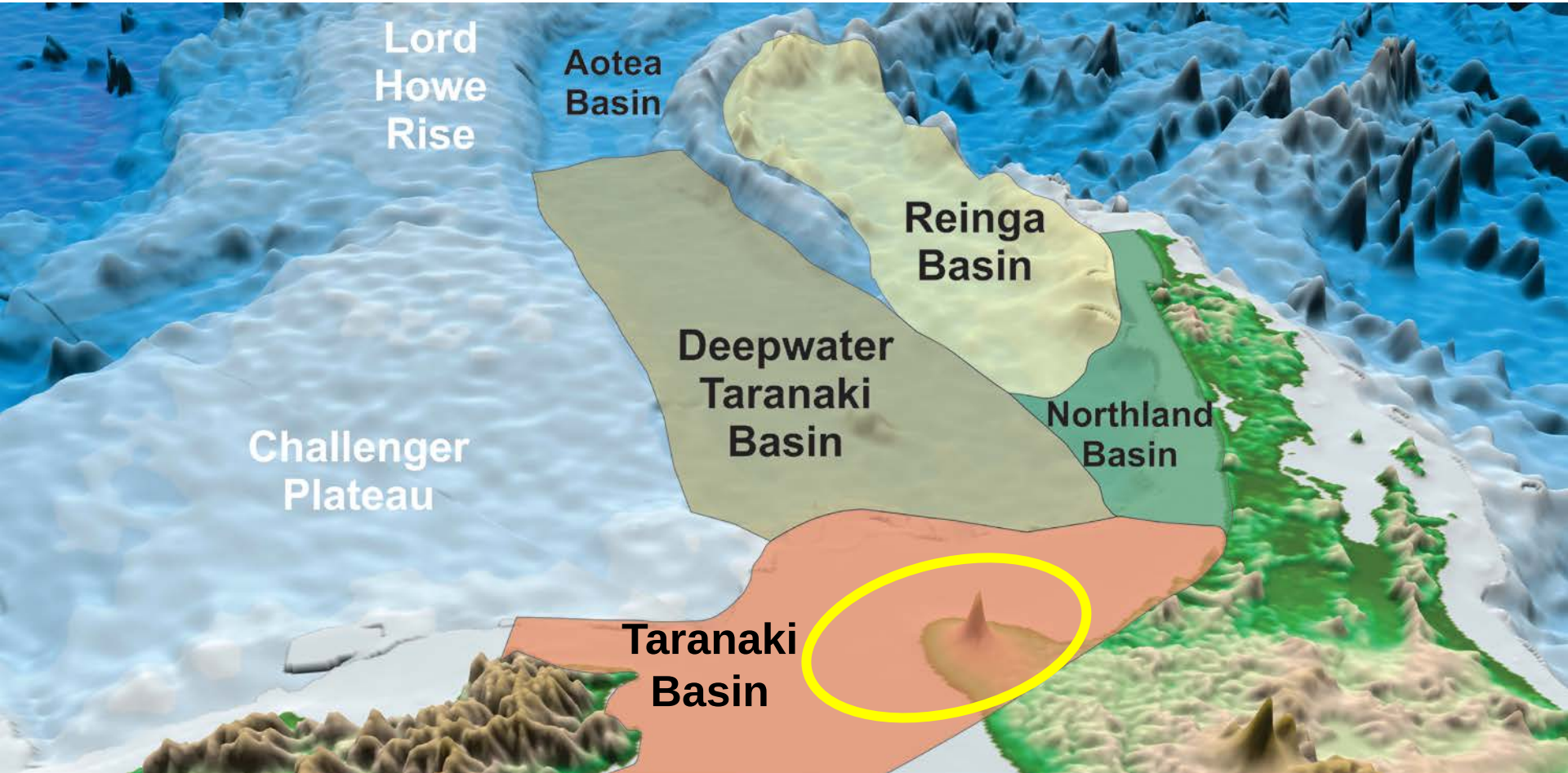
- Highlight areas where data and knowledge are lacking

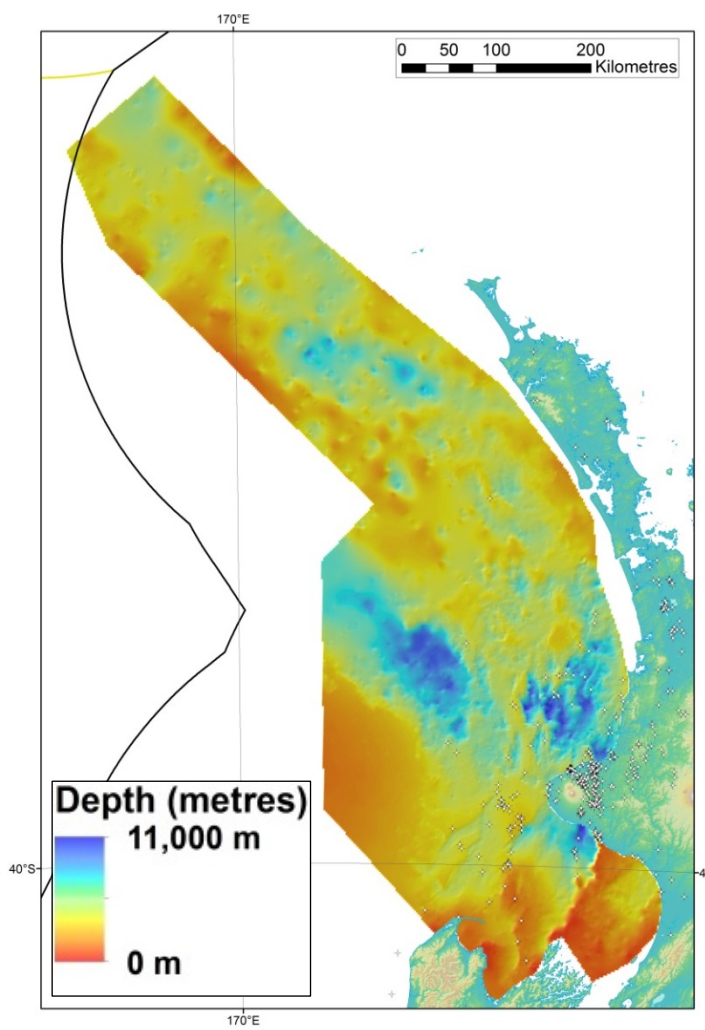
APP programme “provinces”





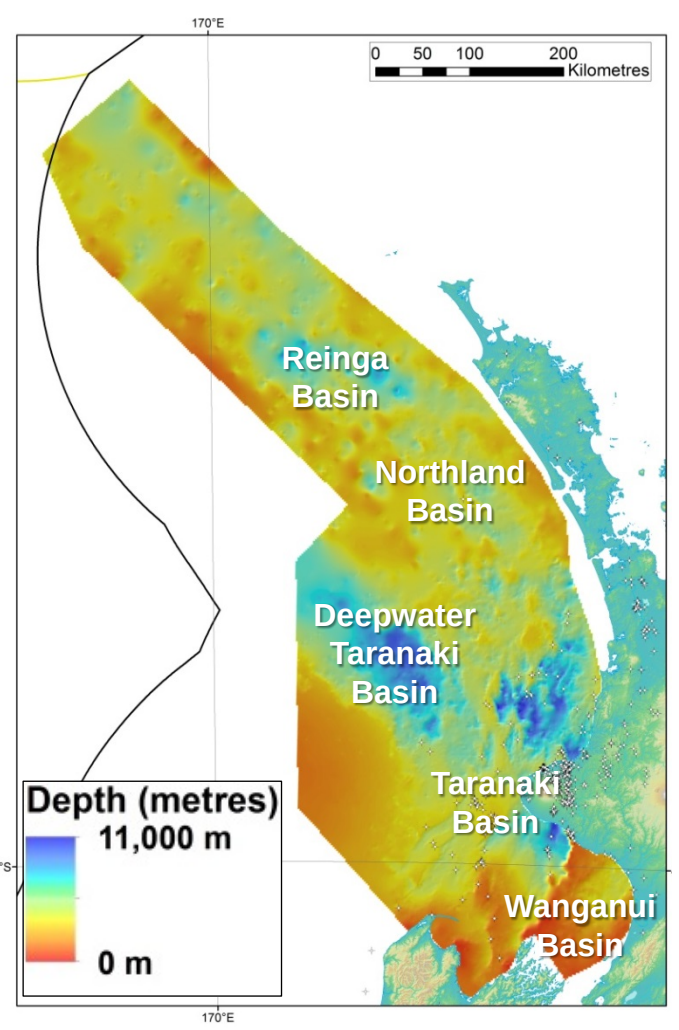
The prospective basins of the NW province

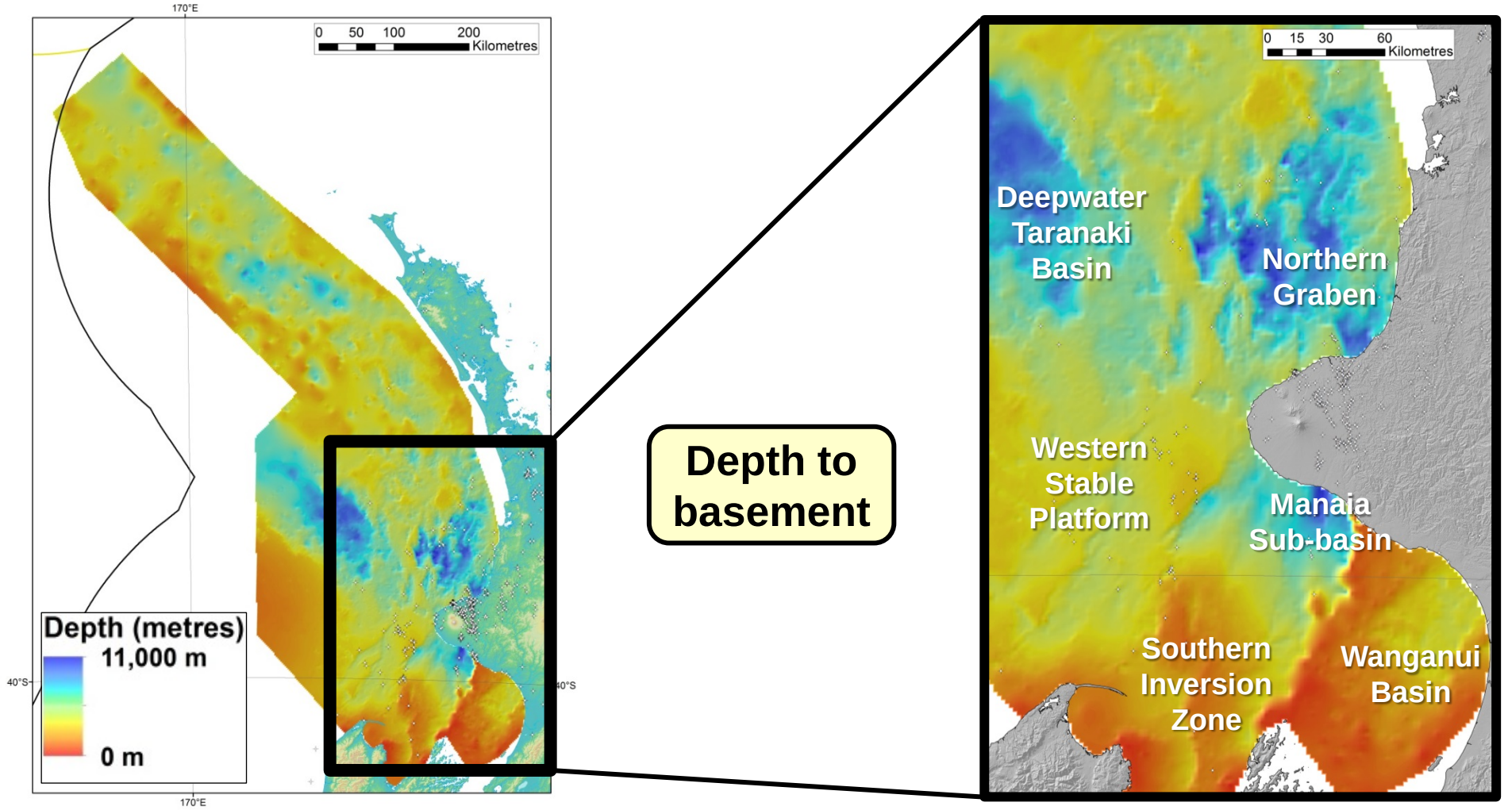


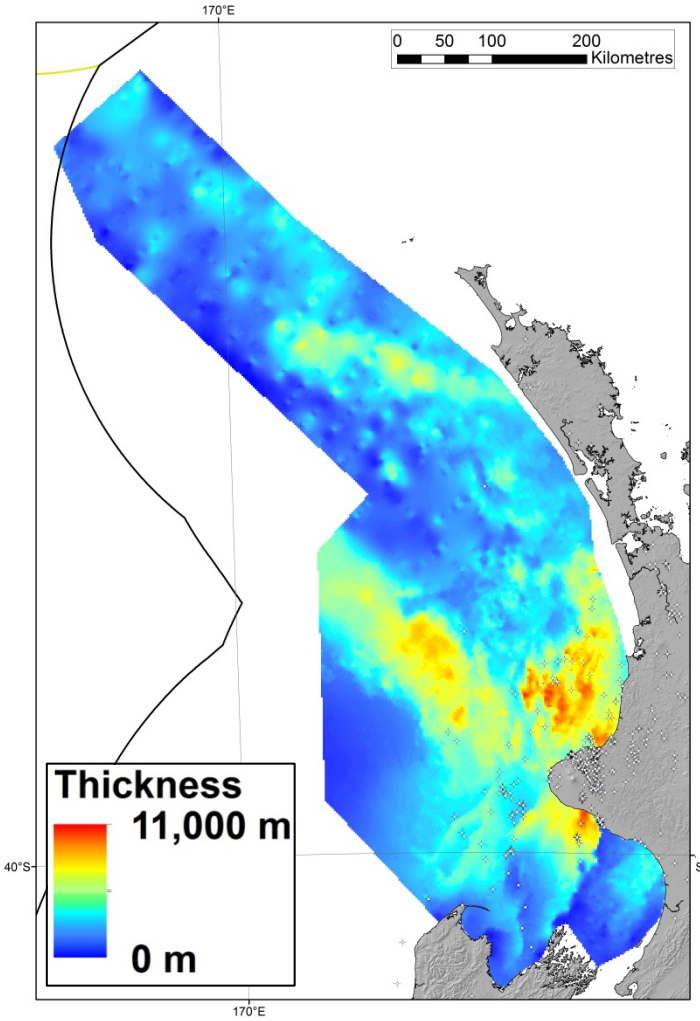


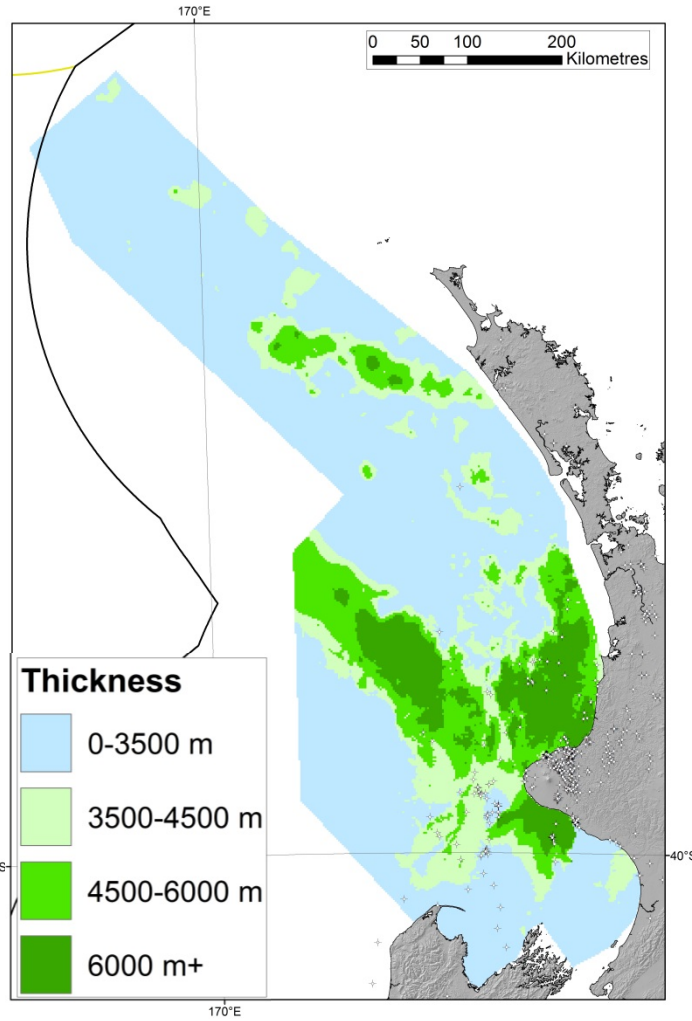
Depth to basement: the first integrated map for all the NW basins

- Depths up to ~11 km
- The basins are contiguous
- Several depocentres are revealed



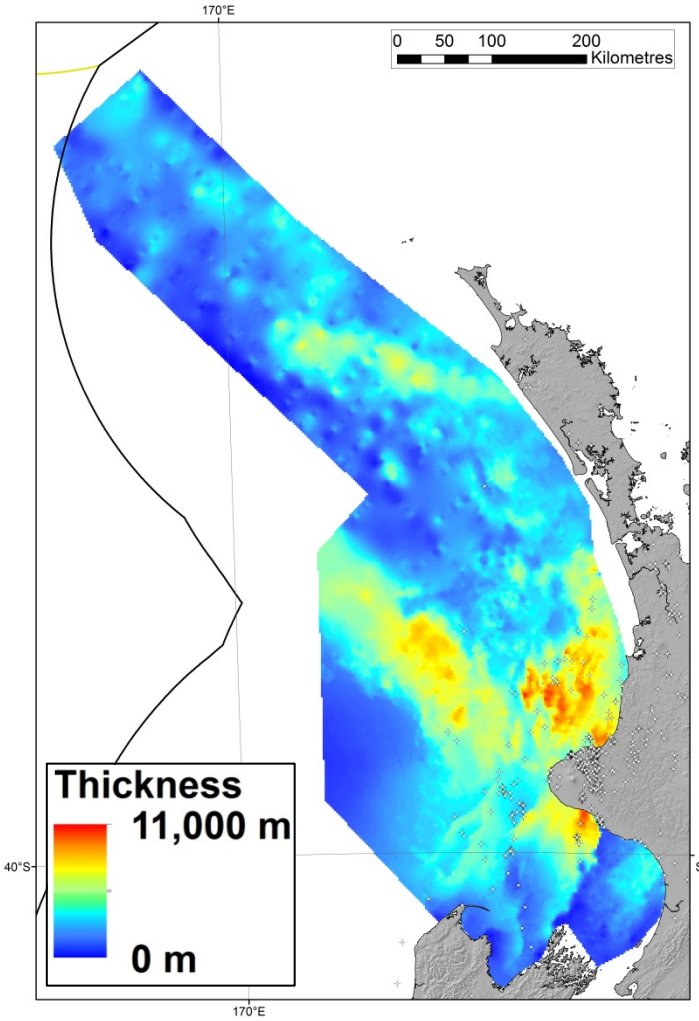

170°E
0 50 100 200 Kilometres
Depth (metres)
11,000 m
0 m
40°S
170°E
Depth to basement
0 15 30 60 Kilometres
Deepwater Taranaki Basin
Northern Graben
Western Stable Platform
Manaia Sub-basin
Southern Inversion Zone
Wanganui Basin

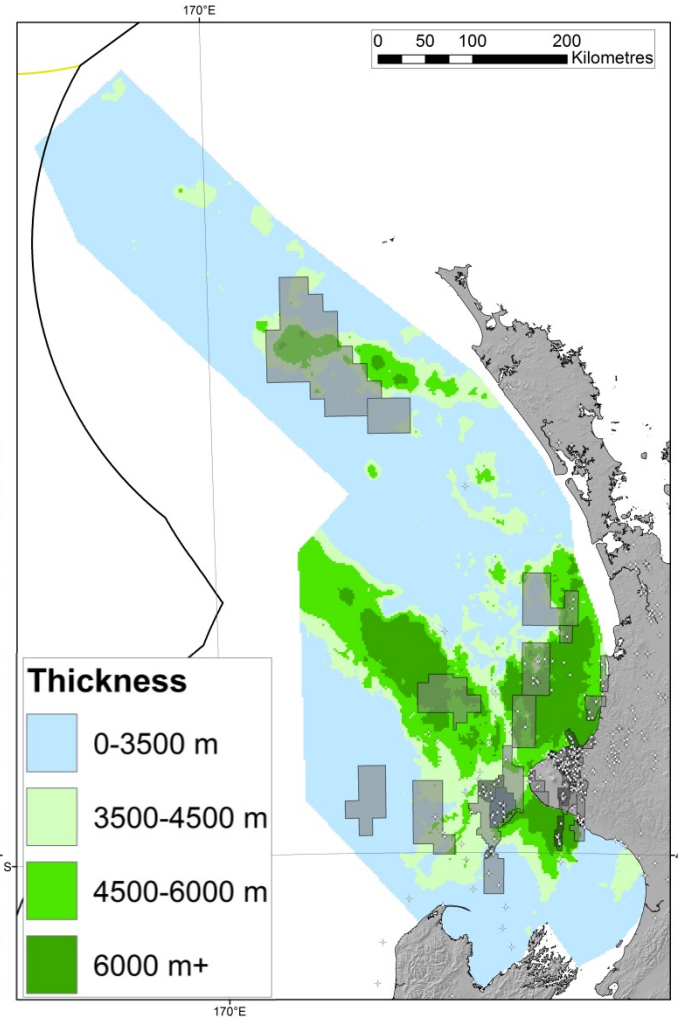




Total sediment thickness: the first integrated map for all the NW basins

- Utilises all open-file data
- Up to 10.8 km thick in Taranaki
- Up to 7–8 km thick in Reinga-Northland





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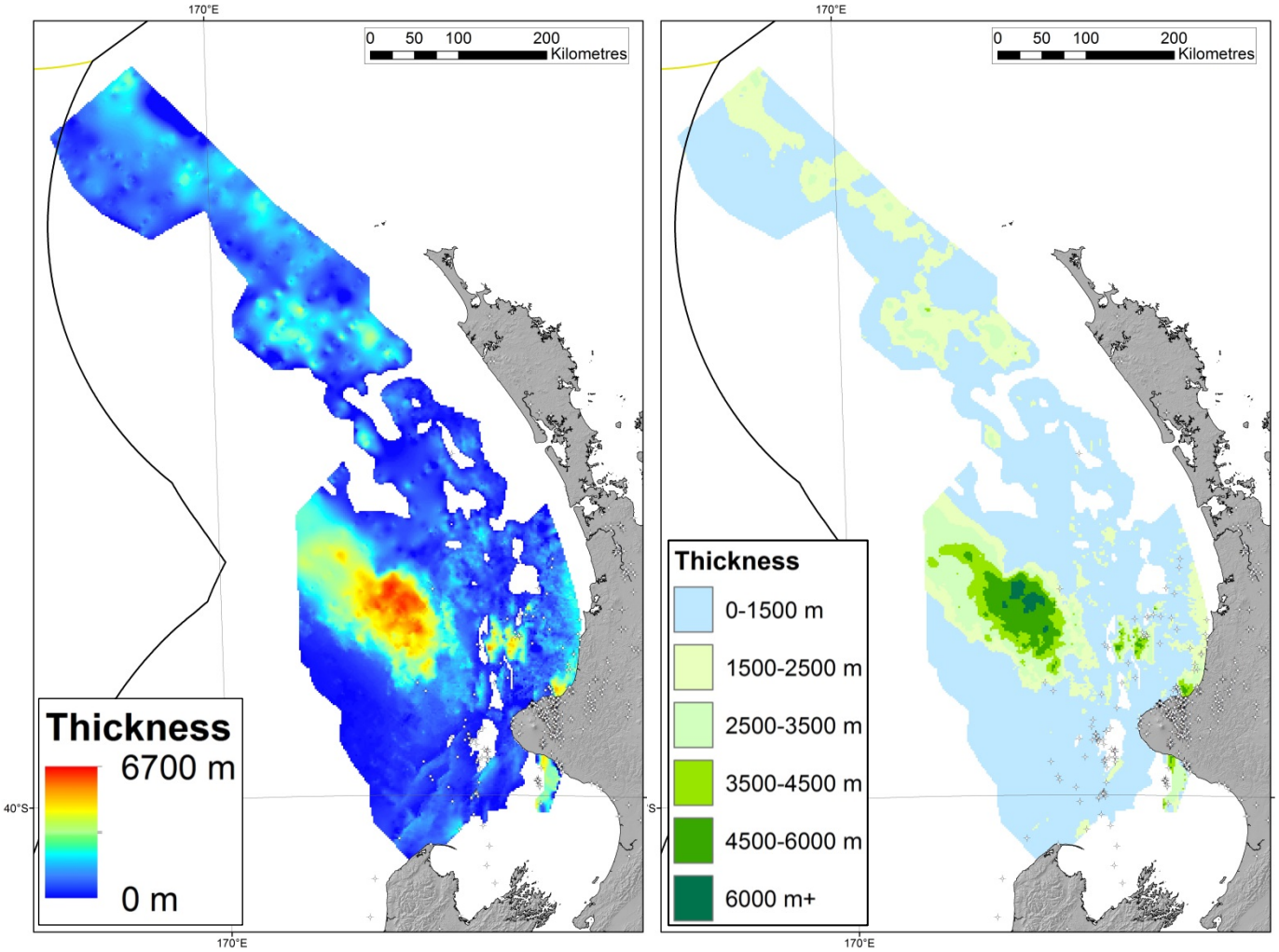
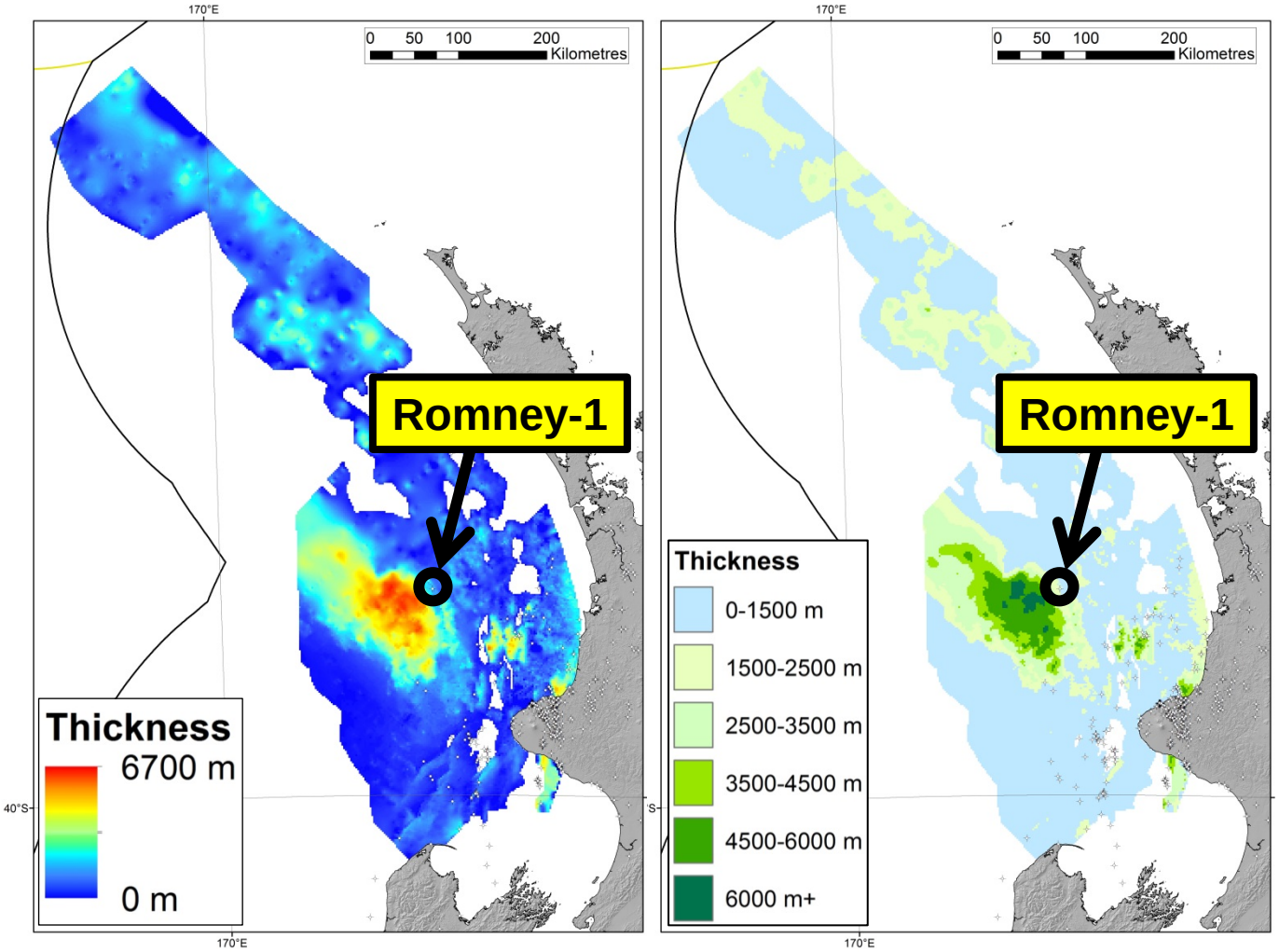


Cretaceous thickness

- Includes the most prospective source rock packages
- Thickest in Deep-water Taranaki
- Taniwha, Taranaki delta, Rakopi, & North Cape Fmns, and correlatives



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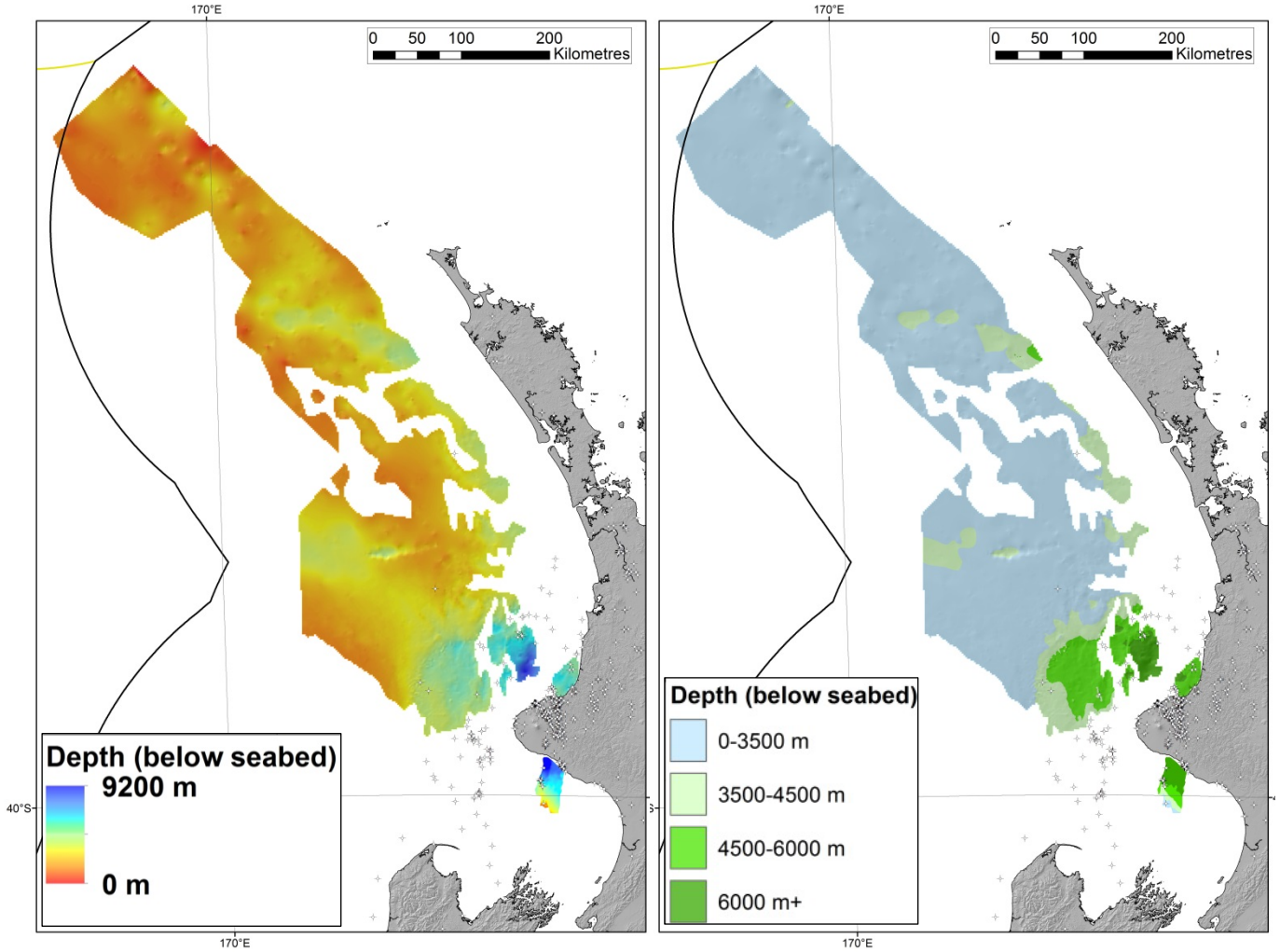
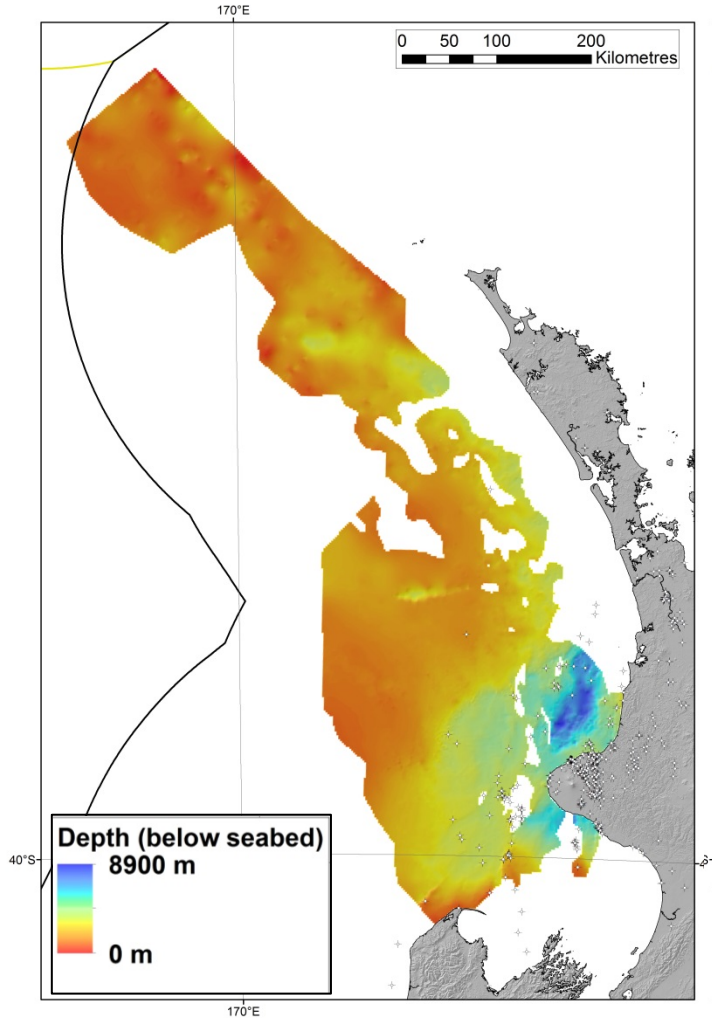
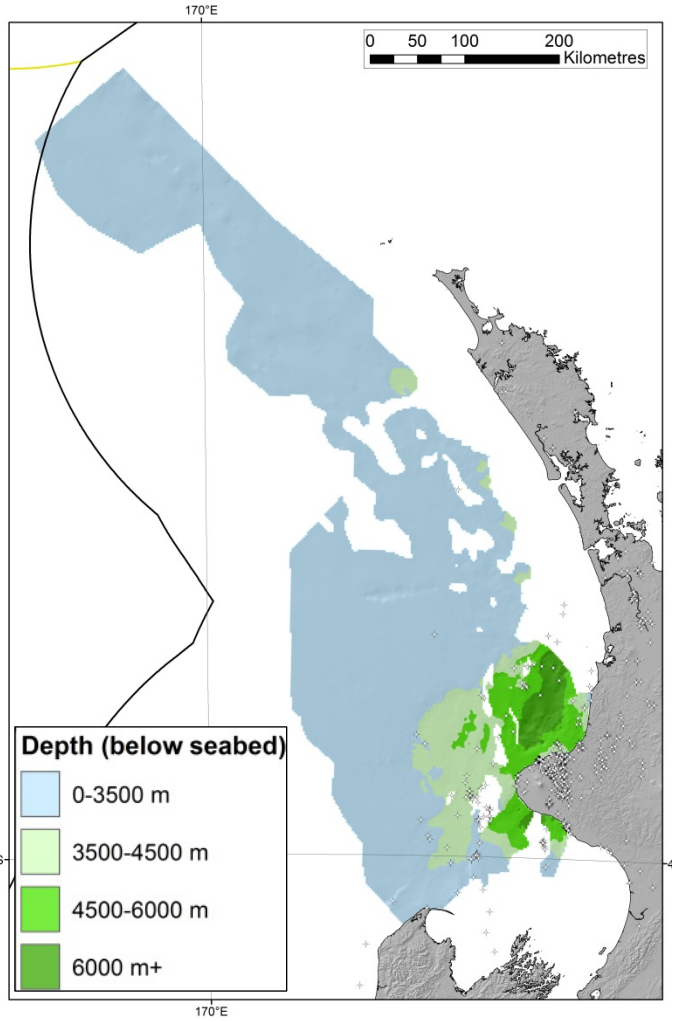


Depth to c. 77 Ma surface

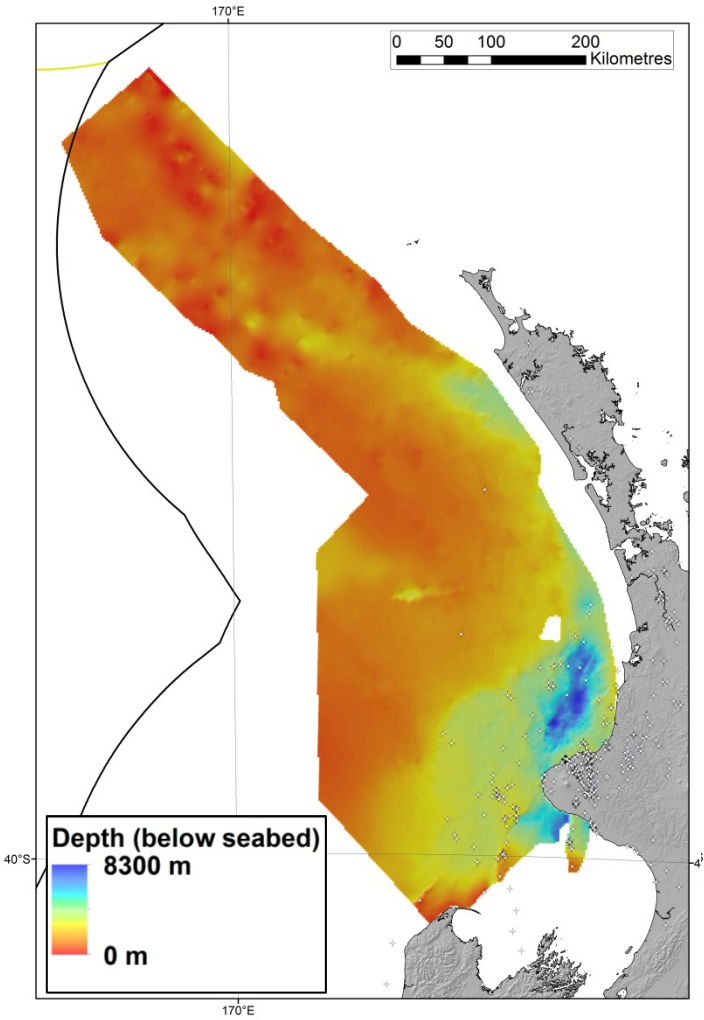
- A proxy for Late Cretaceous source rock burial
- Top-Taranaki Delta, ~base-Rakopi Fmn
- Most deeply buried in southeast areas

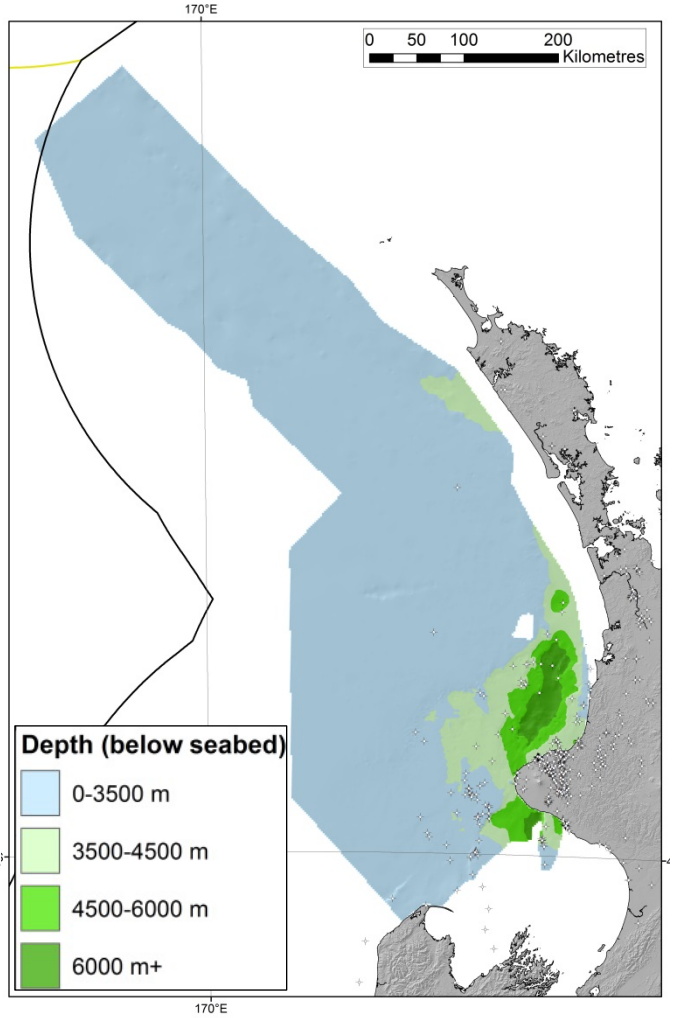




Depth to base Paleocene (66 Ma)

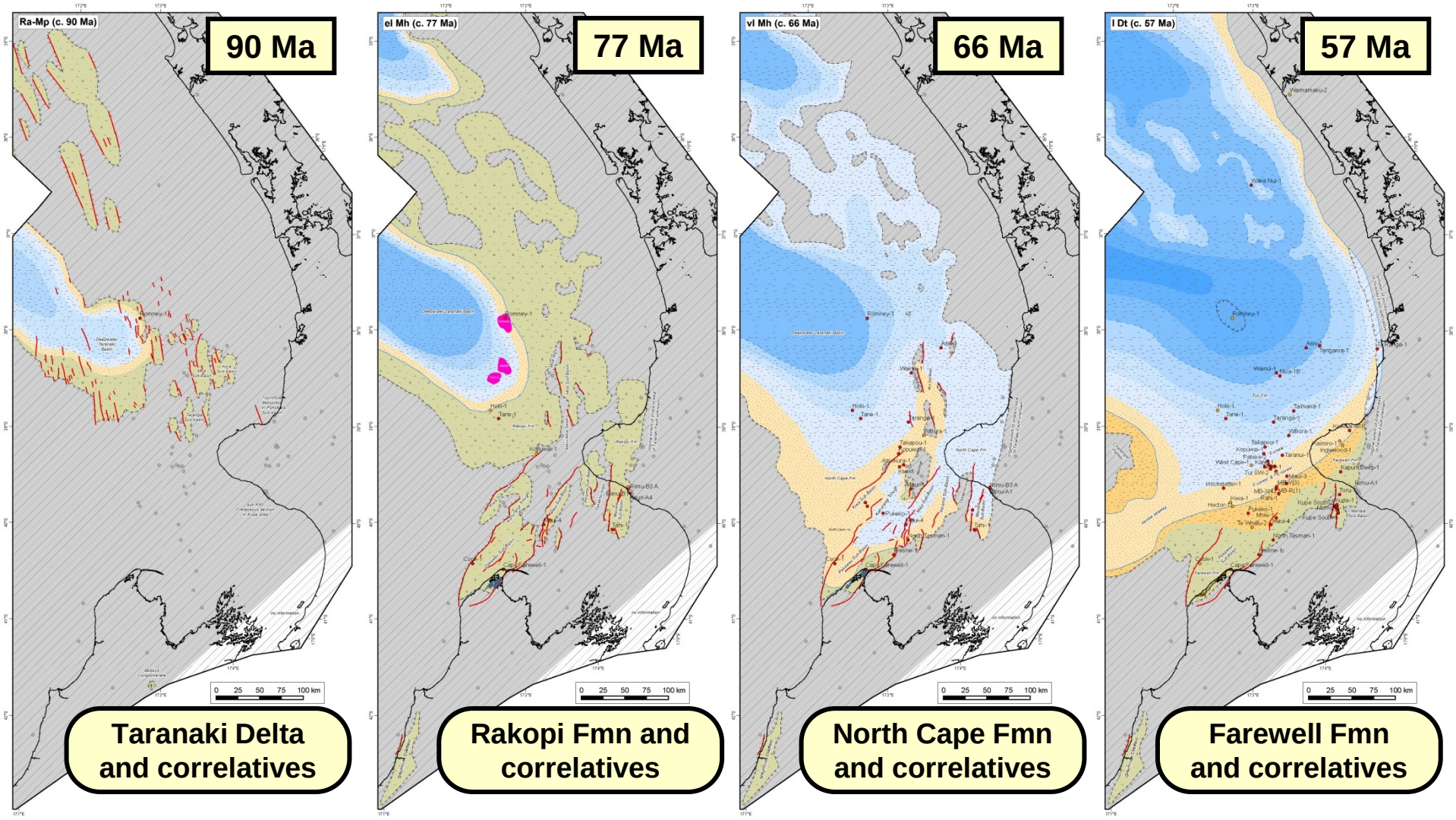
- A proxy for latest Cretaceous source & reservoir rock burial
- Rakopi & North Cape formations
- Proven source rocks in the Maui, Tui, and Maari-Manaia fields
- Most deeply buried in SE areas

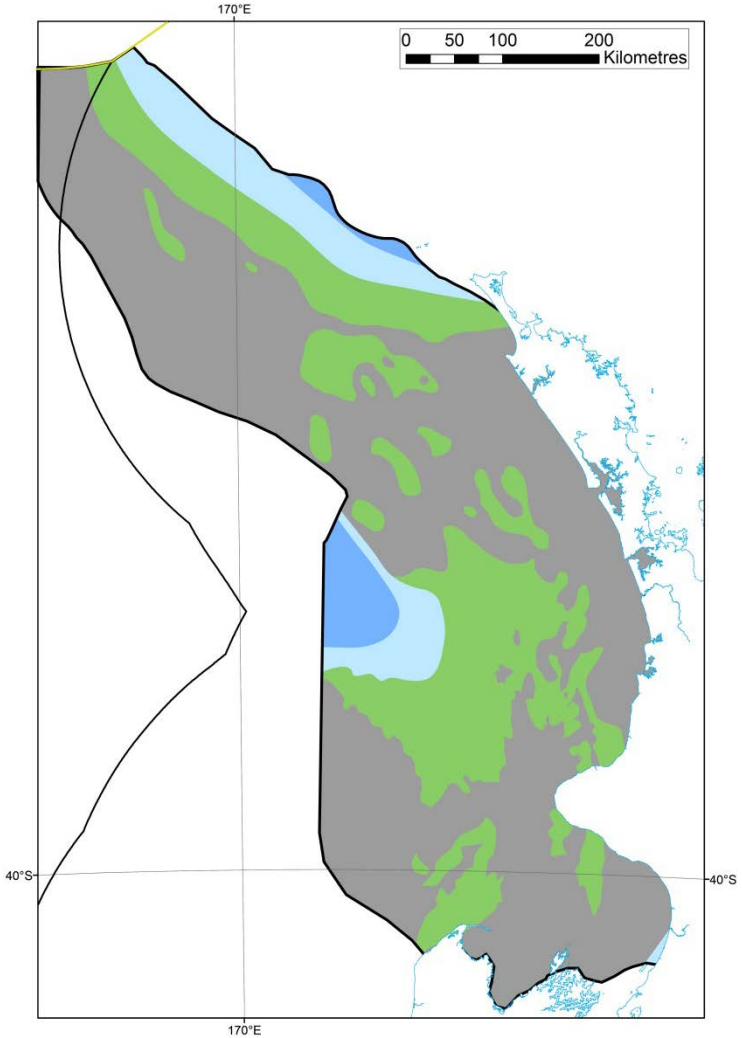




Depth to base Eocene (55 Ma)

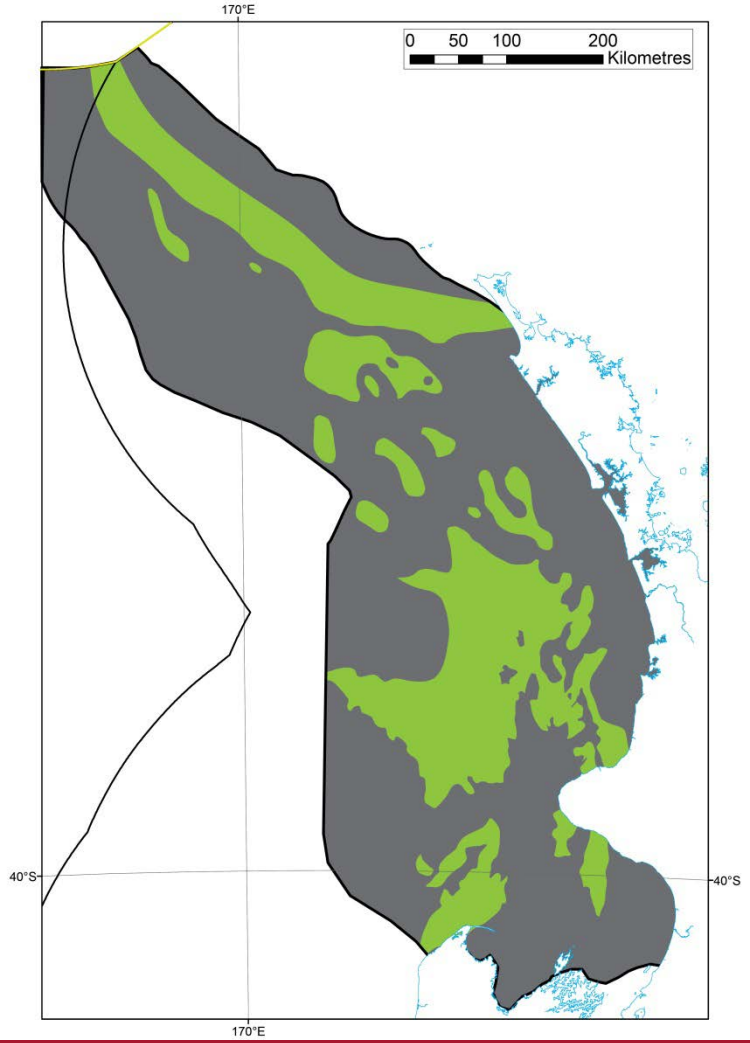
- Proxy for Paleocene source & reservoir rock burial
- Farewell and Waipawa fmns
- Proven sources for the Kupe and Kora fields
- Waipawa Fmn can be mature at depths <3.5 km


Ra-Mp (c. 90 Ma)
90 Ma
el Mh (c. 77 Ma)
77 Ma
vl Mh (c. 66 Ma)
66 Ma
l Dt (c. 57 Ma)
57 Ma
Taranaki Delta and correlatives
Rakopi Fmn and correlatives
North Cape Fmn and correlatives
Farewell Fmn and correlatives



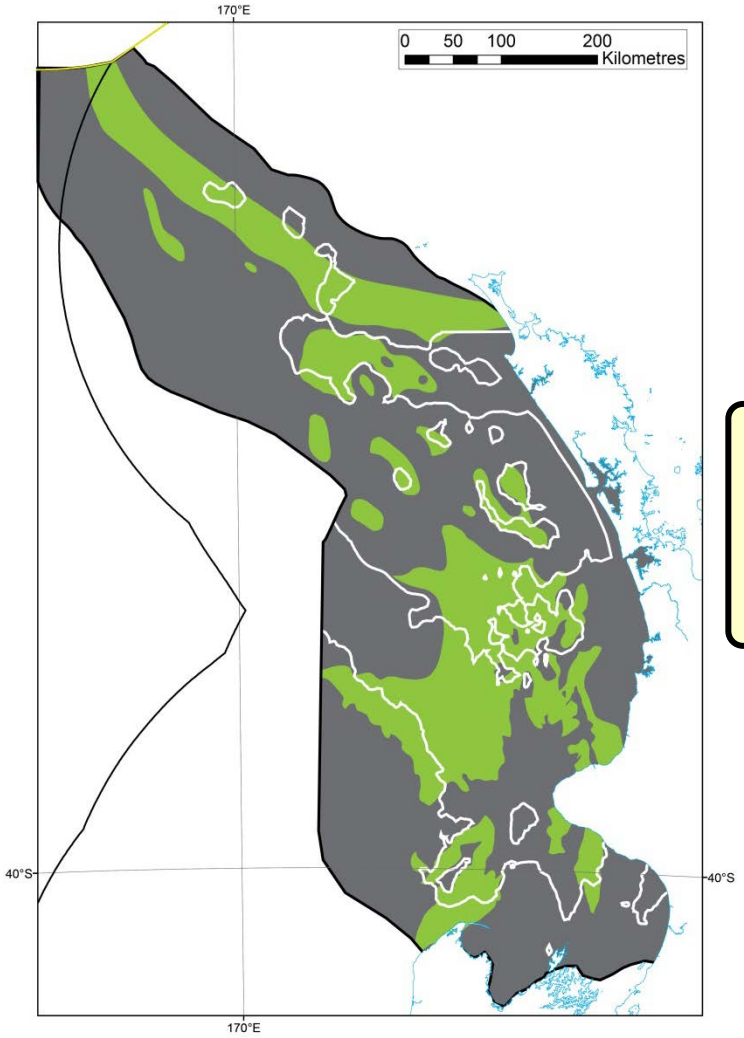
Assessing potential kitchen areas

- Simplified Late Cretaceous facies map
- Green indicates potential coaly source rocks
- Grey indicates non-deposition
- Blues indicate marine settings



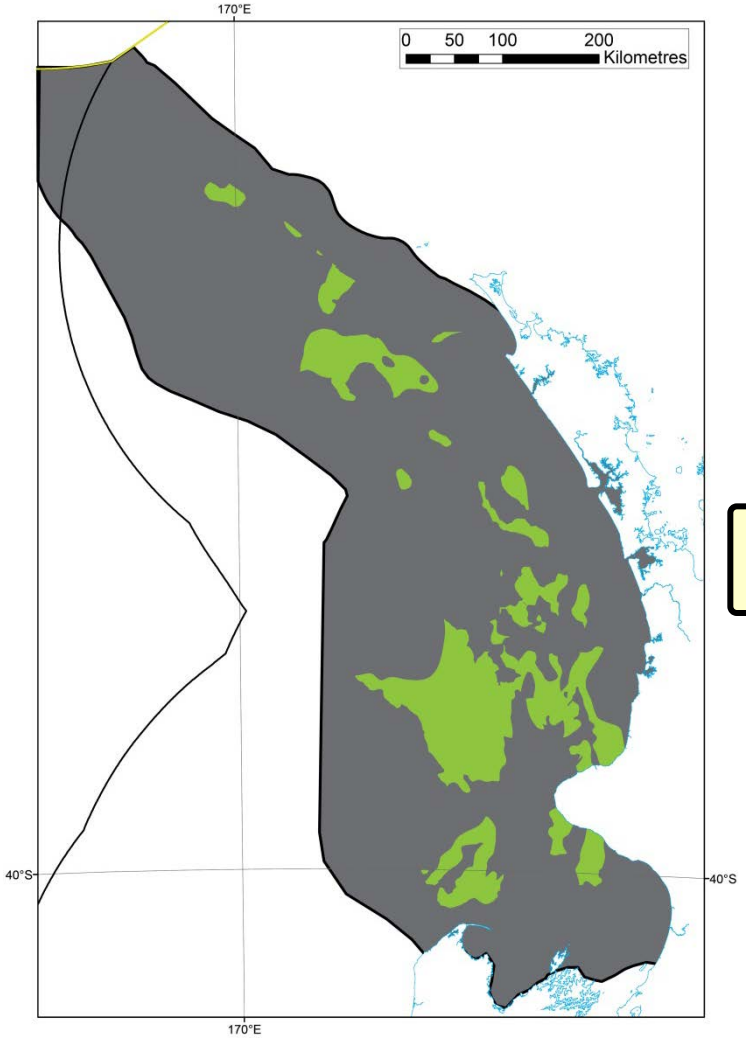
Assessing potential kitchen areas

- **Only areas potentially containing Late Cretaceous coaly source rocks remain**



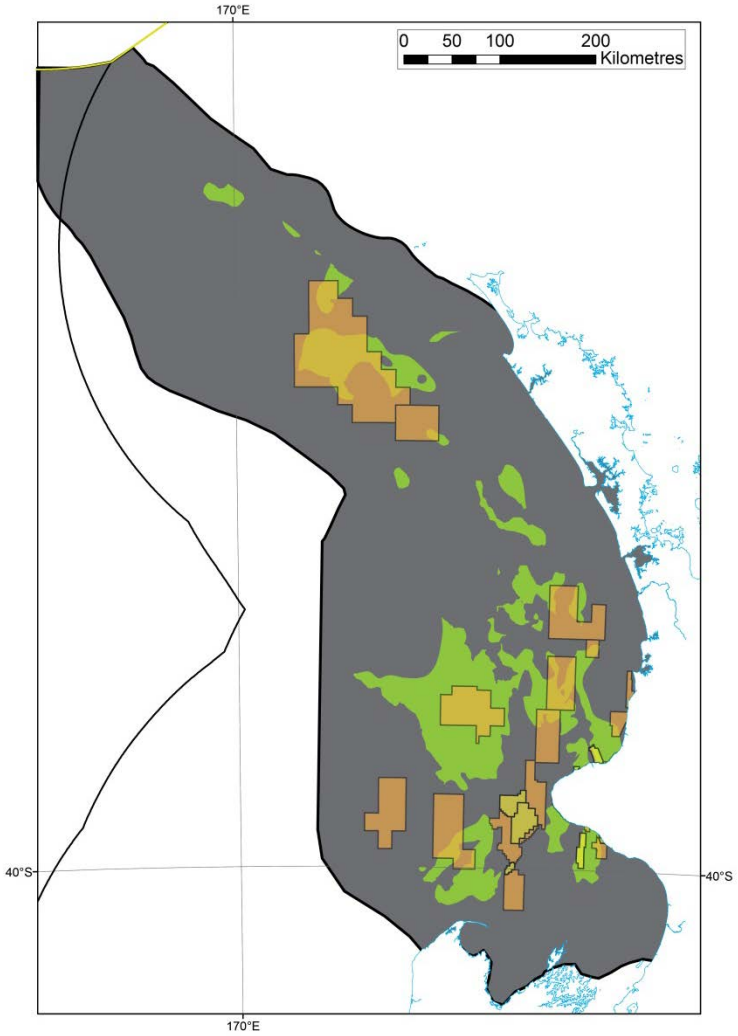
Assessing potential kitchen areas

- White line shows 3500 m total sediment isopach
- A first-order proxy for source rock burial



Assessing potential kitchen areas

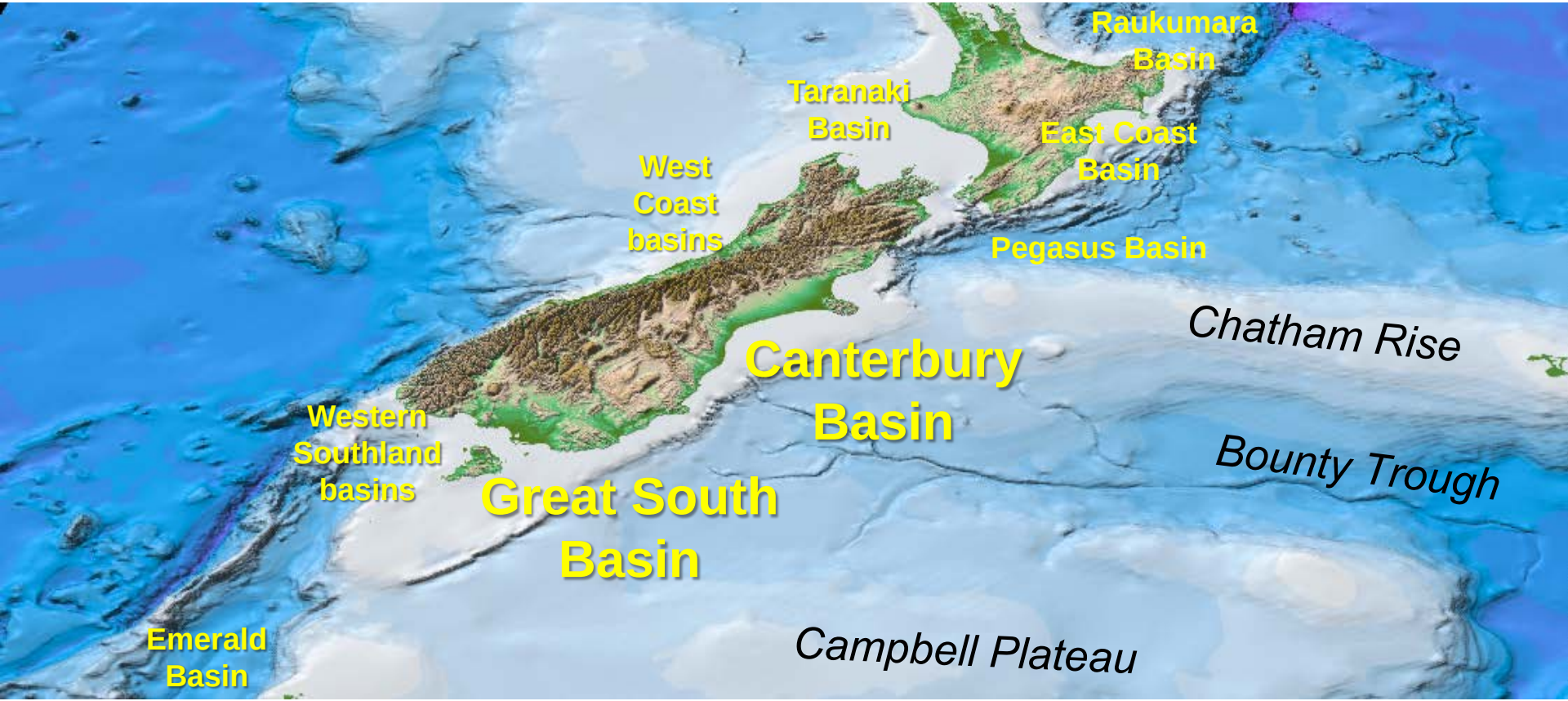
- **Only areas with >3500 m of basin fill remain**



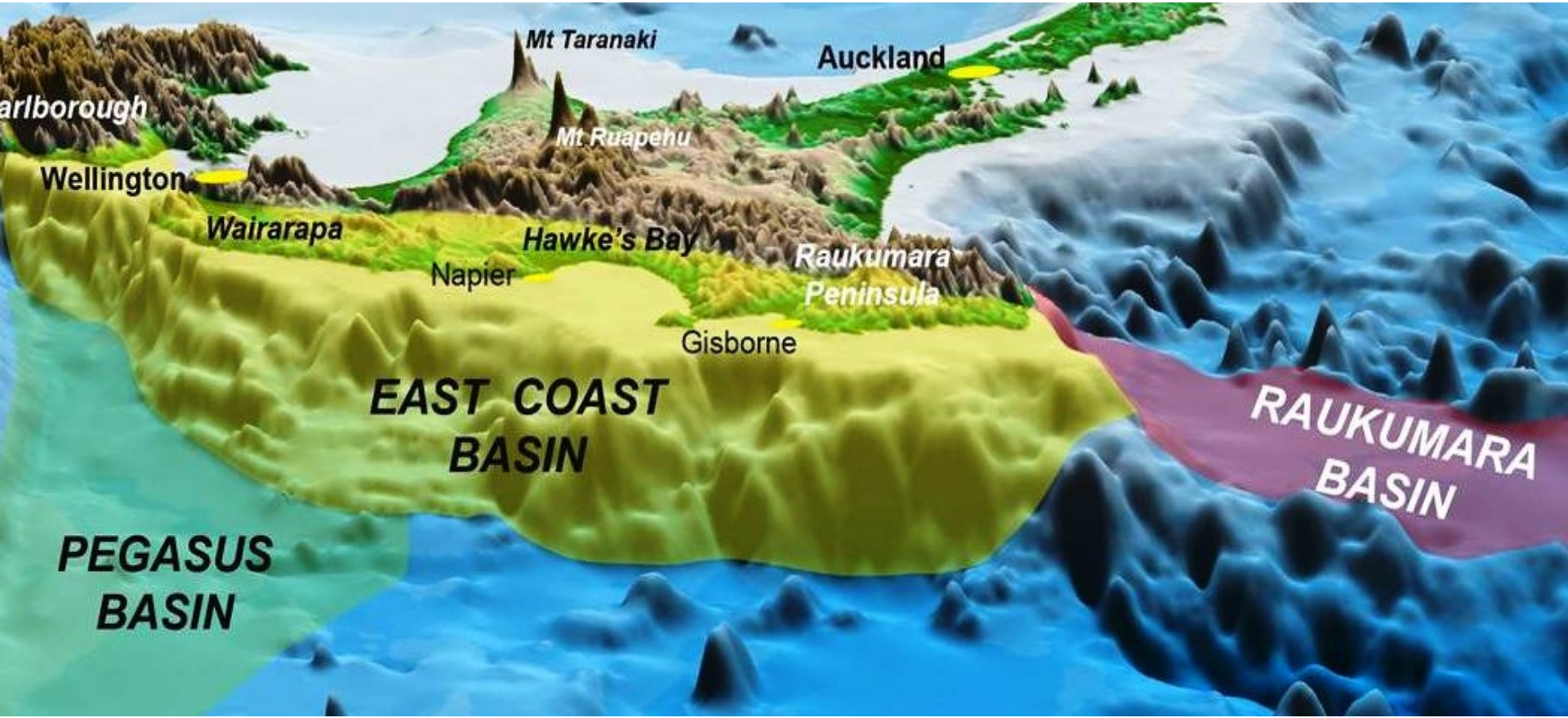
Assessing potential kitchen areas

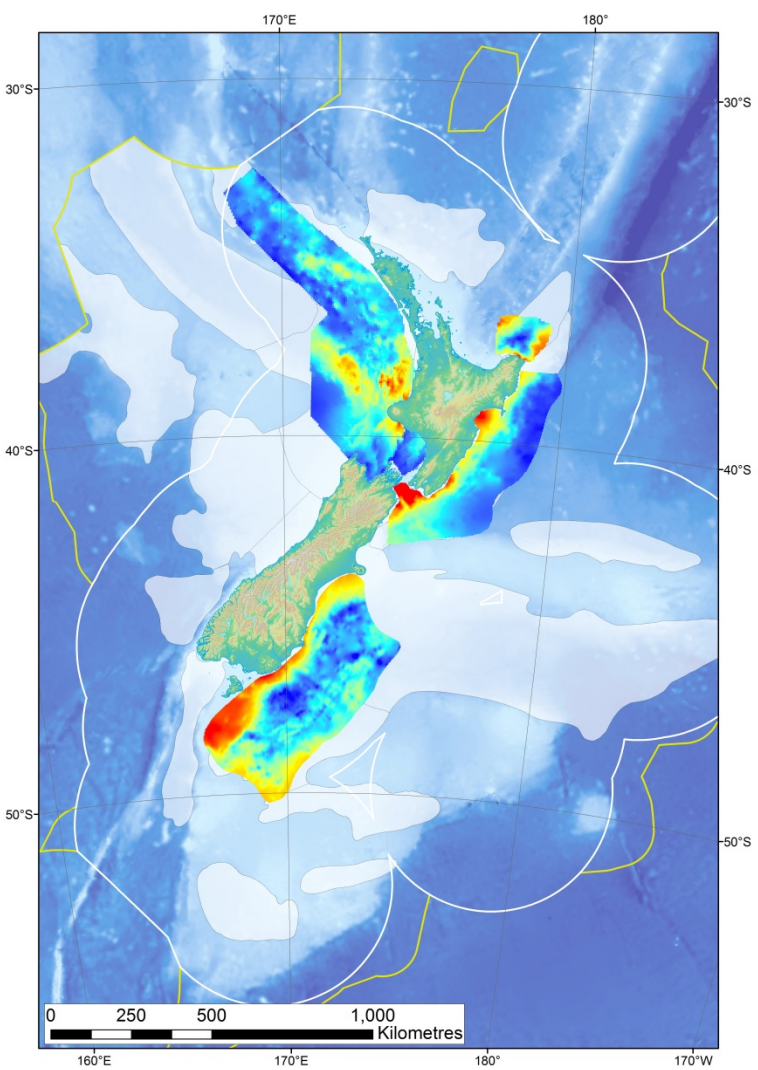
- Potential kitchens and active permits
- Prospective areas are available

The prospective basins of the SE province



The prospective basins of the NE province





The near future…

- Source rock maturity and expulsion in NWP to be assessed soon
- NWP outputs due end June 2016
- Remaining programme outputs will be delivered sequentially

Go to
http://data.gns.cri.nz/pbe/index.html

Adapted from Getty images