Regional Paleogeography and Implications for Petroleum Prospectivity, Taranaki Basin, New Zealand*

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Abstract

The Taranaki Basin, located predominantly offshore of western North Island, is currently the only sedimentary basin in New Zealand with active hydrocarbon production. The basin has had a complex history from the Late Cretaceous through to the Neogene, encompassing rifting, passive subsidence, compressional tectonics related to the evolution of the Australia-Pacific plate boundary, and late back-arc rift phases.

As part of ongoing research into New Zealand's petroleum resources, a regional reassessment of the paleogeographic evolution of the Taranaki Basin and surrounding areas has been undertaken, the results of which are presented here. This forms part of a larger project investigating the Taranaki Basin through new basinwide seismic mapping, biostratigraphy, facies analysis, and basin modelling.

A set of 32 maps spanning the Late Cretaceous to present day have been produced, which synthesise paleobathymetric and paleofacies data. These maps expand, both in number and geographical area, on those from previous studies and incorporate significant new data. Inputs include map data from previous studies, a new compilation of biostratigraphic and bathymetric data from >200 wells in and around the Taranaki Basin and compilation of outcrop data from areas surrounding the basin. Perhaps the most important addition in this study is the use of seismic attribute and facies mapping, leading to better delineation of depositional elements, both in areas covered by 3D data and in sparser regional 2D surveys.

The study was carried out using GIS, allowing for the capture of significant metadata relating to features such as wells, faults, paleofacies and paleobathymetry. The maps were chosen to provide at least one paleogeographic reconstruction for major sequences bounded by regionally mapped seismic reflectors. Where possible, additional maps were constructed to capture major changes in facies or paleobathymetry within sequences.

These new paleogeographic maps provide improved control on crucial elements of the petroleum system, particularly on the distribution of potential reservoir facies, such as Cretaceous-Paleogene marginal- to shallow-marine facies and Miocene-Pliocene submarine fan systems. These maps capture the most important aspects of the tectonic and sedimentary evolution of the Taranaki Basin and form the basis for ongoing more detailed paleofacies mapping, basin modelling studies, and evaluation of regional petroleum exploration play concepts.

References

King, P.R., and G.P. Trasher, 1996, Paleogeographic maps of Taranaki Basin: Geological Society of New Zealand Miscellaneous Publication, v. 91A, 102 p.

Vonk, A.J., and P.J.J. Kamp, 2008, The late Miocene southern and central Taranaki inversion phase (SCTIP) and related sequence stratigraphy and paleogeography: New Zealand Petroleum Conference: Beyond 2008, 17 p.

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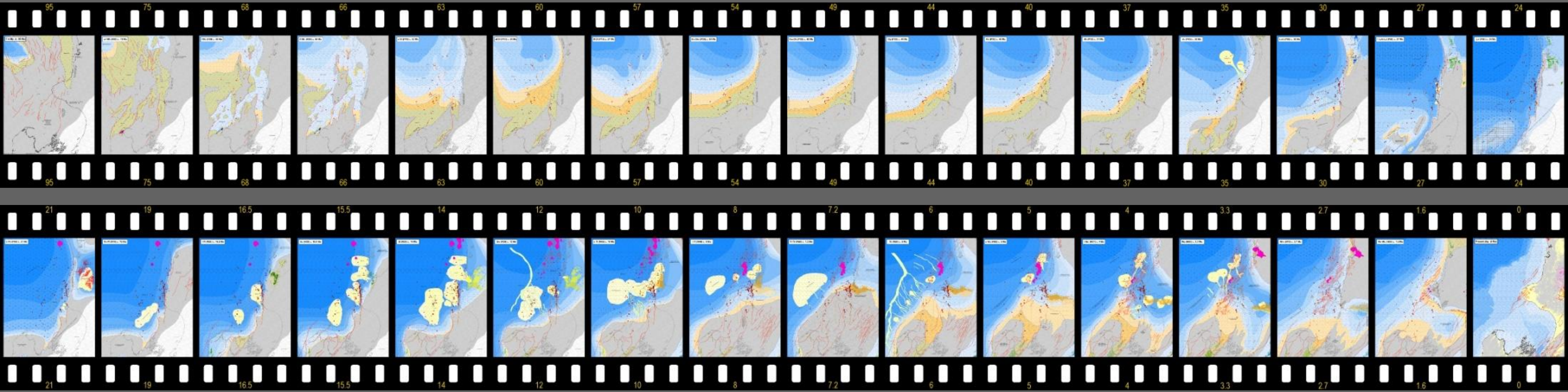

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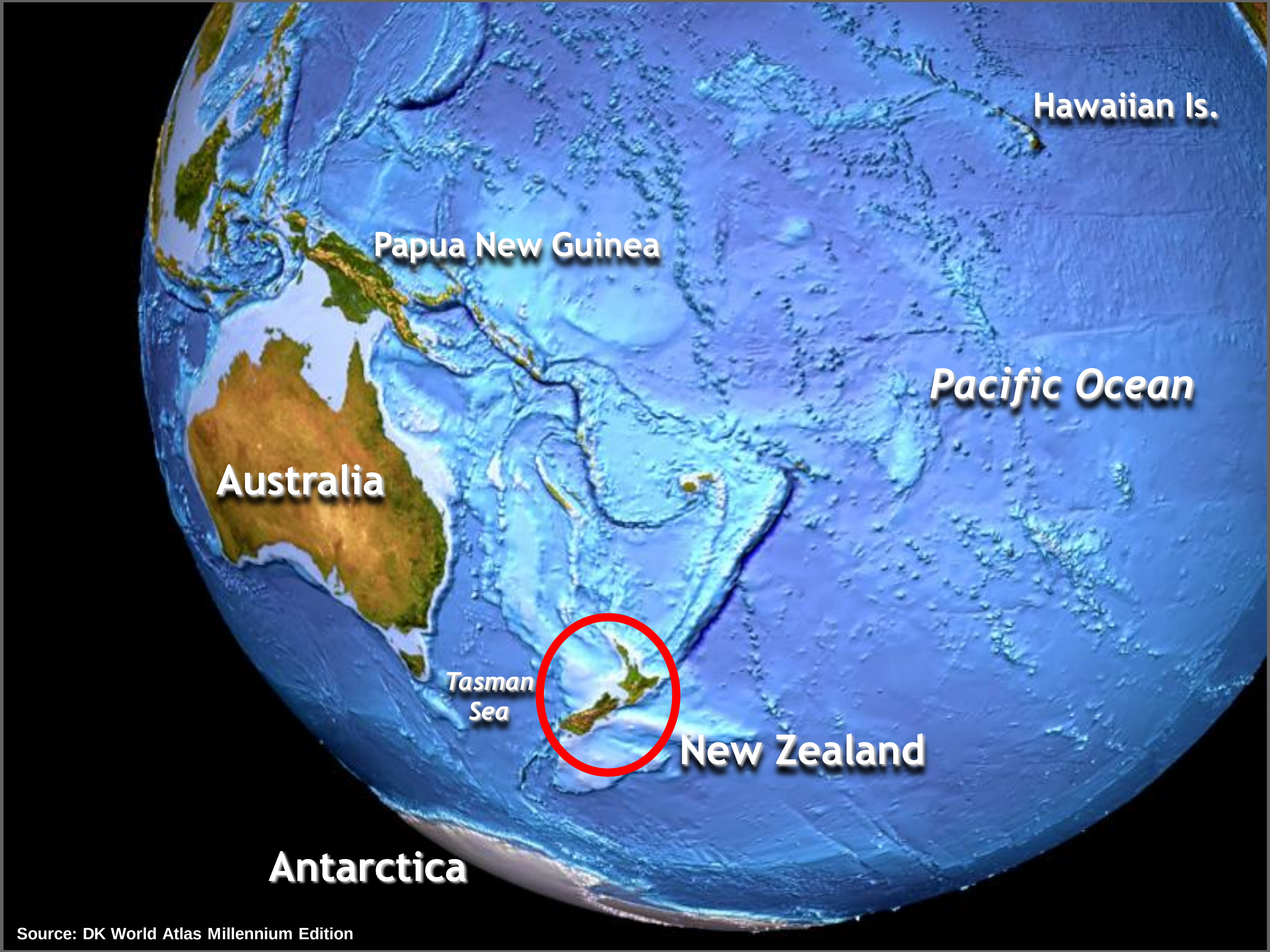
Overview of talk

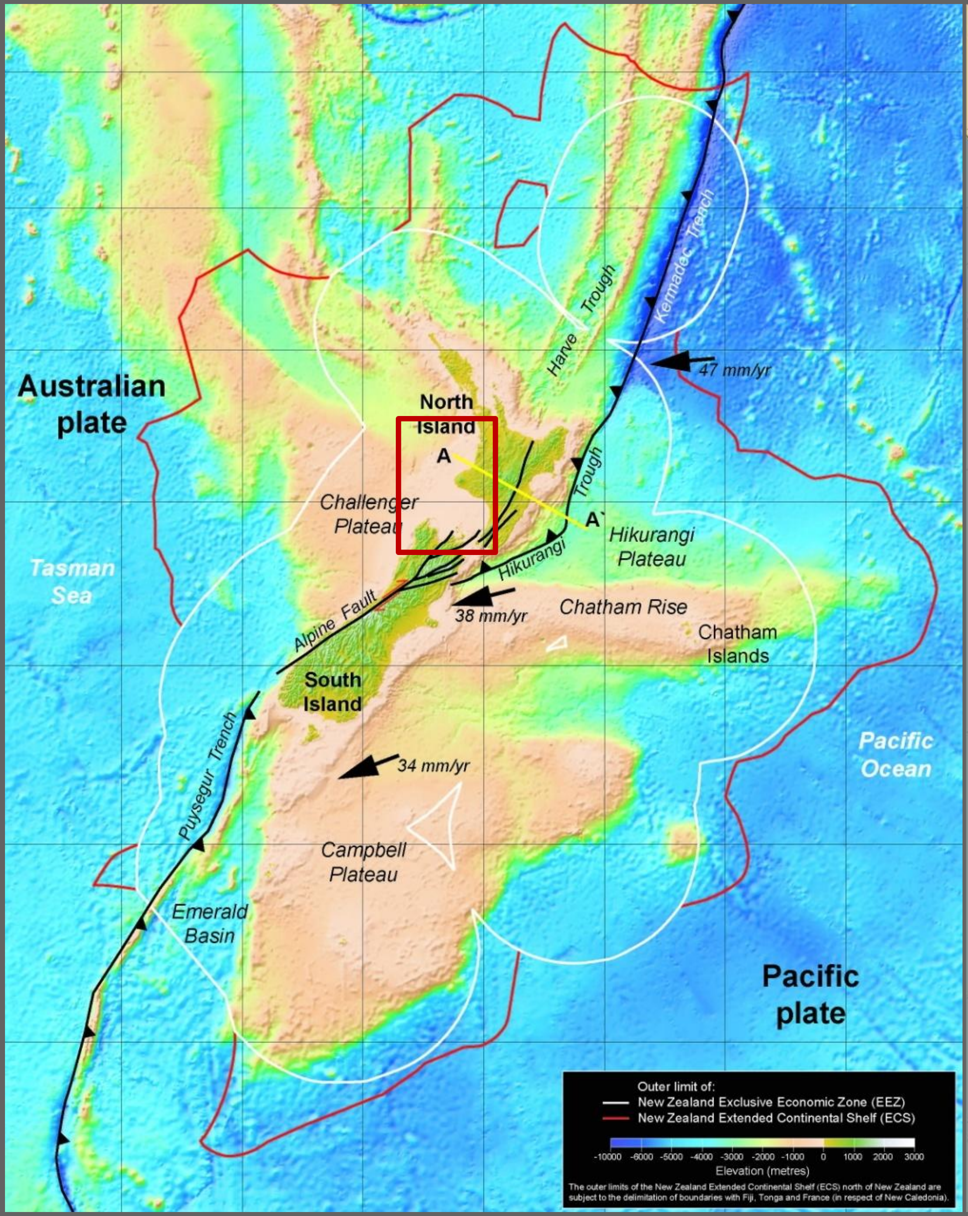
- Introduction to regional New Zealand tectonic setting
- Methods and data sources for paleogeographic map production
- Paleogeographic maps and comments on petroleum system
- Discussion and conclusions

Regional setting of New Zealand within the SW Pacific



Source: DK World Atlas Millennium Edition

Regional setting of Taranaki Basin within Zealandia



Tectonic setting of the Taranaki Basin

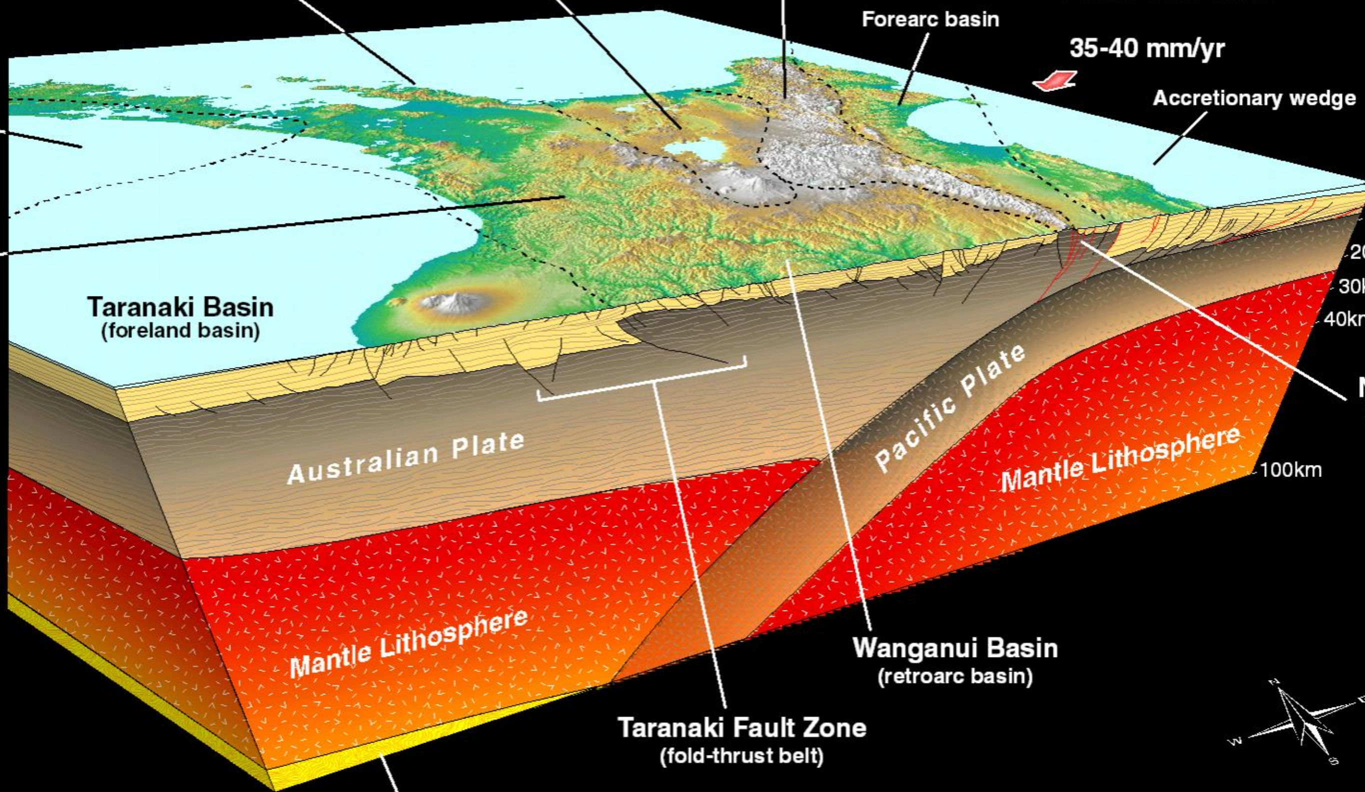


Diagram courtesy of A.J. Vonk

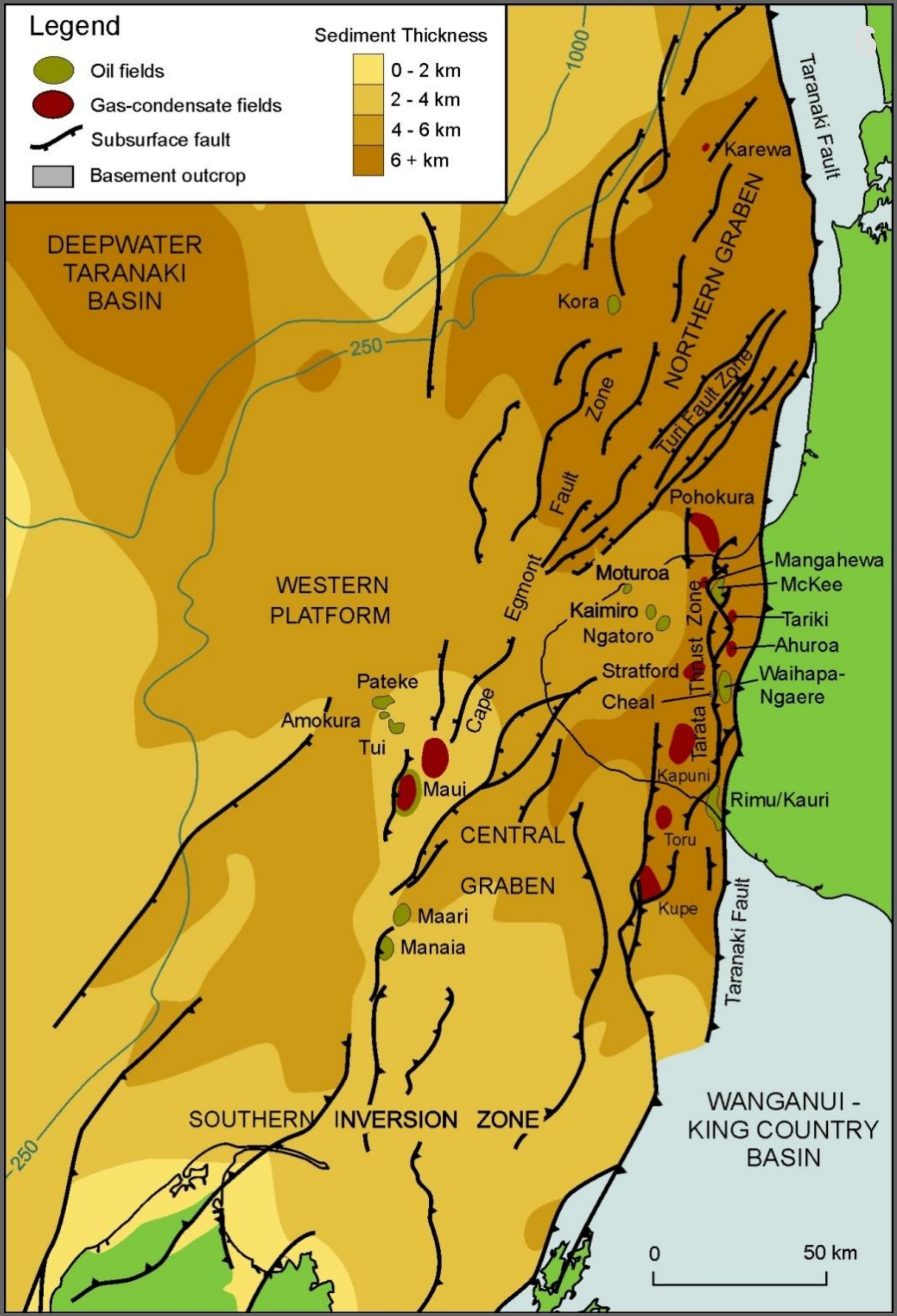
Currently located close to plate boundary, but this only formed c. 23 Ma

Aims of this study

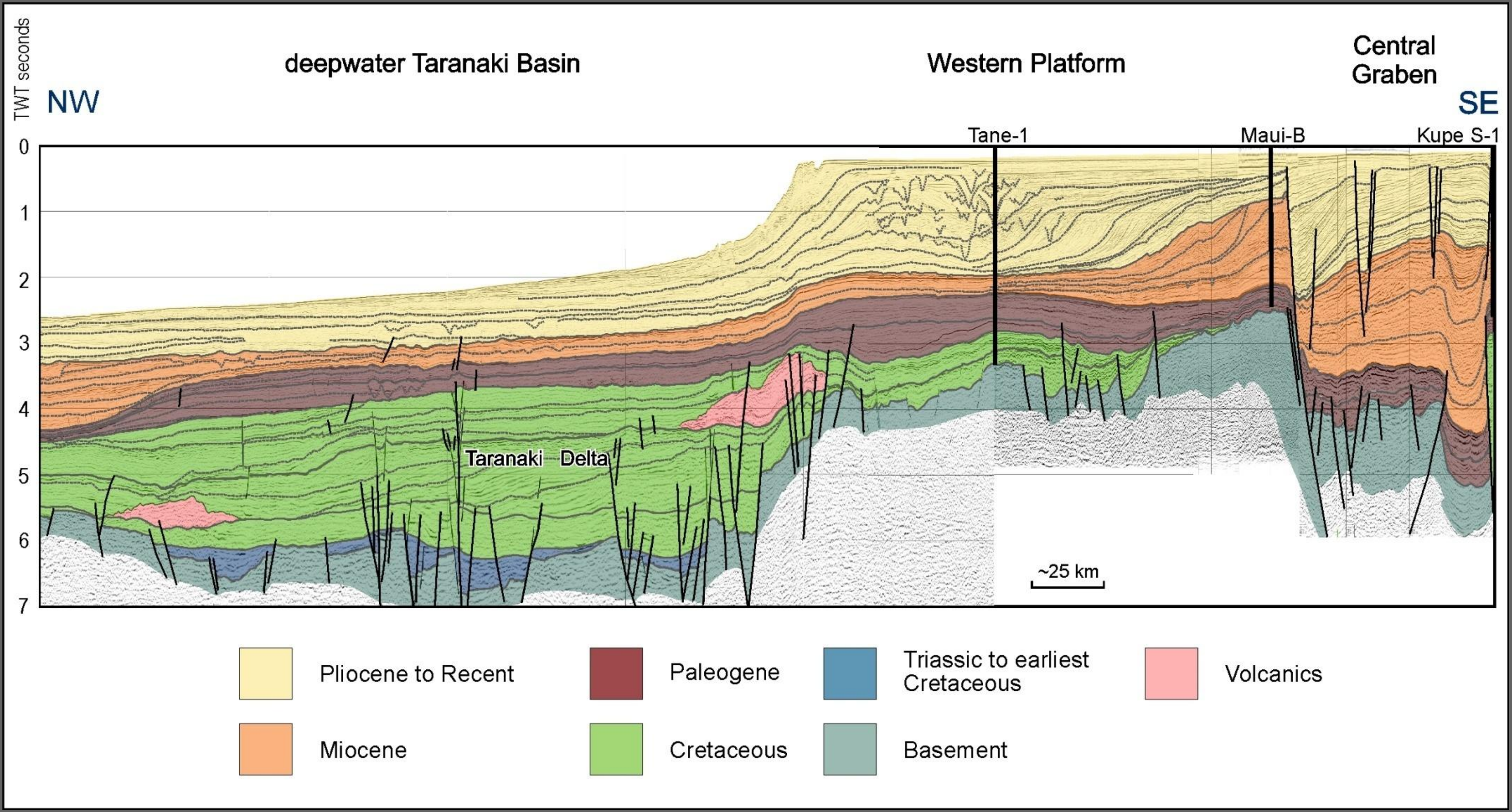
This study forms part of the 4D Taranaki Project and aims to produce a suite of maps (32 in total) spanning the Late Cretaceous to present day.

Maps cover the Taranaki Basin and adjacent areas, with at least one paleogeographic reconstruction for each major sequence bounded by mapped seismic reflectors.

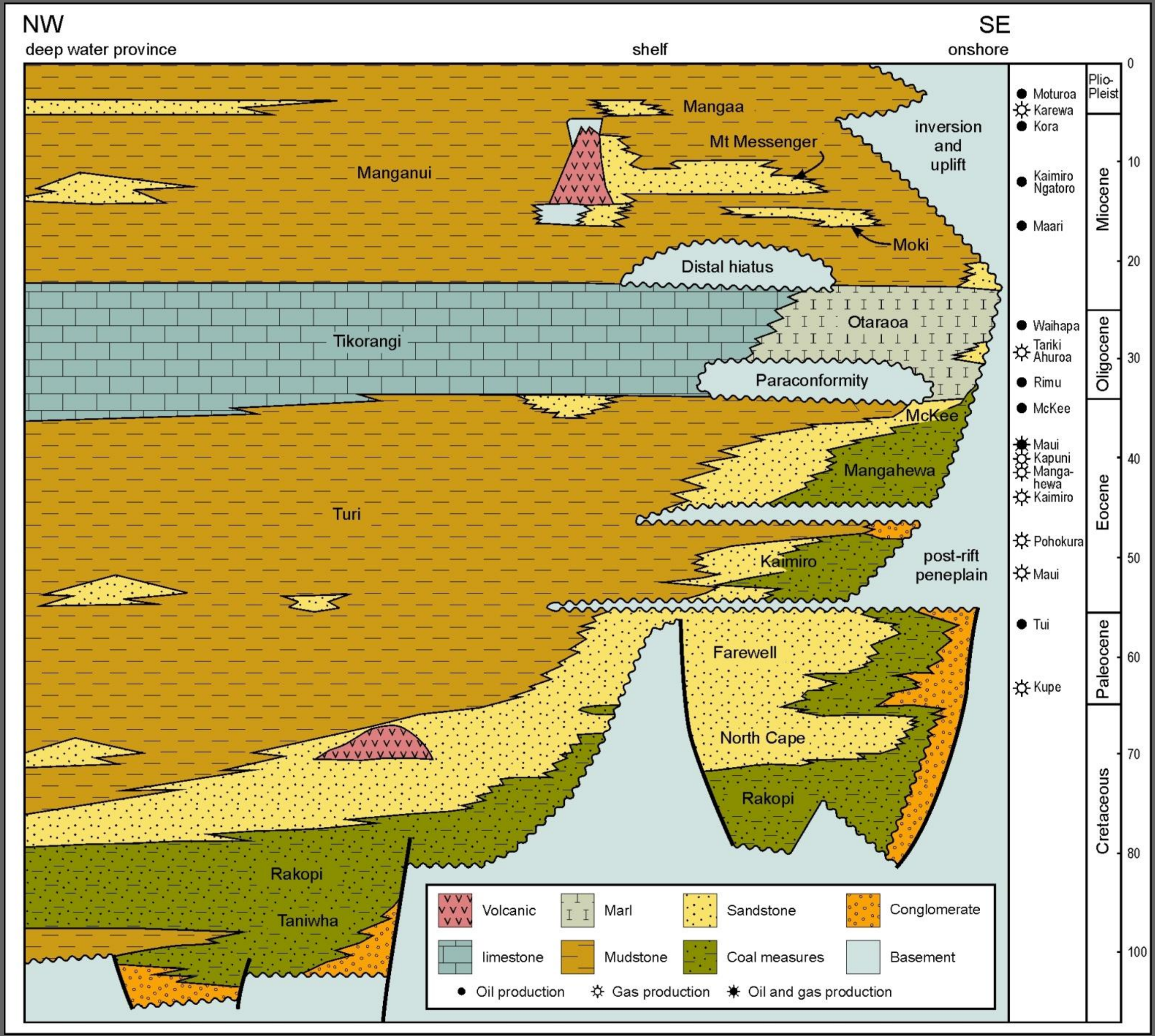
4D Taranaki Project: Remapping the Taranaki Basin using calibrated well and seismic data, to provide a new generation of subsurface structure and depositional systems maps, as a framework for developing 3D and 4D models of basin evolution and petroleum systems.



Example regional seismic transect of the Taranaki Basin



Generalised stratigraphy of the Taranaki Basin



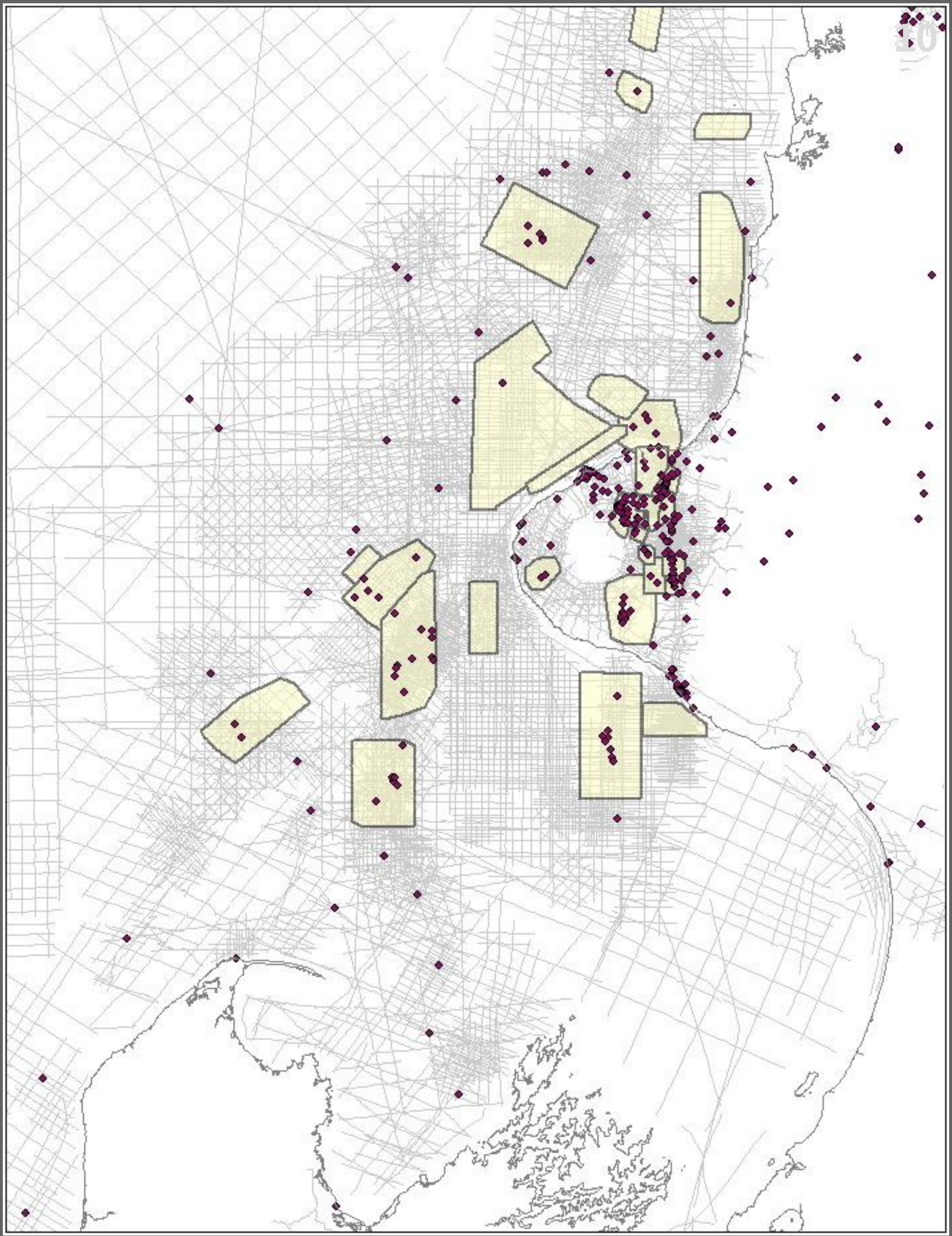
Inputs to paleogeographic mapping

- Compilation of existing paleogeographic interpretations.
- New compilation of well data (212 wells) – both lithology and extensive biostratigraphic and paleobathymetric database.
- Information from outcrops, both literature and new 1:250k geological mapping in surrounding onshore areas.
- New facies data from seismic attribute mapping.
- Detailed reservoir studies of selected intervals.
- Data compiled in ArcGIS.

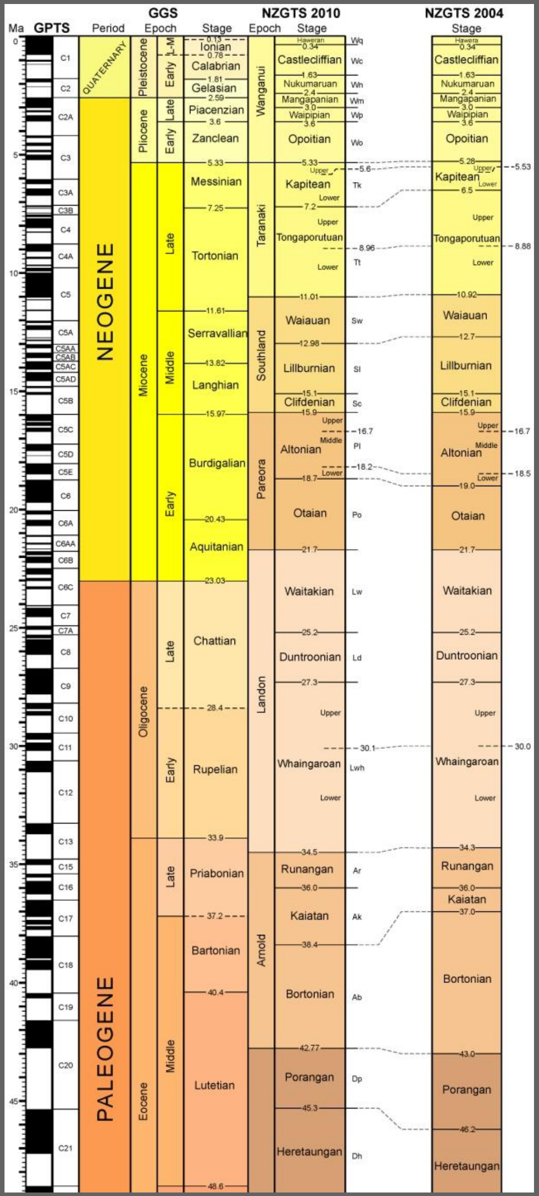
Open file data

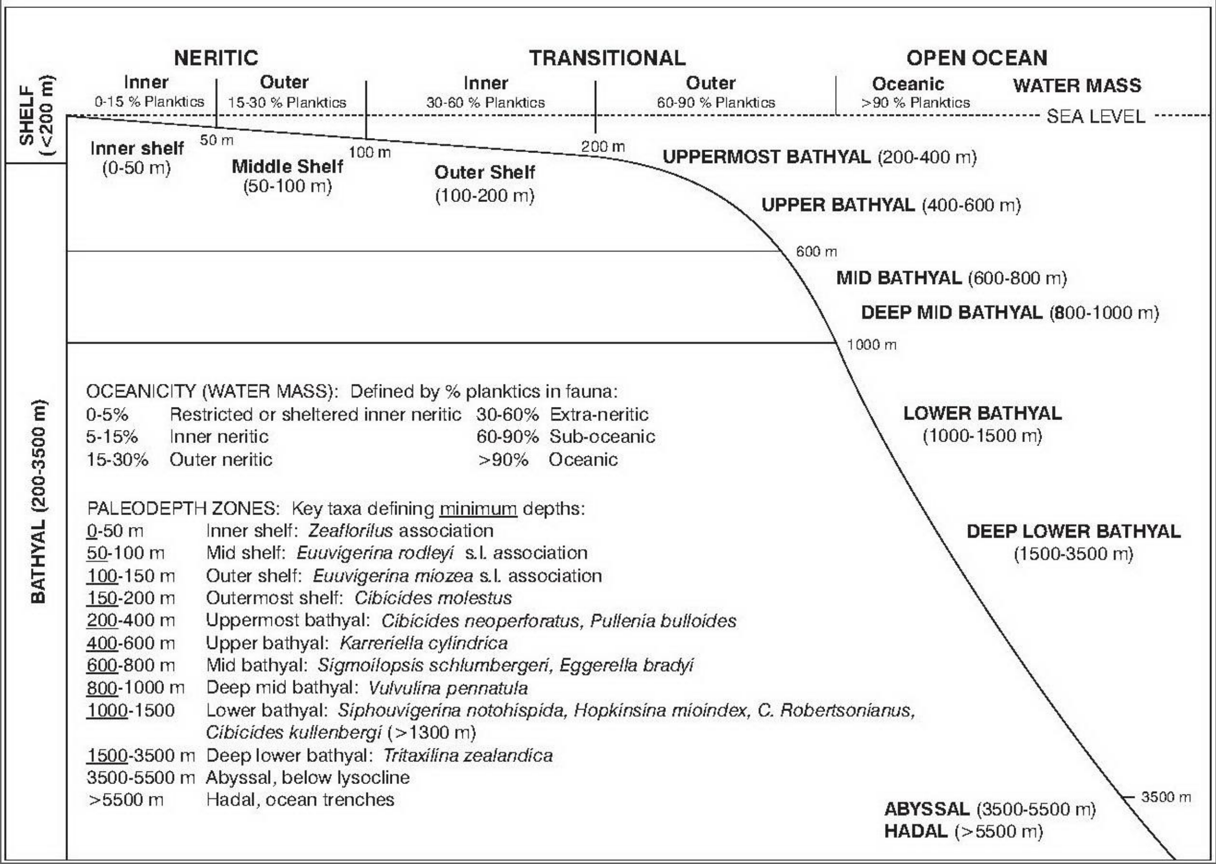
This project is possible due to the existence of a very large open file dataset available for the Taranaki Basin:

- >200 wells
- Large 2-D seismic dataset (grey; ~21000 km)
- 35 3-D seismic surveys (~6000 km^2)

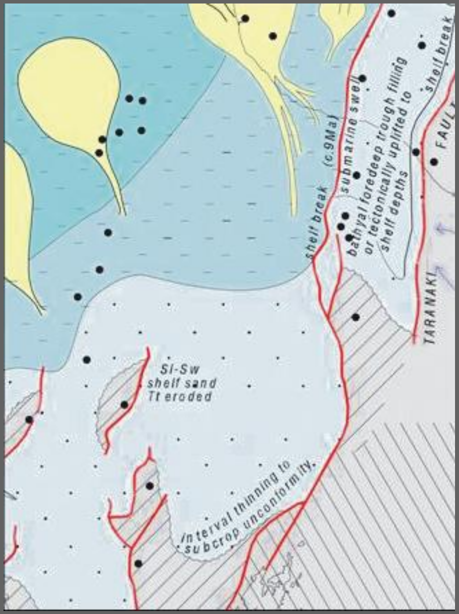


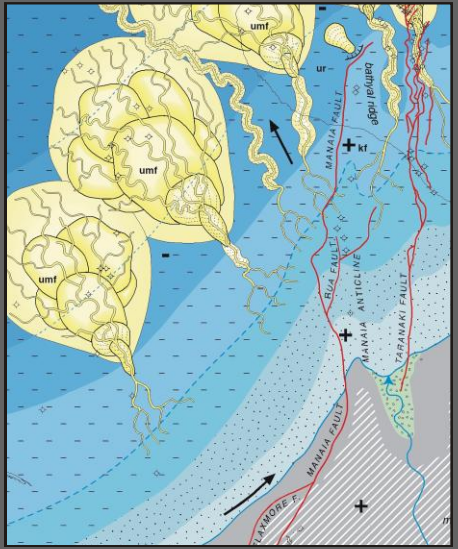
Biostratigraphy and paleobathymetry

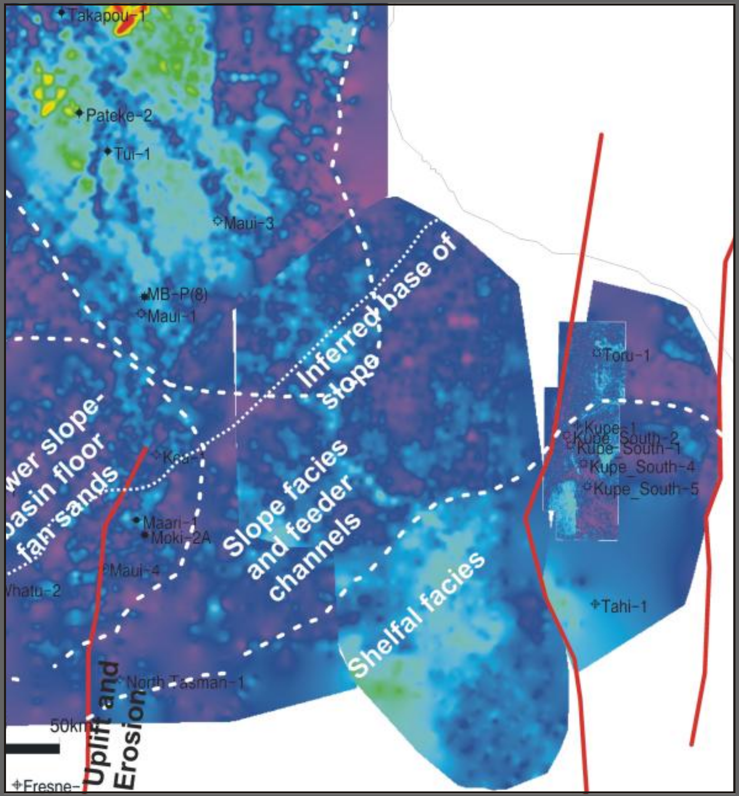




New inputs: seismic attribute mapping





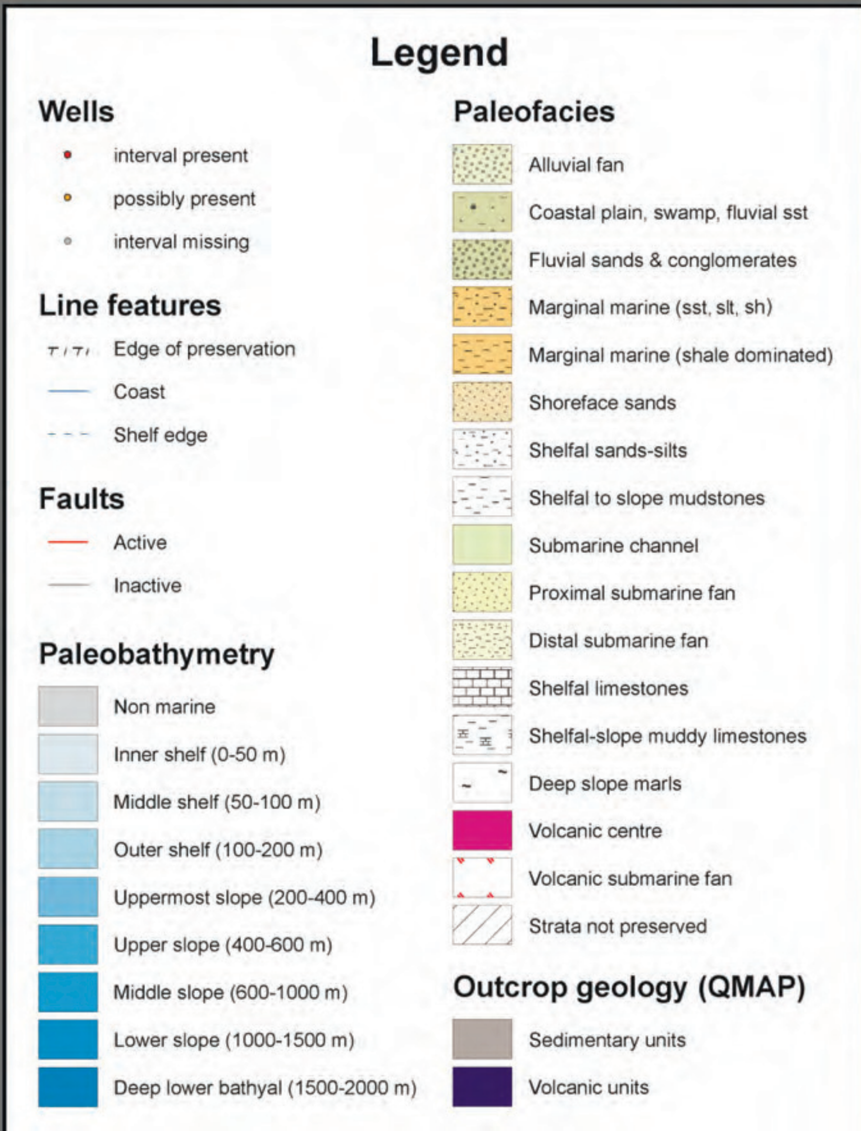


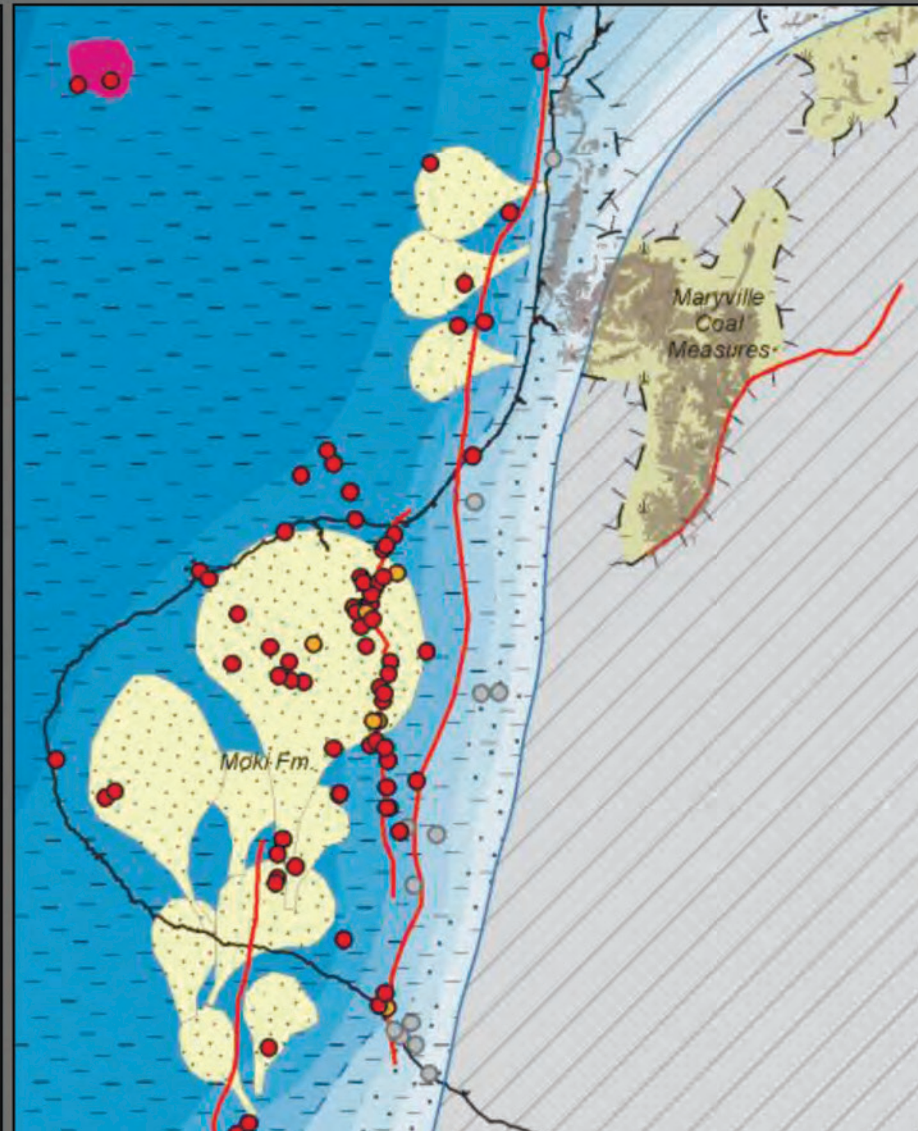
Seismic stratigraphic and attribute mapping (Jan Baur Ph.D.) has been used to constrain paleofacies interpretations.

Pre-existing paleogeographic maps were based solely on well data. Left: Two late Miocene examples shown (after King and Thrasher, 1996; and Vonk et al., 2008).

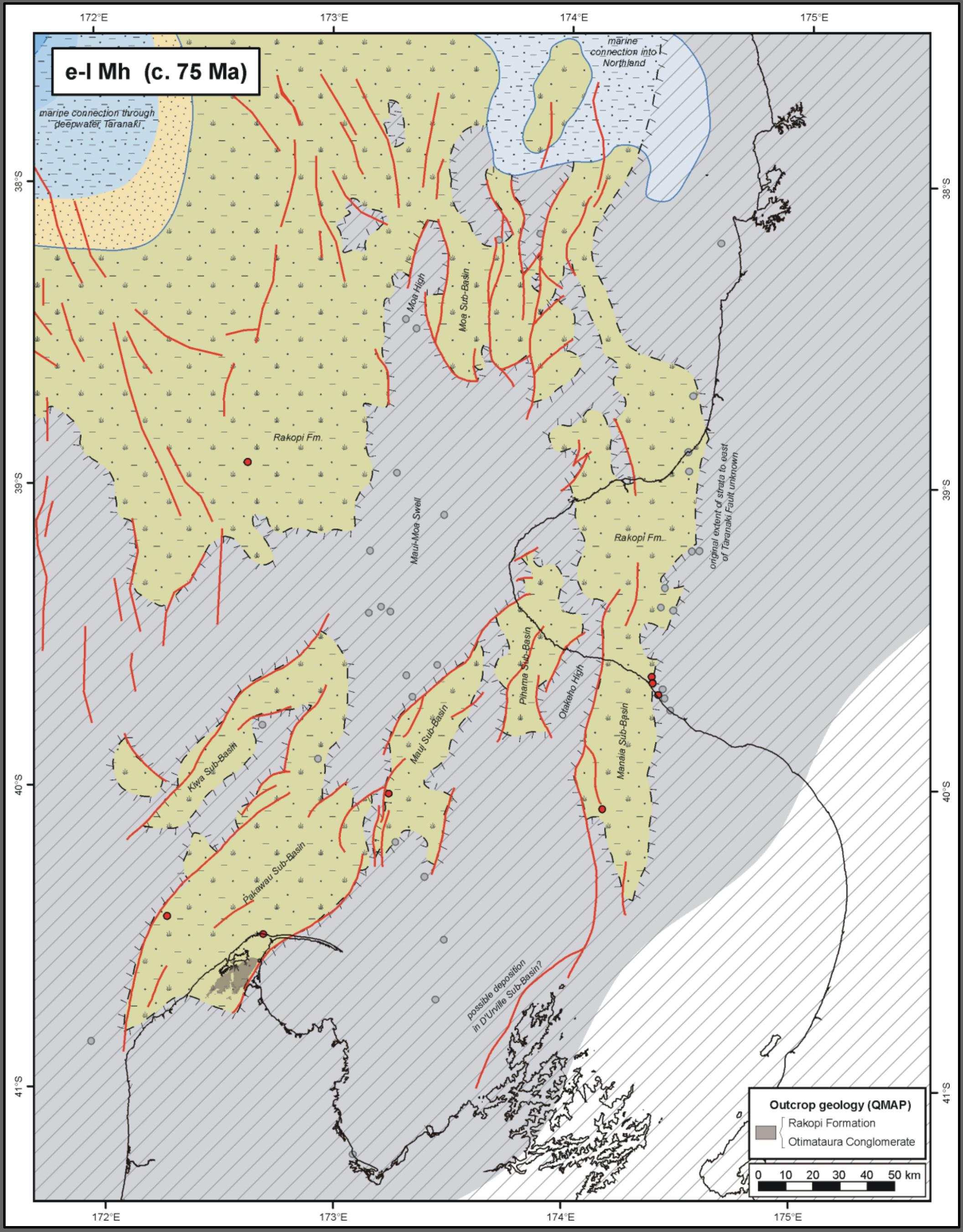
Seismic attribute mapping improves upon existing maps by delineating depositional features, with the shelf edge, slope feeder channels and basin-floor fans well imaged.

Key to paleogeographic maps and example maps



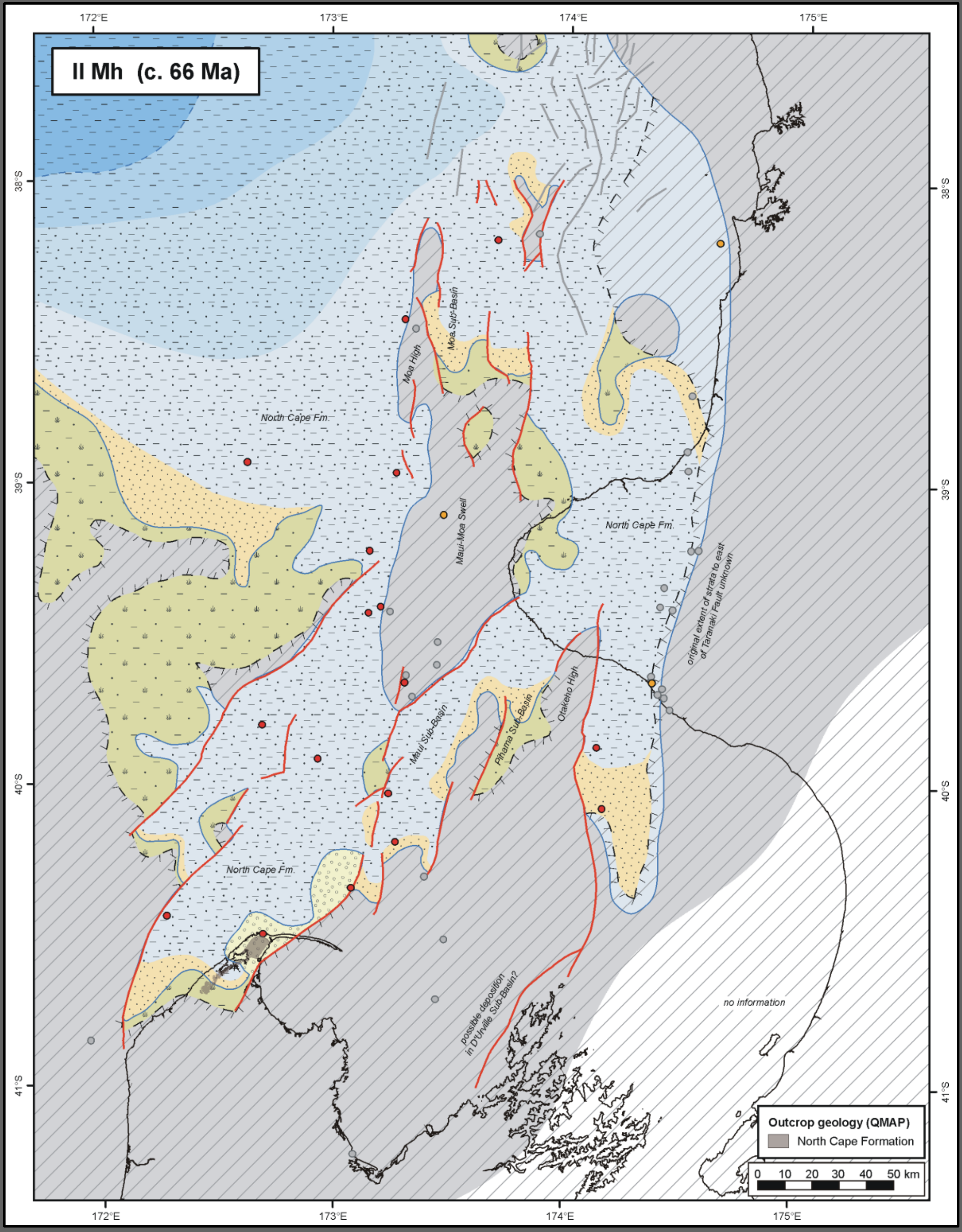


Late Cretaceous
(c. 75 Ma, Campanian)



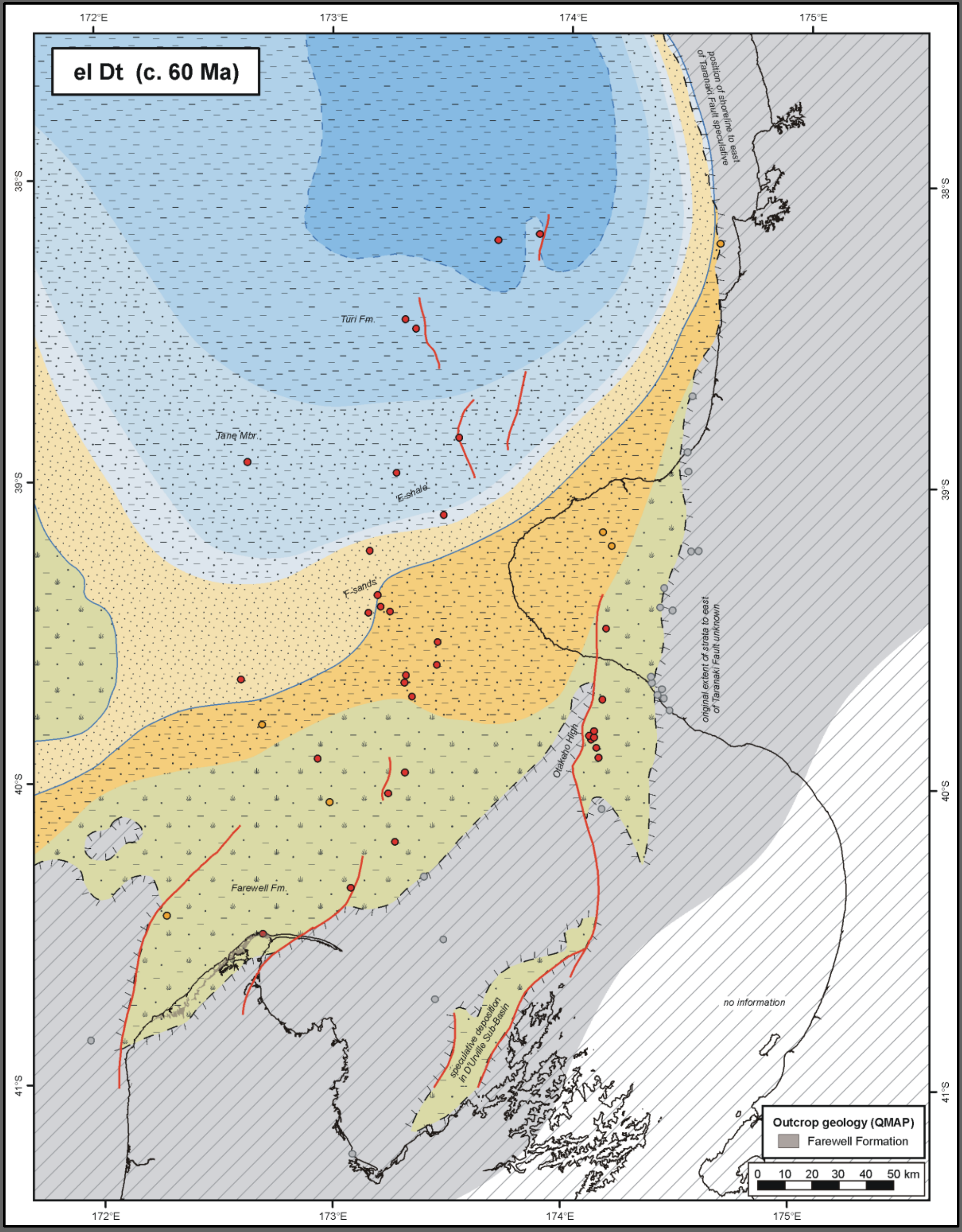
- Dominated by nonmarine deposition, with a link to marine deepwater Taranaki and Reinga basins.
- Deposition in active fault-controlled sub-basins. Absent on many highs
- Fluvial (to deltaic in the NW) sandstones form a potential reservoir, although no current discoveries at this level.
- Coals of this age (Rakopi Fm) form an important source rock unit.

latest Cretaceous
(c. 66 Ma, late Maastrichtian)

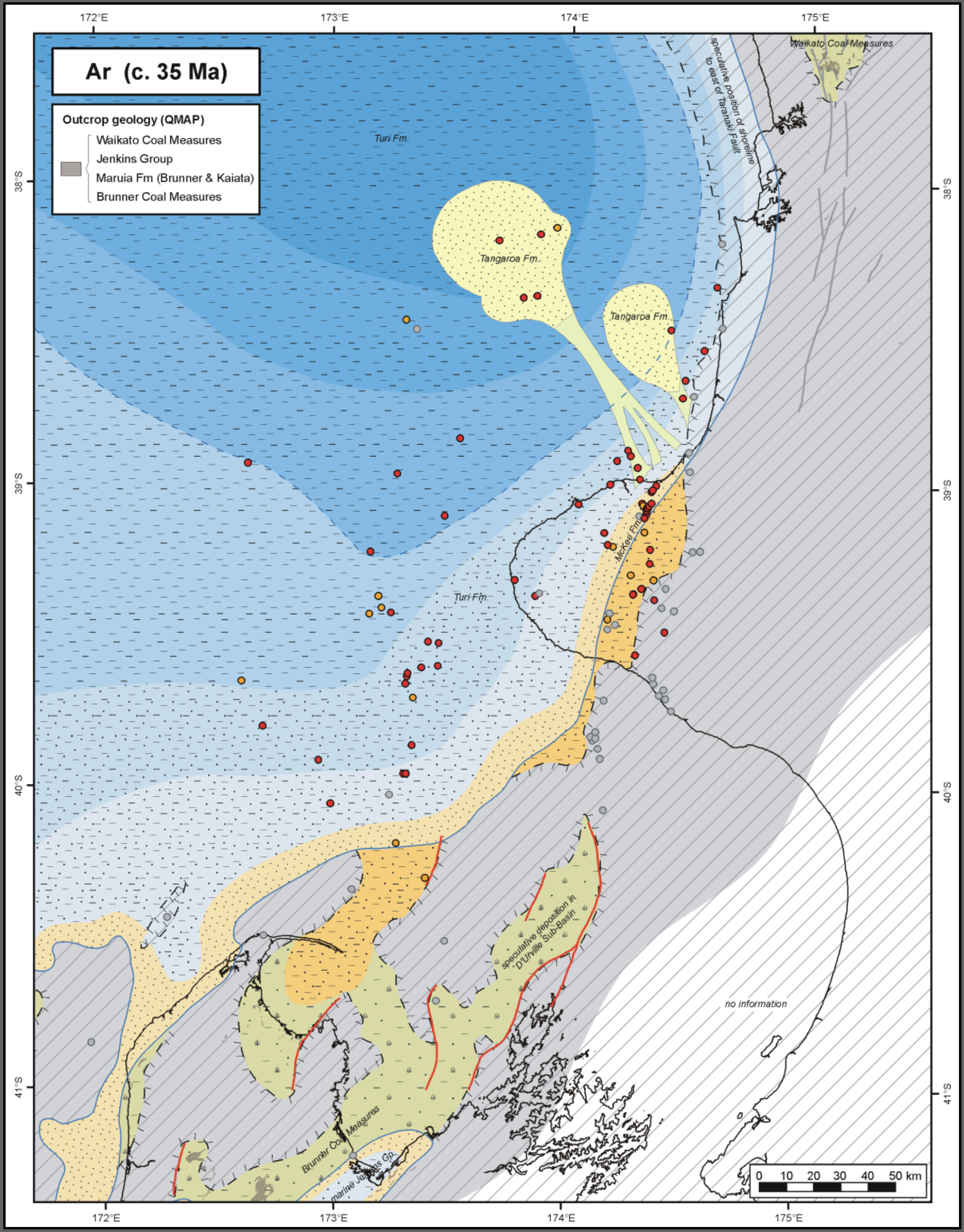


- Dominated by shallow marine deposition during latest Cretaceous marine transgression.
- Deposition in active fault-controlled sub-basins. Absent on some highs, but onlapped further than at 75 Ma.
- Although no production from this level, sandstone facies (North Cape Fm) have good reservoir potential.
- Coals in marginal areas also have source potential.

Mid-Late Paleocene
(c. 60 Ma, Selandian)

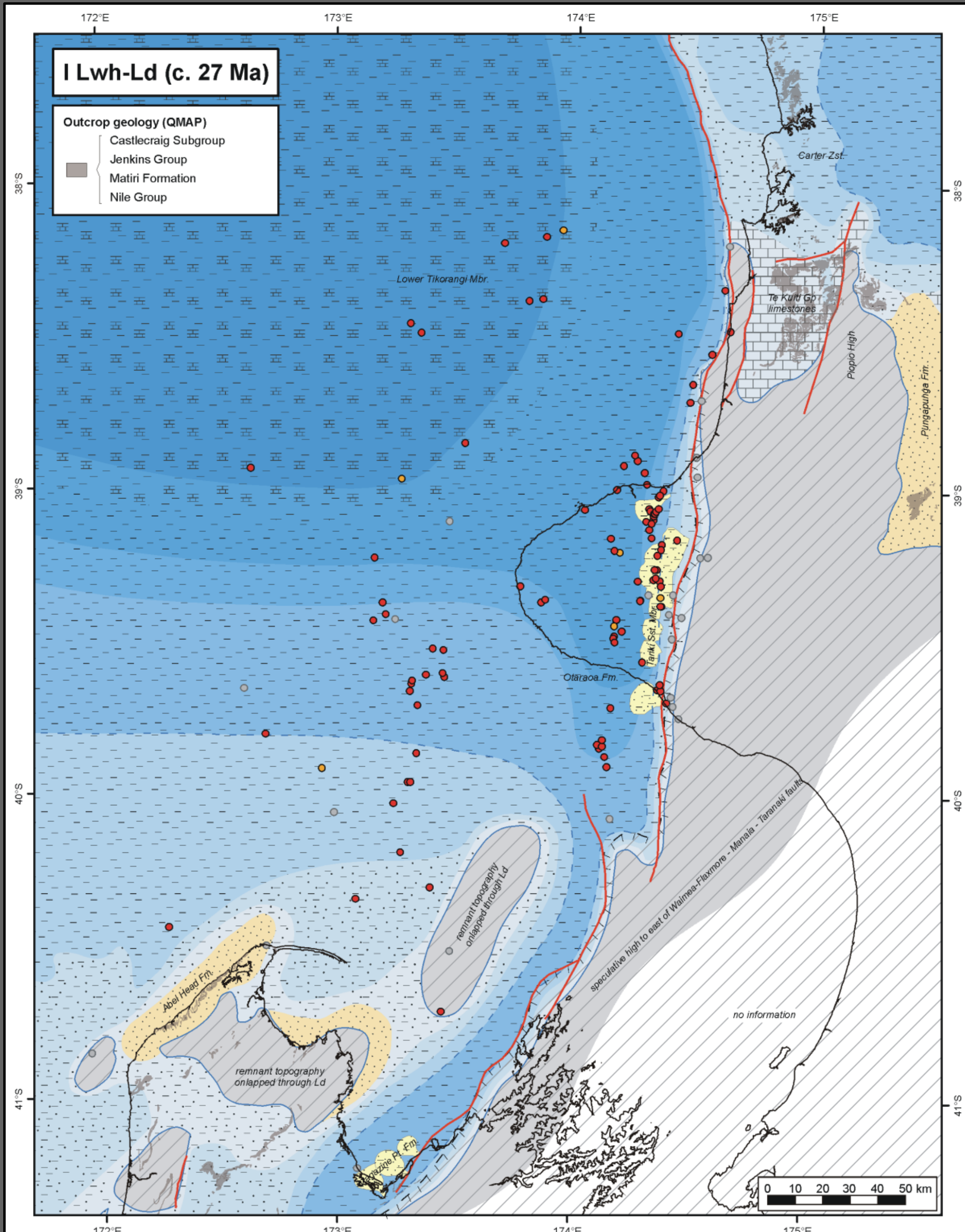


- Nonmarine through to shoreface system at head of embayment. Typical of Paleocene-Eocene.
- Paleocene active fault-controlled sub-basins in south. Passive subsidence underway elsewhere. Highs fully onlapped.
- Good reservoir potential, with production in the Tui, Maui and Kupe fields.
- Proximal coaly facies have source potential.
- Some development of Late Paleocene marine source rocks in distal areas (Waipawa facies) .



Late Eocene
(c. 35 Ma, Priabonian)

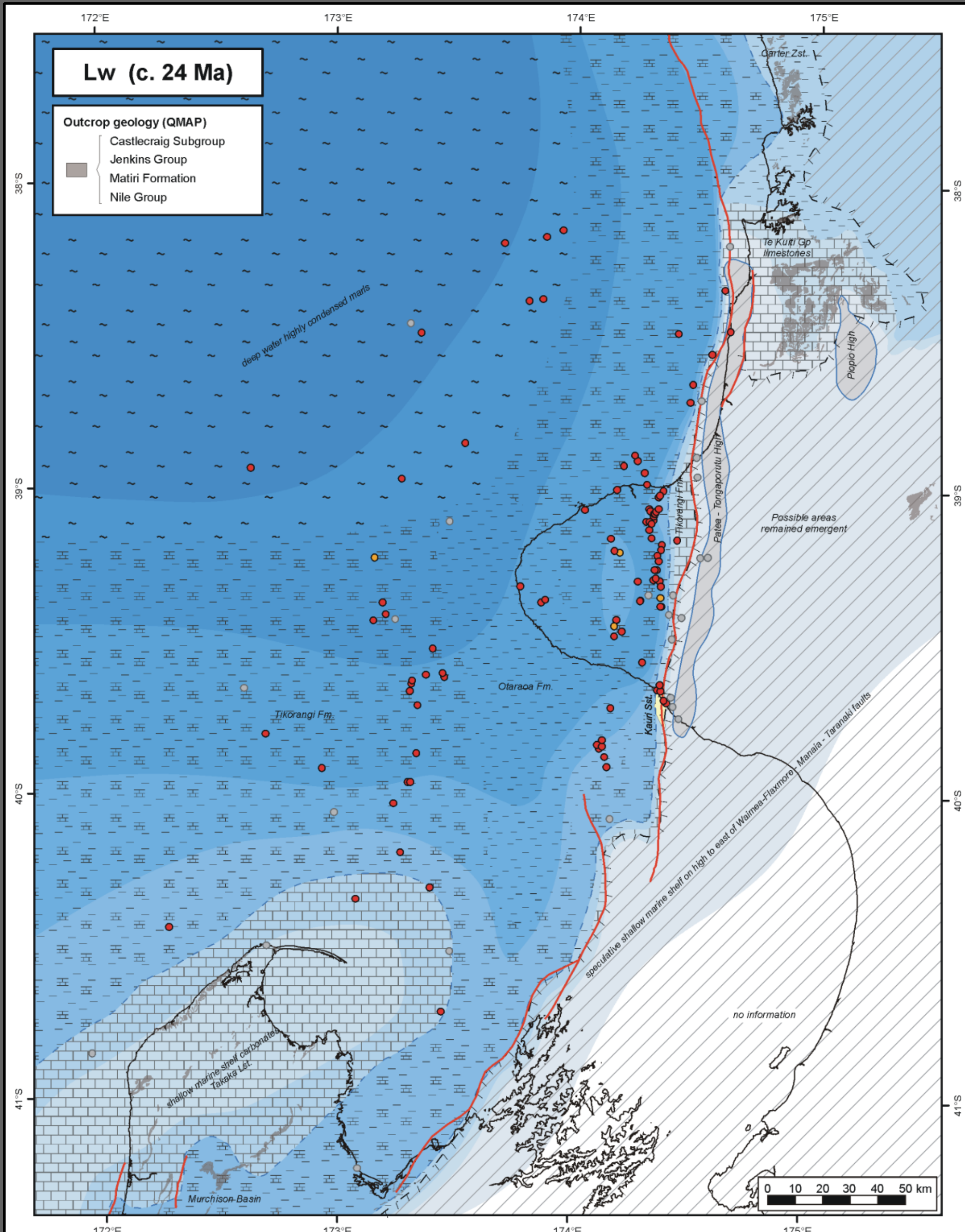
- Transgressed coastal plain through to shoreface system.
- Widespread nonmarine deposition in southern sub-basins and Waikato in NE.
- Some extensional faulting in S (related to Emerald Basin rifting?). Compression to the north in the Reinga Basin.
- Shoreface sandstones (McKee Fm) form reservoir in onshore fields.
- Deep marine fan sandstones (Tangaroa Fm) form good potential reservoirs in N (with shows).



early Late Oligocene

(c. 27 Ma, early Chattian)

- Onset of reverse movement on major faults, with formation of foredeep.
- Slope muds with local sandy fans. Condensed calcareous ooze in distal NW.
- Gradual transgression of highs away from faults, by shelfal deposits
- Fans (Tariki Sst Mbr) have good reservoir potential with production in onshore fields (TAWN, McKee).
- Distal Otaraoa/Tikorangi fms form good seals.



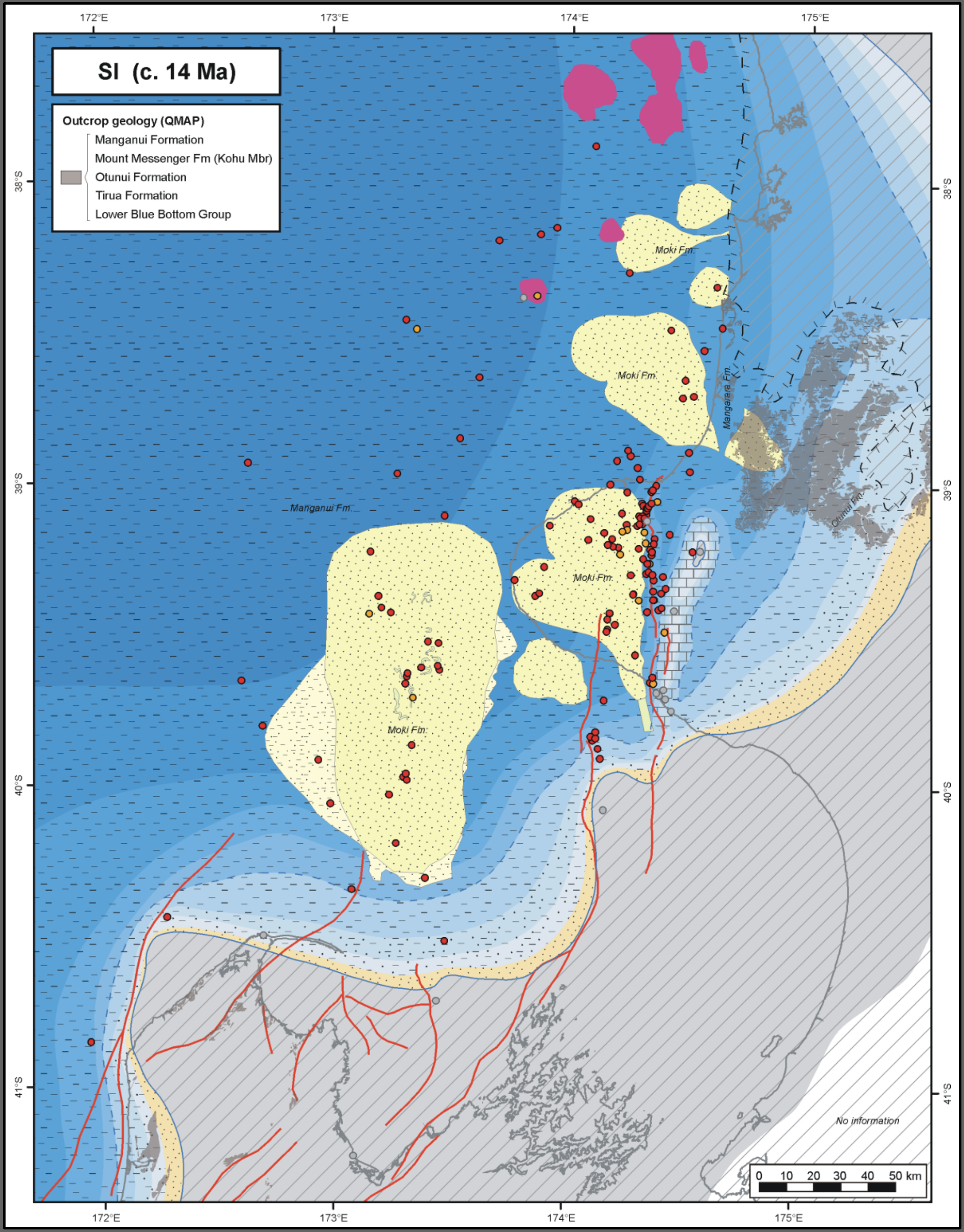
latest Oligocene-earliest Miocene

(c. 24 Ma, l Chattian-e Aquitanian)

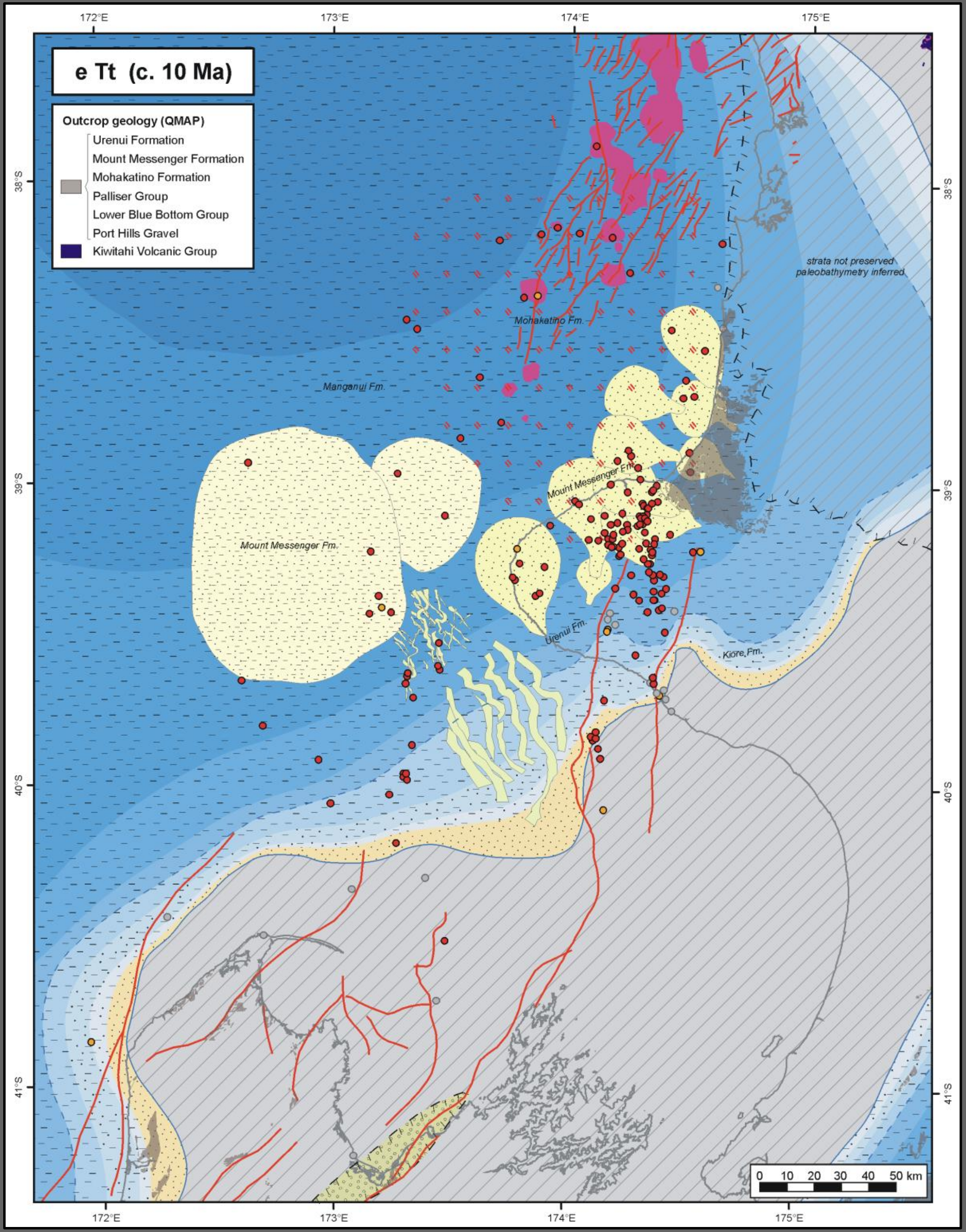
- Maximum flooding, transgression of most of study area (and also possibly of much of Zealandia?)
- Deposition dominated by carbonate facies .
- Full extent of transgression to E of TFS is unclear, as is the extent of surviving highs.
- Resedimented carbonates (Tikorangi Fm) form reservoirs in onshore fields.
- Distal facies forms good seal across much of basin.

Middle Miocene

(c. 14 Ma, Langhian-Serravillian)



- Slope to basinal muds with development of basin-floor fans.
- Significant inversion in SW and start of progradation of shelf and shoreline to N.
- Volcanism in north.
- Moki Fm fans have good reservoir potential (Maari, Ngatoro, Kaimiro fields).

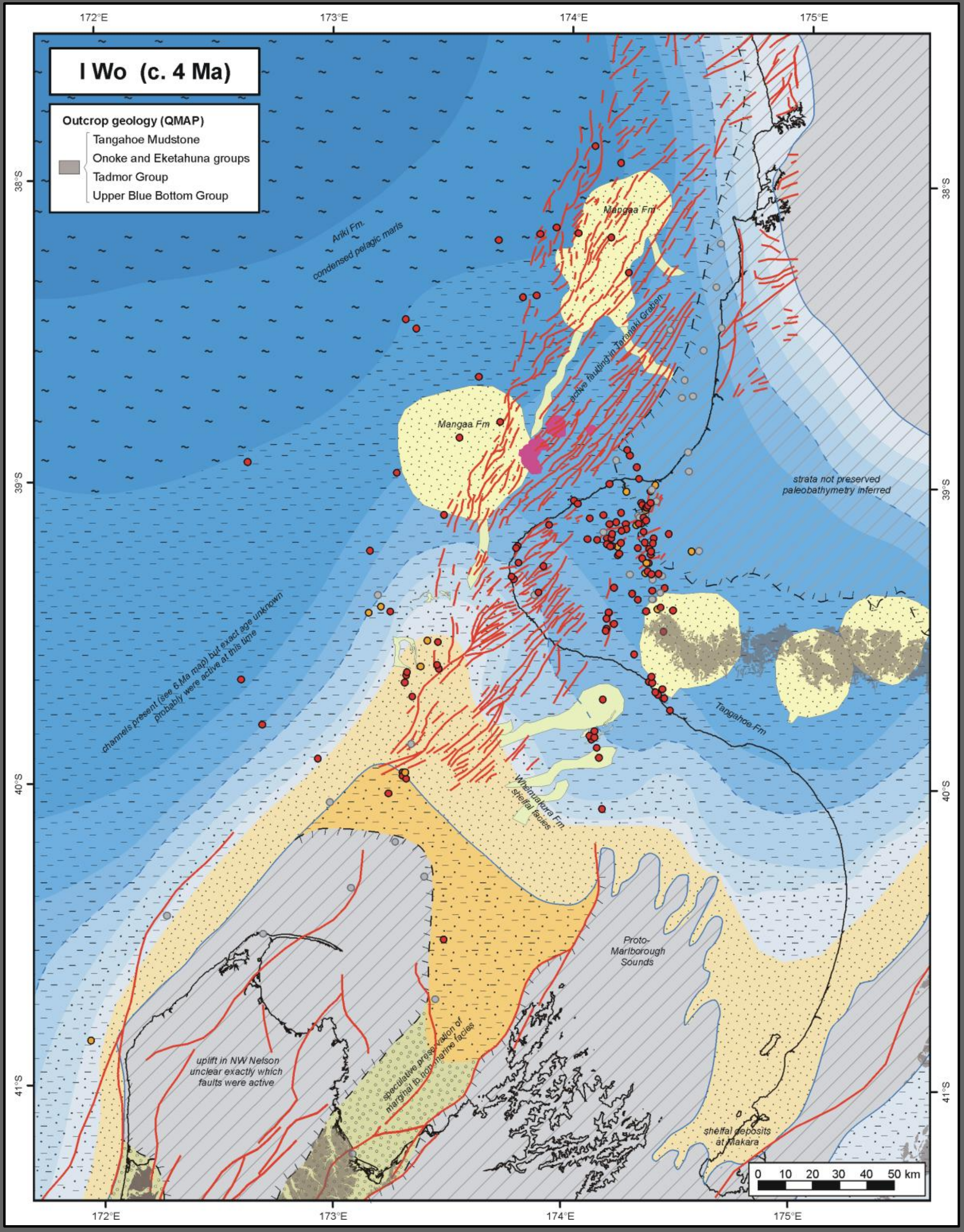


early Late Miocene

(c. 10 Ma, early Tortonian)

- Slope-shelf system rapidly prograding out into deep basin.
- Change from N to NW sediment transport.
- Mudstone dominated, but with basin-floor fans and slope channel systems.
- Mount Messenger Formation fans and Urenui Fm slope channels systems form good reservoirs in numerous onshore fields.
- Volcaniclastic fans (Mohakatino Fm) also have reservoir potential.

Early Pliocene
(c. 4 Ma, late Zanclean)



- Major subsidence in E (Wanganui Basin) and Northern Graben.
- Deposition of slope-basinal muds with submarine fans. Condensed marls in NW.
- Southward jump and spread in active extension in Northern and Central grabens and die-off in volcanism.
- Mangaa Fm fans form good potential reservoirs (e.g., Karewa Field).

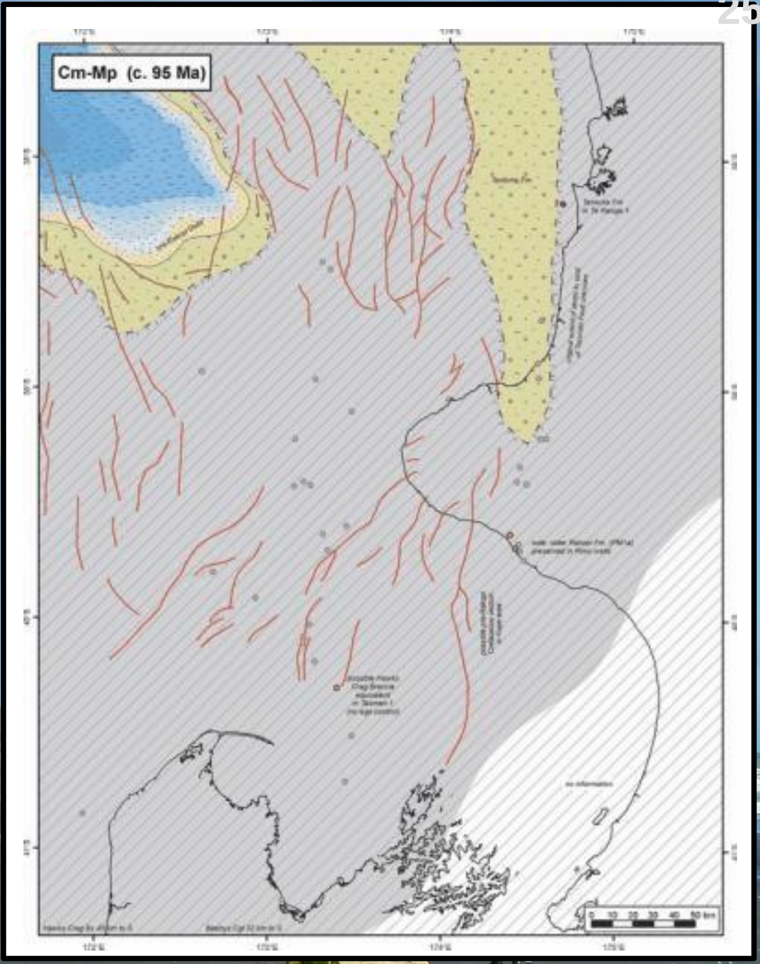
Discussion

- Taranaki Basin has a complex history – with Cretaceous (to Paleocene) rifting and a transition to passive thermal subsidence in the Paleogene.
- Inversion from the Oligocene, more severe in Neogene. Restricted to eastern areas, more proximal to plate boundary.
- Complex interaction of extension, and associated volcanism, in N, and compression in S through Neogene. The transition from extension to compression has moved south through time.
- Cretaceous-Paleogene nonmarine to shallow marine strata form good potential reservoirs, with associated coals providing the majority of potential source rocks.
- Oligocene-Neogene fans/slope channel systems also provide well tested reservoirs.

Conclusions

- A new suite of regional paleogeographic maps (32) has been produced for the Taranaki Basin and surrounding areas, spanning the Late Cretaceous to present.
- These greatly expand in area and detail on the previous set of regional maps and incorporate large quantities of new well and outcrop data.
- For the first time, these maps incorporate seismic-attribute mapping, allowing more accurate delineation of facies. This is especially important in areas with limited well control.
- These maps allow better prediction of important aspects of the petroleum system, such as the distribution of source and reservoir facies and should improve analysis of potential plays.

Thank you!



For more information on New Zealand geology see the GNS website: http://www.gns.cri.nz/
and the in particular the Petroleum Basin Explorer website: http://data.gns.cri.nz/pbe

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