

Depositional Framework of Petroleum Systems, Browse Basin, Offshore North West Shelf, Australia*

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Search and Discovery Article #11026 (2017)**

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Abstract

The Browse Basin is a proven hydrocarbon province hosting gas with associated condensate on Australia's North West Shelf. Geoscience Australia has undertaken a multi-disciplinary study to identify the various hydrocarbon sources and high-graded areas of increased liquids prospectivity within a primarily gas-prone province. Updated biostratigraphy, well correlations, seismic and paleogeographic and play fairway interpretations were completed for ten Hettangian to Maastrichtian supersequences. These data together with geochemical analyses were integrated into a regional petroleum systems model to better understand source rock distribution, character, generation potential, and play prospectivity. Isochore maps and depositional environmental models suggest multiple source rock units in compartmentalised Jurassic–Cretaceous source pods resulting in four geochemically distinct petroleum systems. Source pod location is influenced by regional basin architecture and entrenched fluvial systems forming a complex network of sedimentary inputs to the basin. Gas generated by the Lower–Middle Jurassic source rocks within the J10–J20 supersequences (Plover Formation) have migrated through the basin and accumulated at multiple stratigraphic levels. The Jurassic J10–J50 supersequences (Plover and lower Vulcan formations) in the Heywood Graben have generated fluids of a different composition to those elsewhere in the basin, and are most similar to a petroleum system in the neighbouring Bonaparte Basin. Gases with the highest liquid content are reservoired within the K10 supersequence (Brewster Member, Vulcan Formation) in the Ichthys/Prelude and Burnside accumulations. These fluids are probably sourced by shales of the Upper Jurassic–Lower Cretaceous J40–K10 supersequences (Vulcan Formation) encasing the K10 sandstone reservoir. Marine Lower Cretaceous source rocks in the K20–K30 supersequences (Echuca Shoals Formation) have sourced oil and gas in Cretaceous reservoirs of the Caswell Sub-basin and on the Yampi Shelf. The latter accumulations contain a mixture of Cretaceous oil mixed with gas generated by higher maturity Jurassic source rocks. A proposed scenario is that these Cretaceous-sourced liquids were mobilised and carried to the shelf edge by co-migrating Plover-derived gas with subsequent biodegradation and leakage. These results open up shallow liquid-prone plays, in the southern Caswell Sub-basin and on the basin margins.

References Cited

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Australian Government

Geoscience Australia

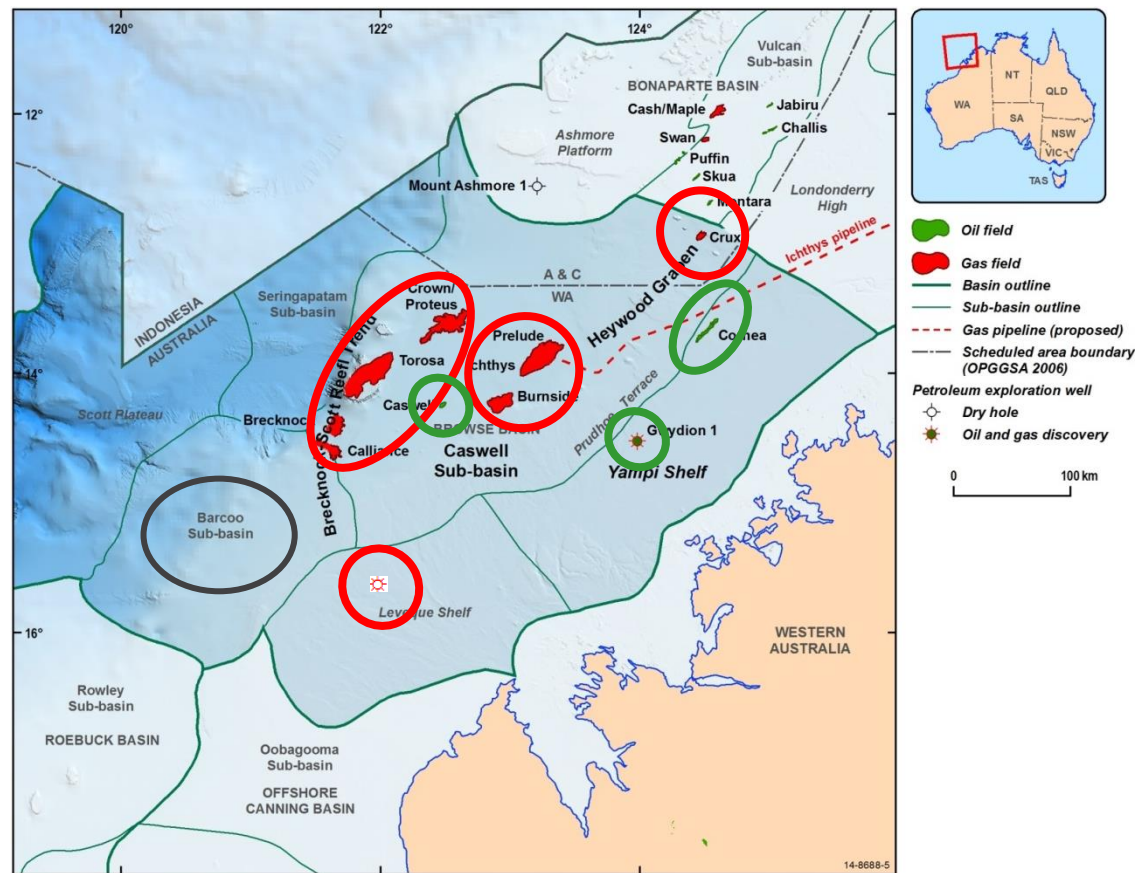


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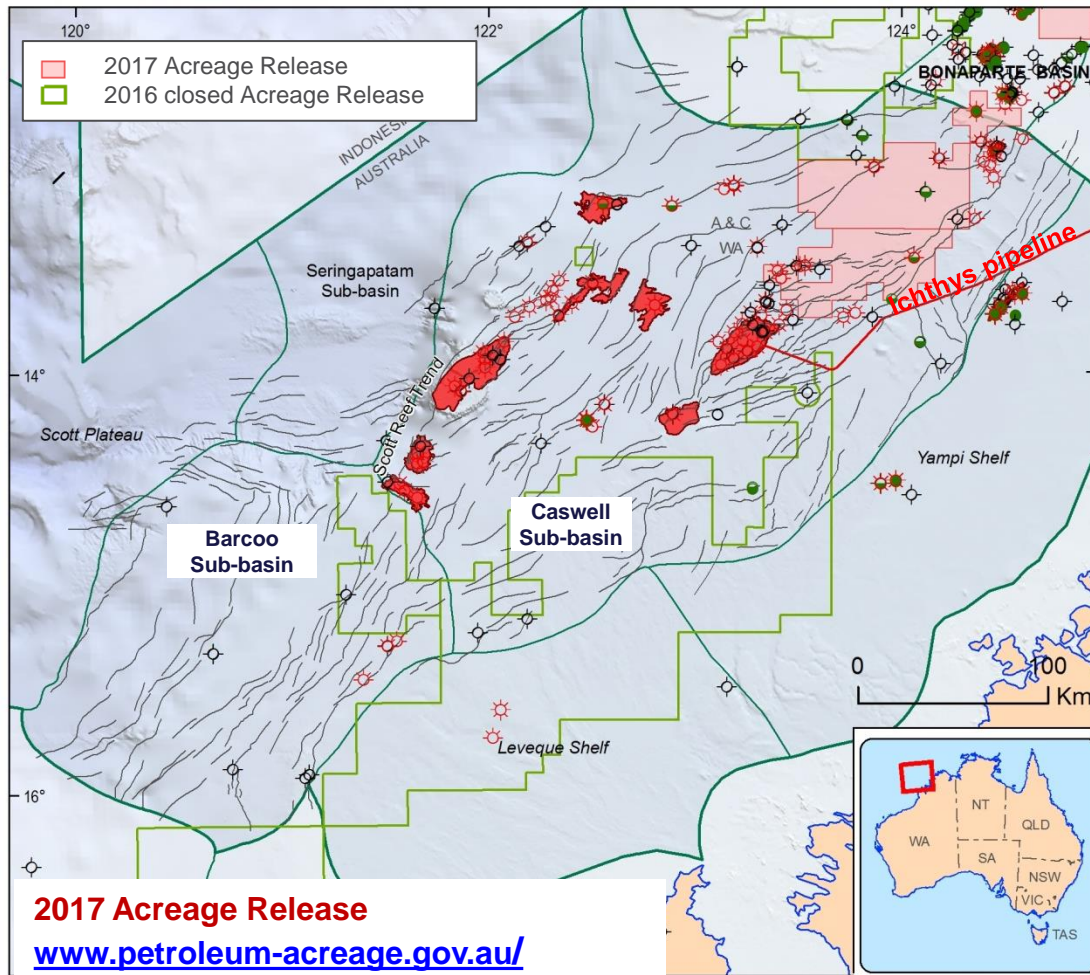
Browse Basin oil and gas accumulations



- Large undeveloped gas resources
- Gas accumulations in Calliance/Brecknock/Torosa, Ichthys/Prelude and Crux
- Ichthys/Prelude currently under development for LNG production
- Oil accumulations:
 - Caswell 1 and 2
 - Cornea/Gwydion 1: biodegraded

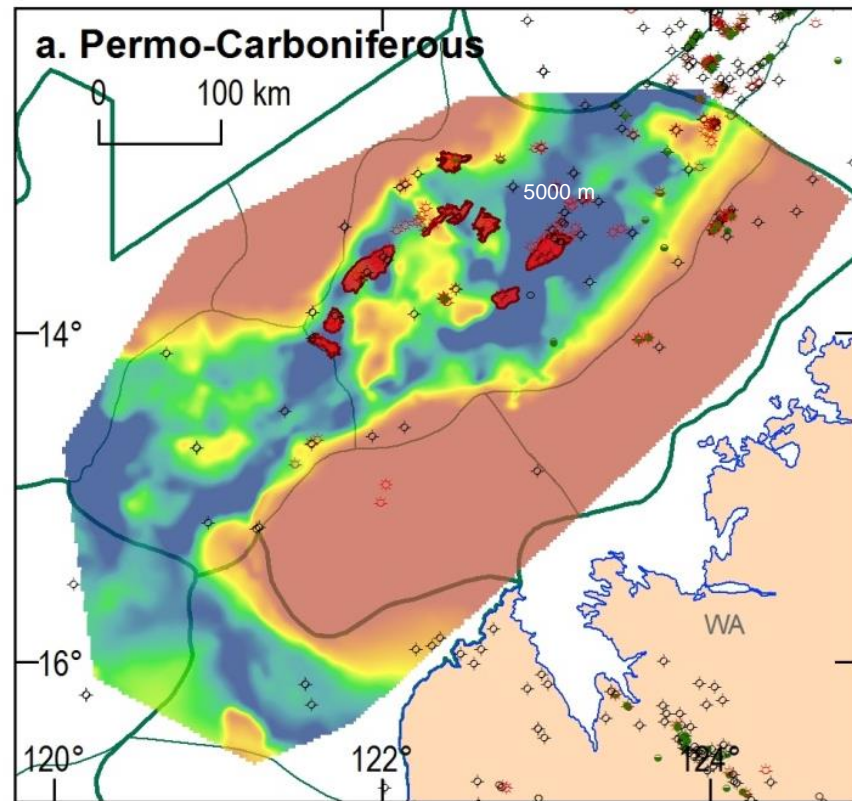
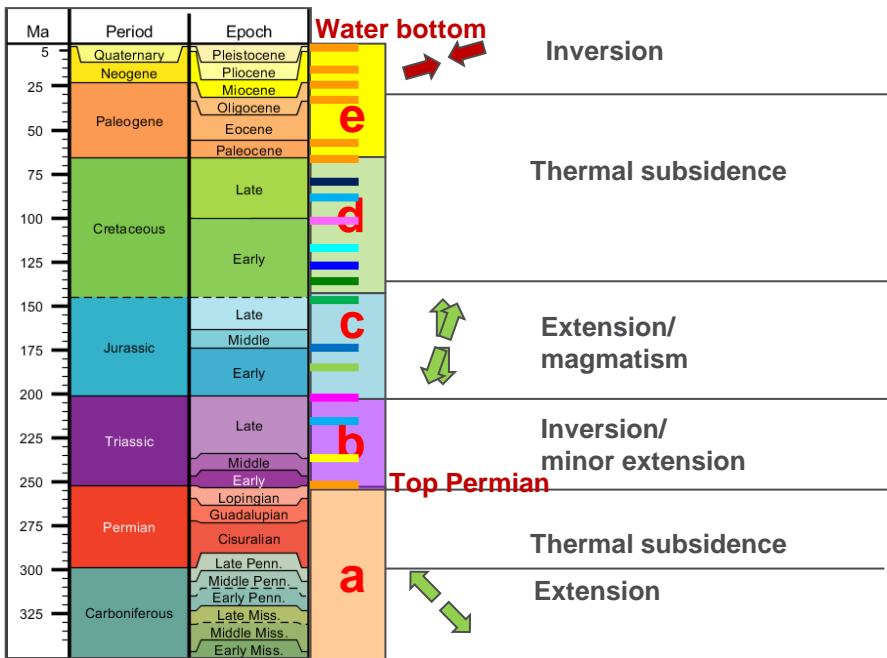
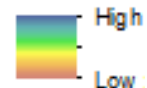
Study Aims

- GA has recently completed a regional prospectivity study
- Integrate palaeogeography, geochemical & petroleum systems analysis to understand the source rocks characteristics and origin of hydrocarbon fluids
- High-grade areas with increased oil and gas prospectivity



Regional sediment deposition through time

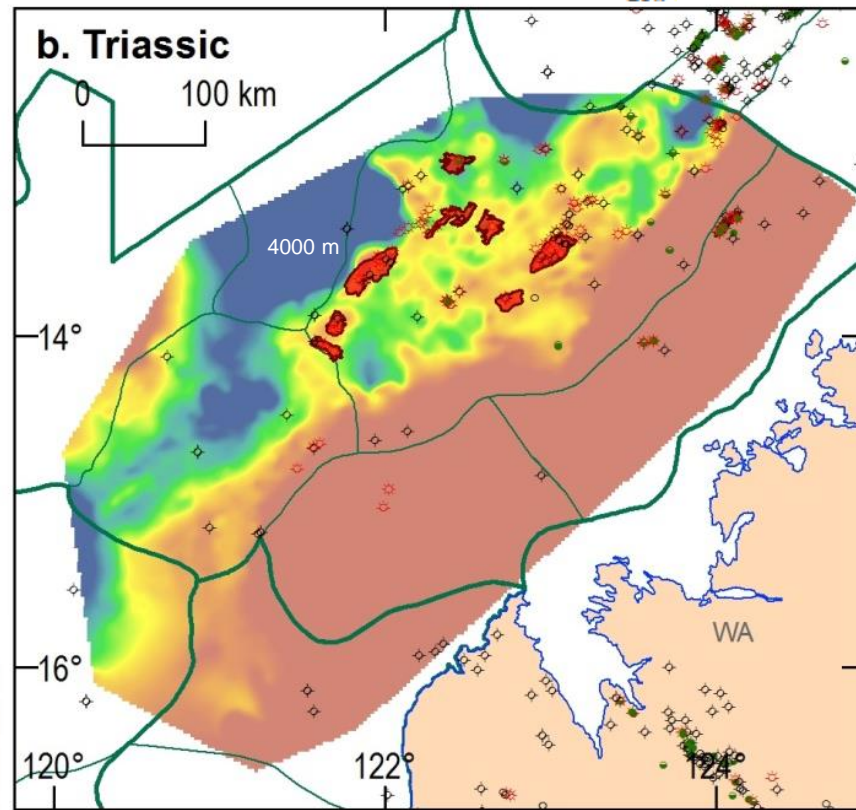
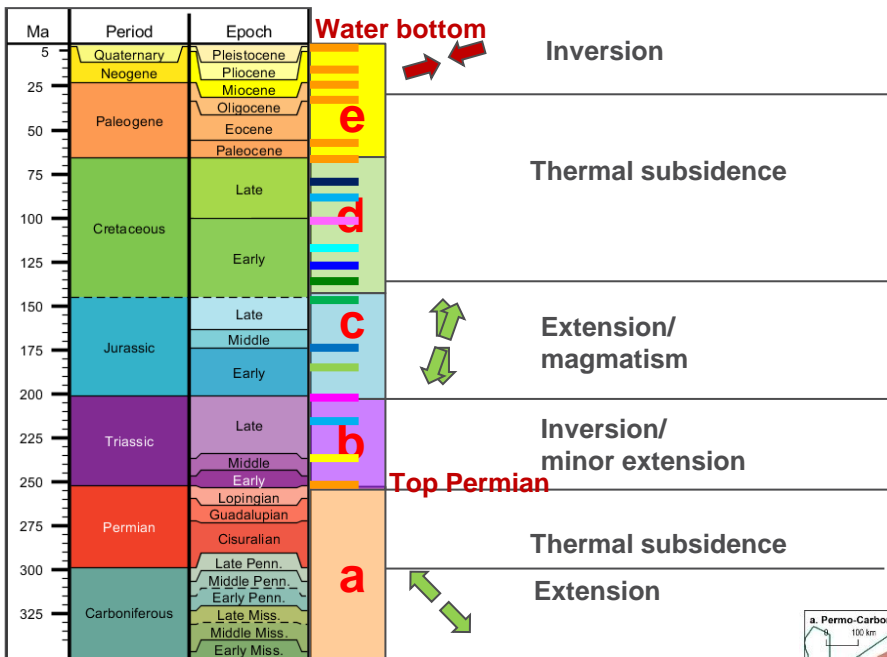
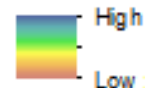
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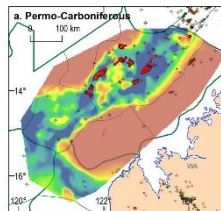
Some input into the Jurassic and older seismic horizon interpretation has been procured from Bradshaw Geoscience Consultants

Regional sediment deposition through time

Thickness

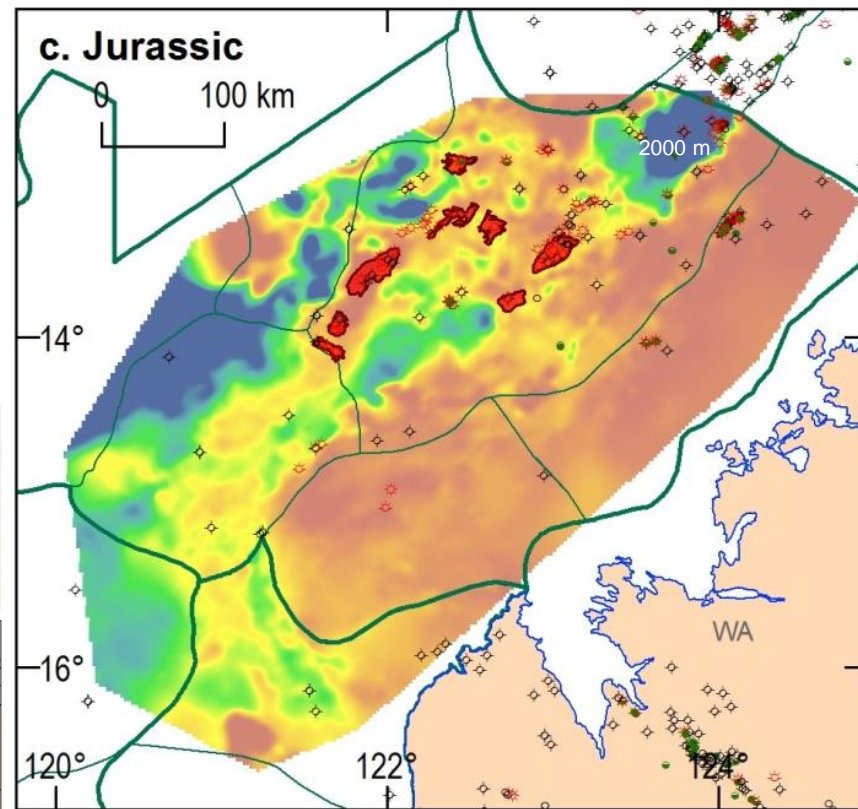
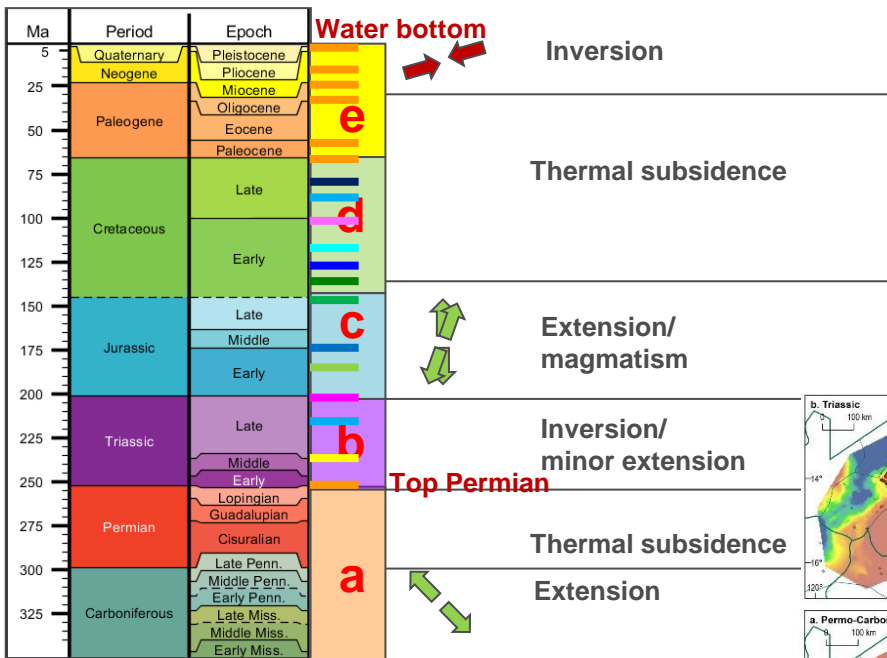
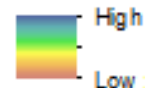


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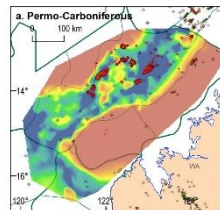
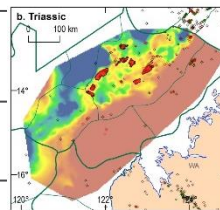


Regional sediment deposition through time

Thickness

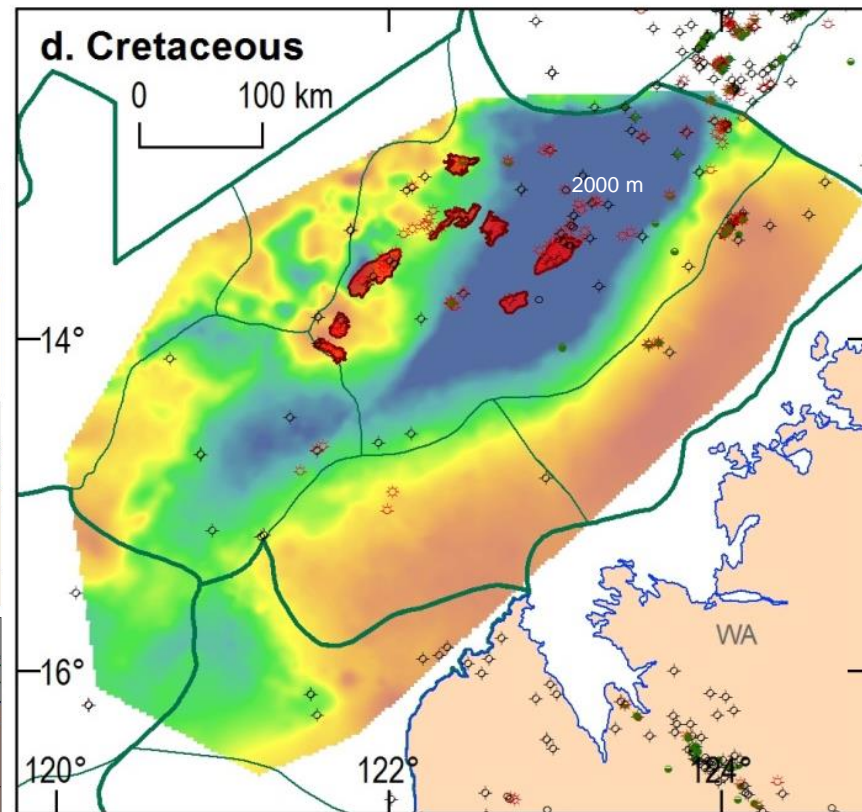
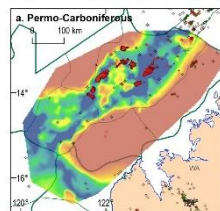
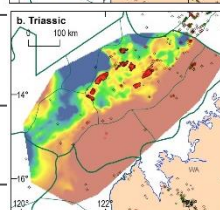
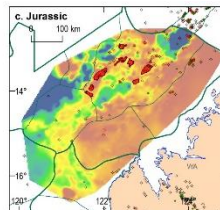
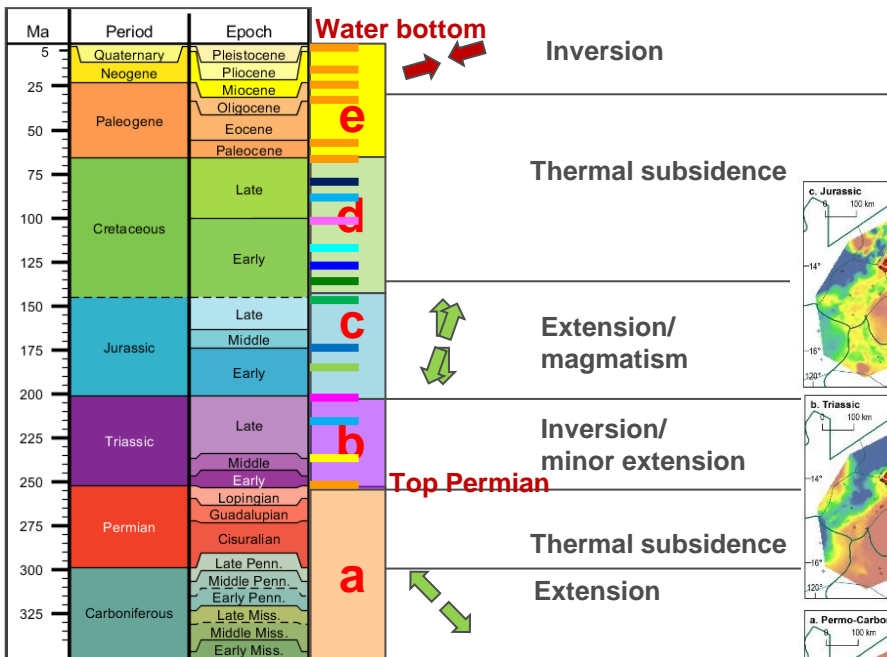
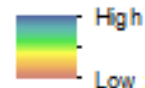


Some input into the Jurassic and older seismic horizon interpretation has been procured from Bradshaw Geoscience Consultants



Regional sediment deposition through time

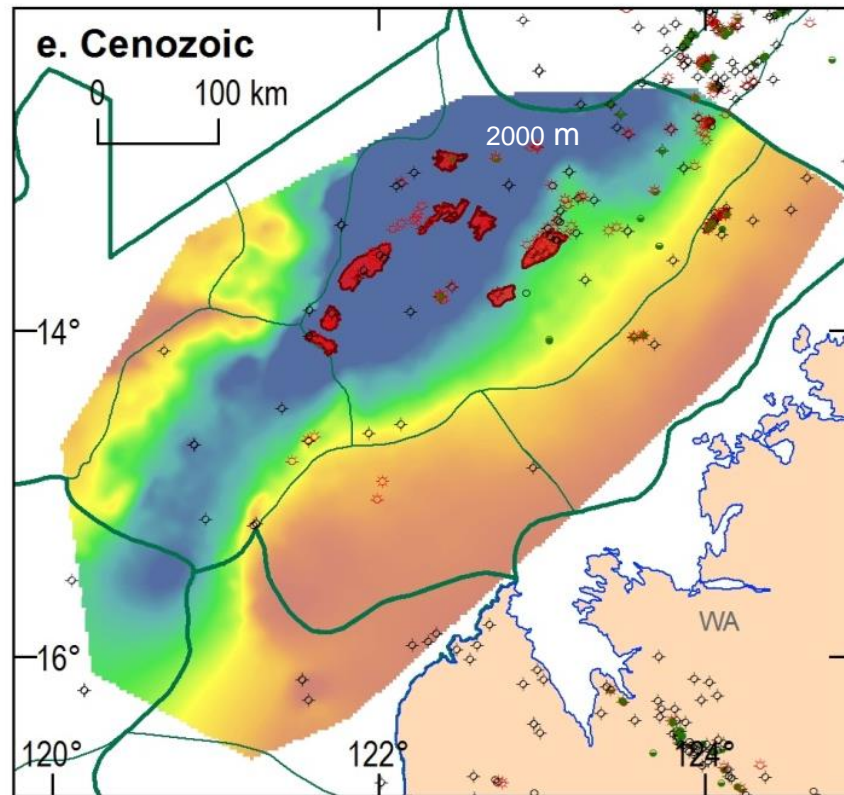
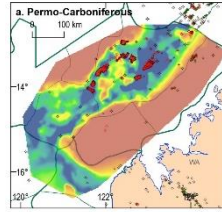
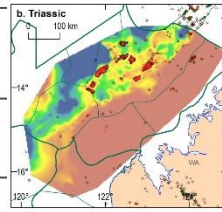
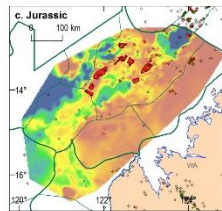
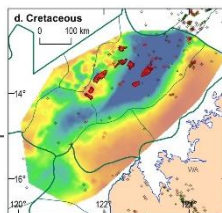
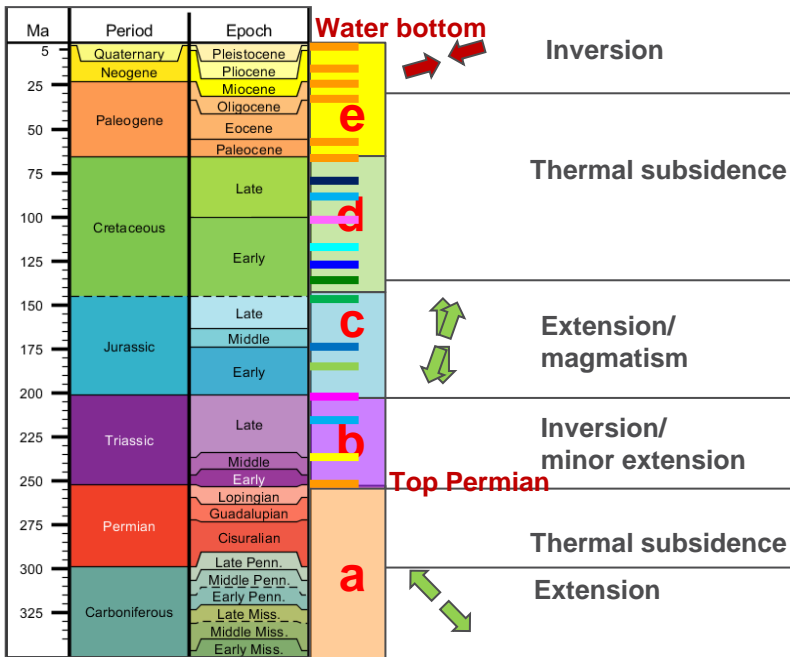
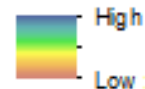
Thickness



Some input into the Jurassic and older seismic horizon interpretation has been procured from Bradshaw Geoscience Consultants

Regional sediment deposition through time

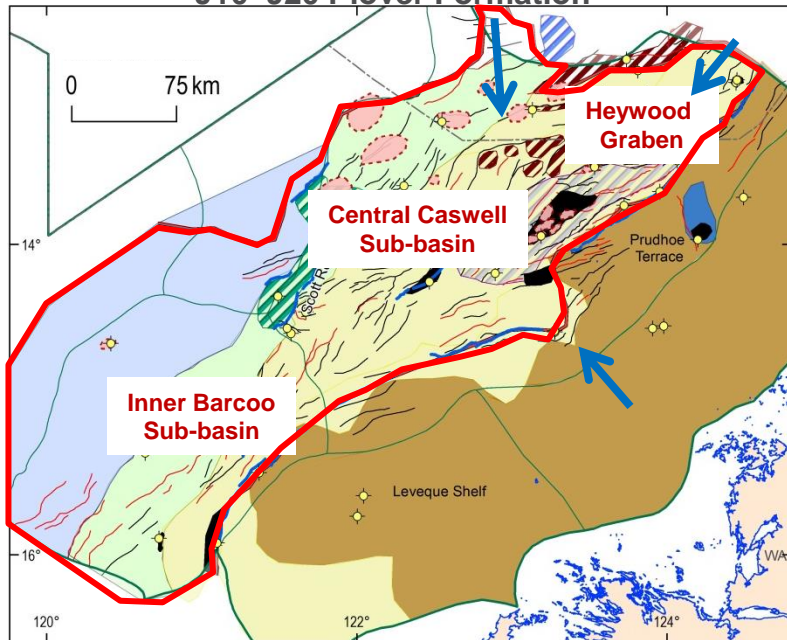
Thickness



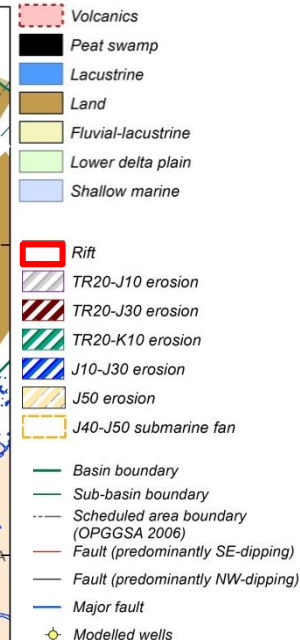
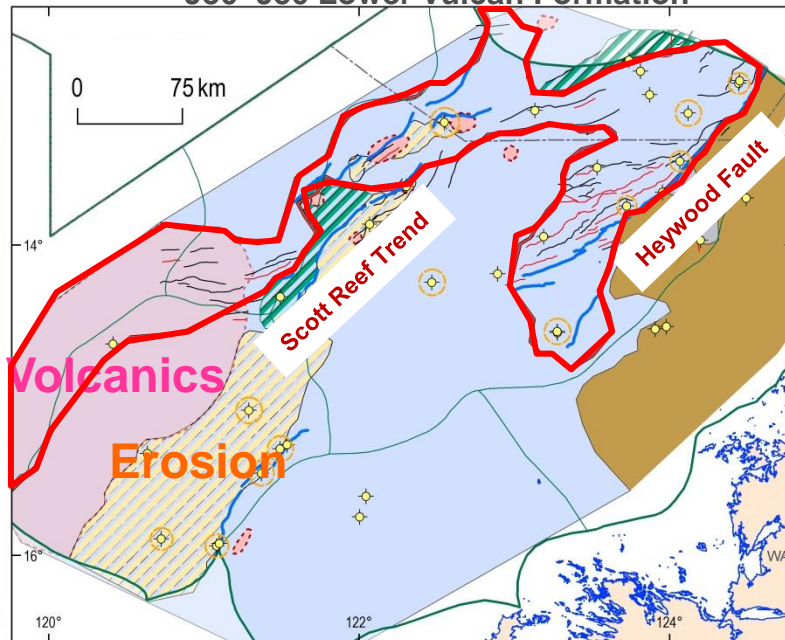
Some input into the Jurassic and older seismic horizon interpretation has been procured from Bradshaw Geoscience Consultants

Palaeogeographic mapping – Jurassic

Early–Middle Jurassic fluvial-deltaic
J10–J20 Plover Formation



Late Jurassic marine
J30–J50 Lower Vulcan Formation



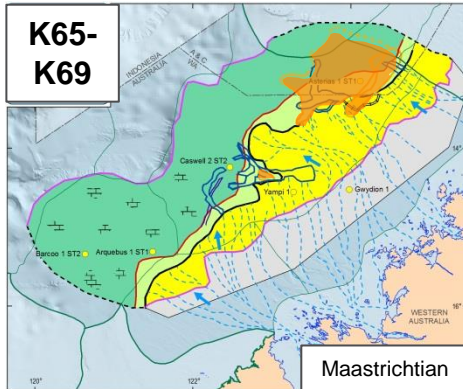
From Rollet et al., submitted AEGC 2018

→ Insights into spatial and temporal distribution of reservoirs, seals and source rocks

Palaeogeographic mapping – Cretaceous

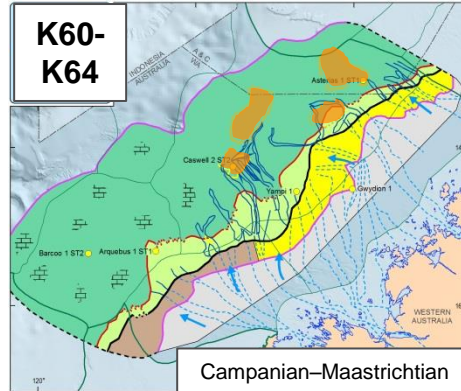
-  Basin floor (mud prone)
-  Calcareous/marl
-  Slope (silt/mud prone)
-  Shelf, coastal and fluvial (sand prone)
-  Erosion/non-deposition
-  Shelf, coastal and fluvial (mud prone)
-  Basal sands (predom. submarine fan)
-  Submarine canyon

K65-K69



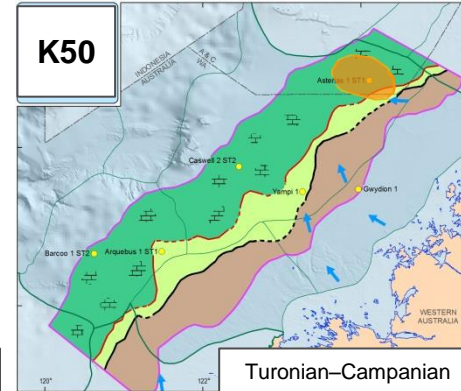
Maastrichtian

K60-K64



Campanian-Maastrichtian

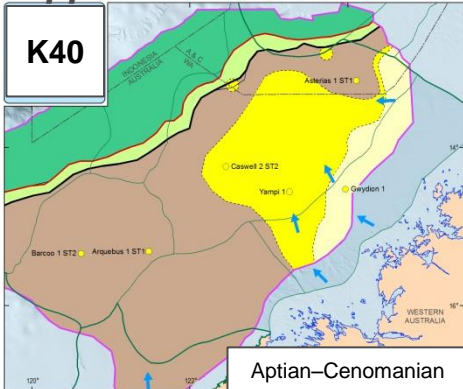
K50



Turonian-Campanian

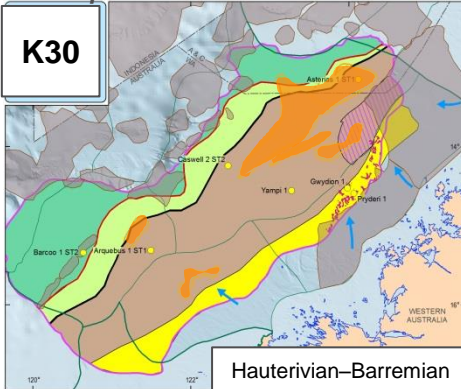
Upper Cretaceous – more sand-prone

K40



Aptian-Cenomanian

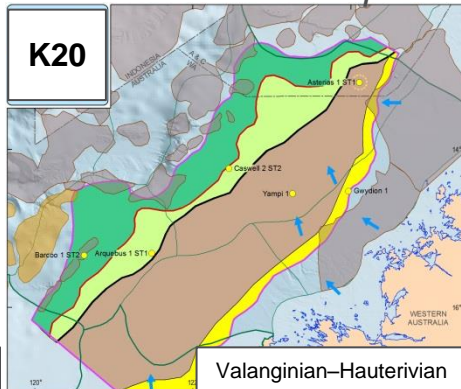
K30



Hauterivian-Barremian

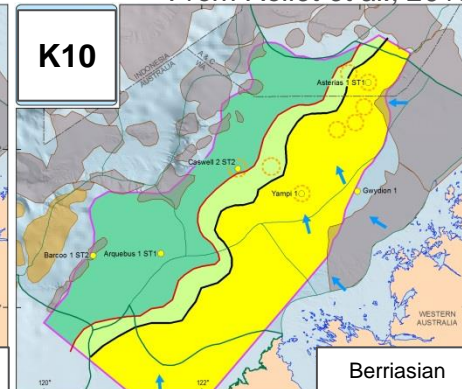
Lower Cretaceous – more mud-prone

K20



Valanginian-Hauterivian

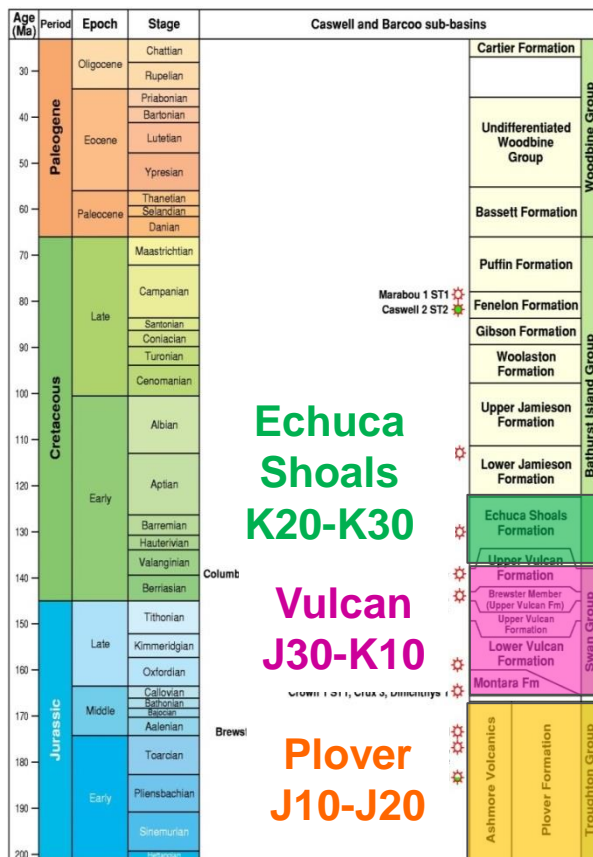
K10



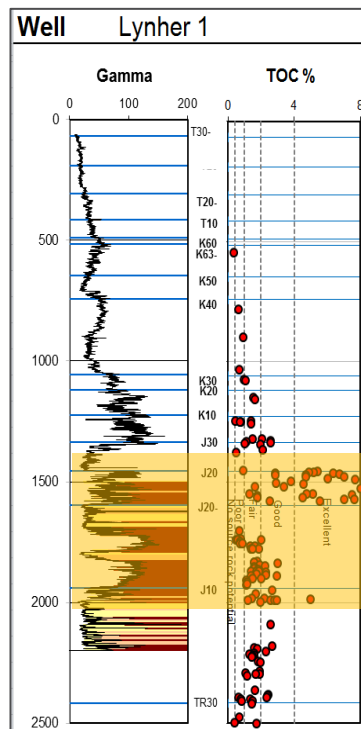
Berriasian

From Rollet et al., 2016

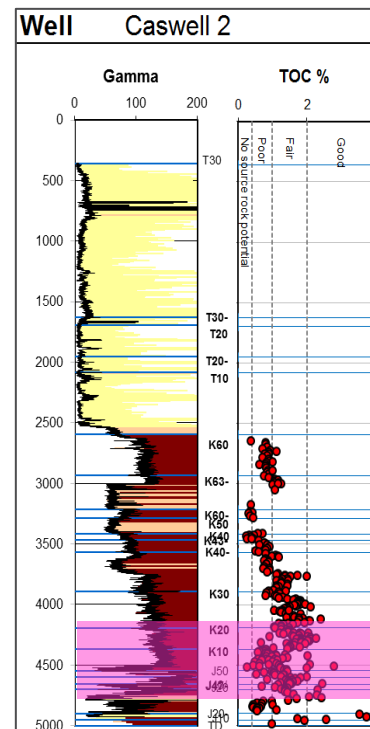
Source rocks (TOC, HI, kinetics)



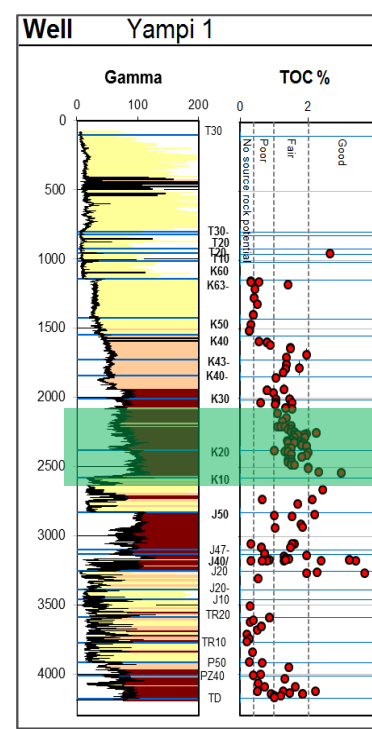
J10-J20
Plover



J30-K10
Vulcan

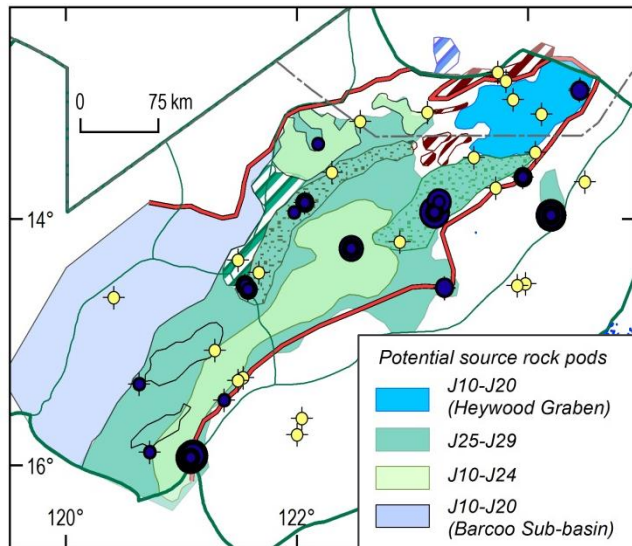


K20-K30
Echuca Shoals

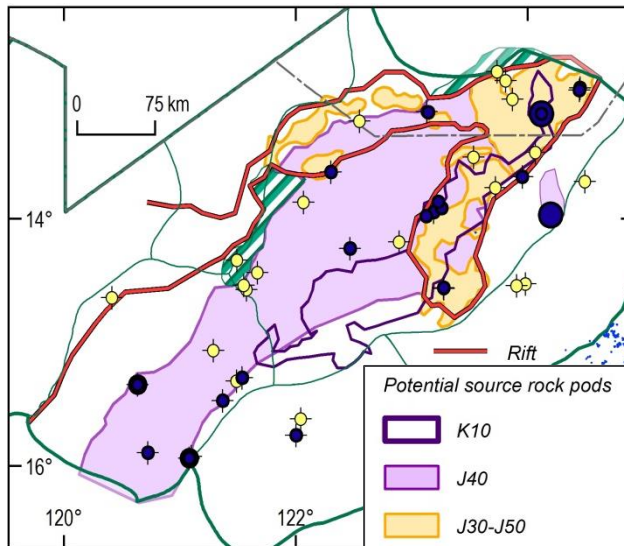


Source rocks distribution

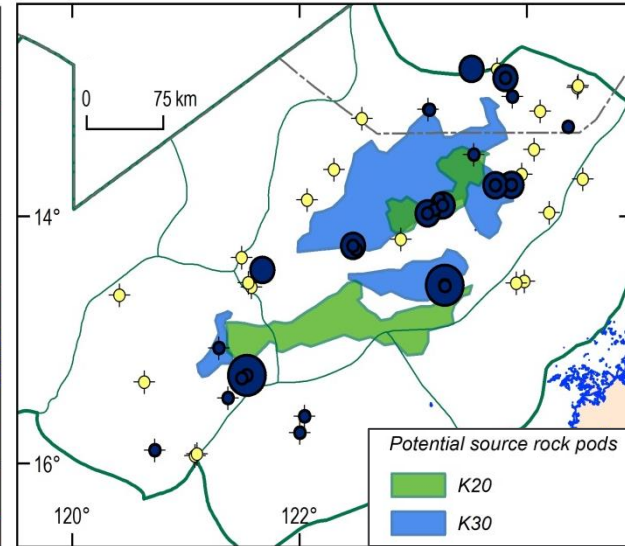
J10–J20 Plover



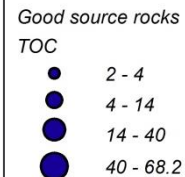
J30–K10 Vulcan



K20–K30 Echuca Shoals

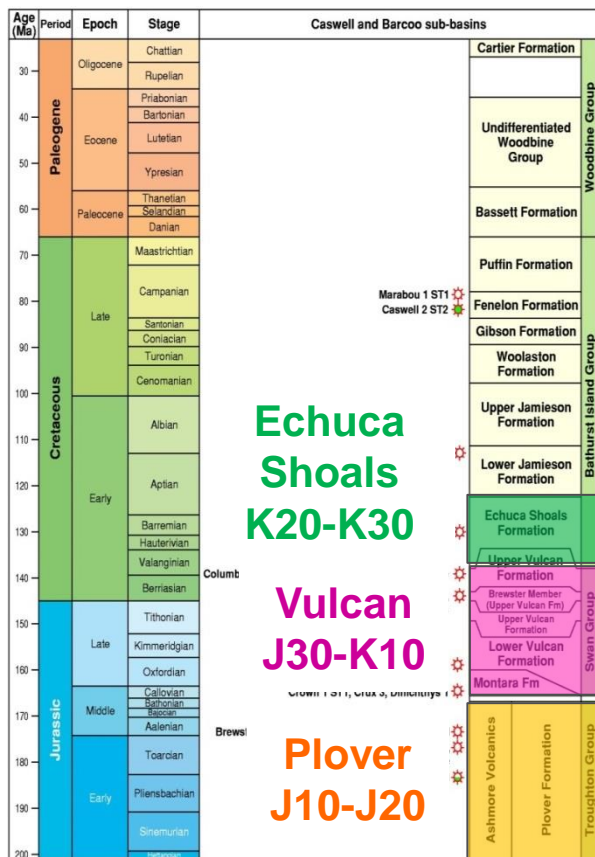


- Contribution to the known hydrocarbon accumulations and charge history

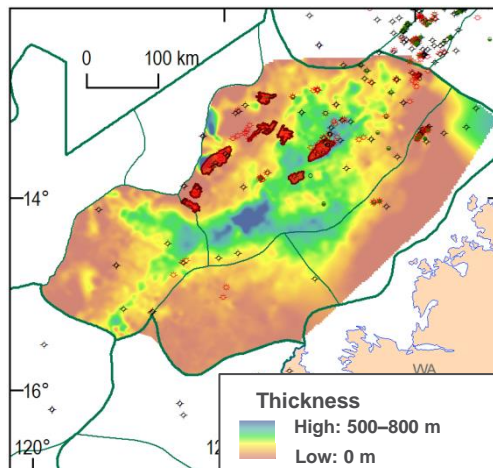


Source rocks

Regional 3D geological model based on new seismic interpretation and sequence framework

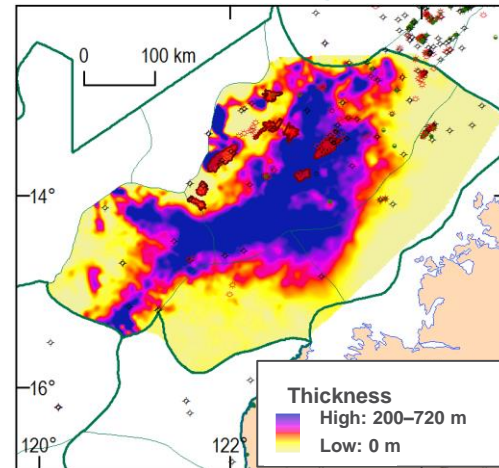


Total sequence thickness map



K20-K30
Echuca Shoals

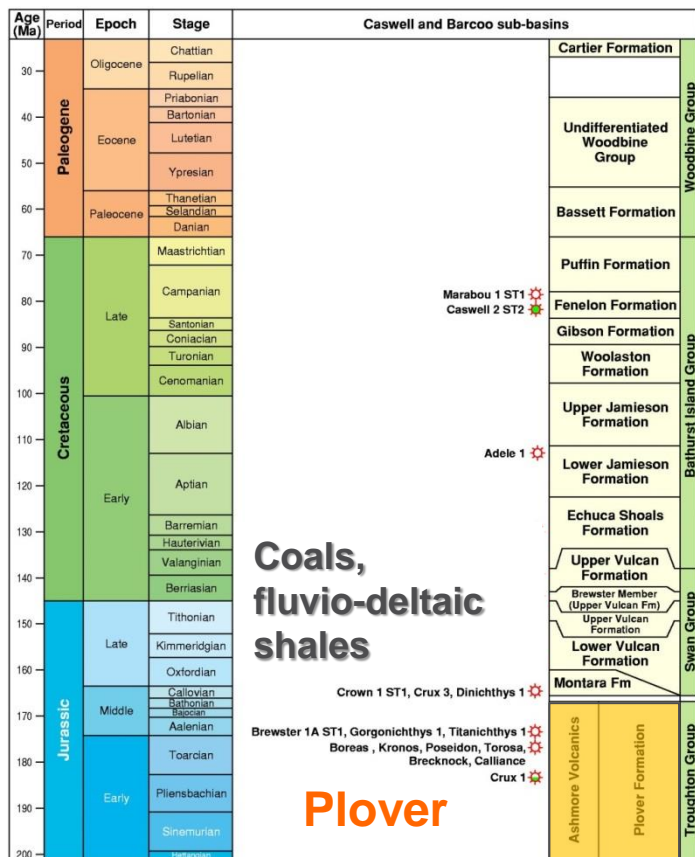
Estimated shale thickness map (in progress)



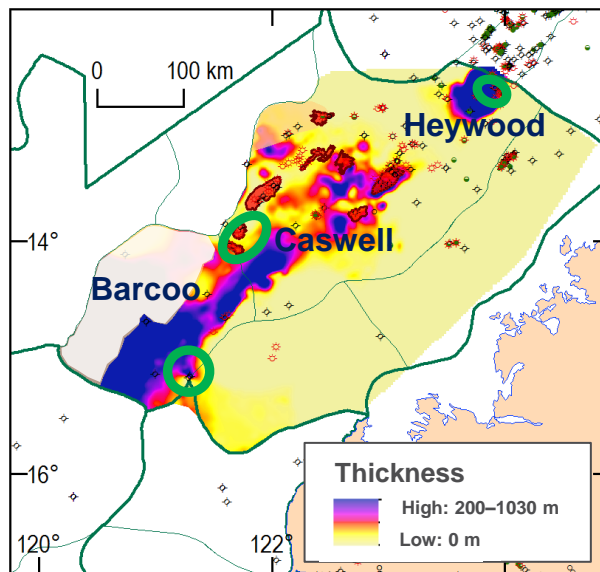
K20-K30
Echuca Shoals

- Shale thickness maps estimated based on lithological constraints from 60 wells and sequence thickness maps

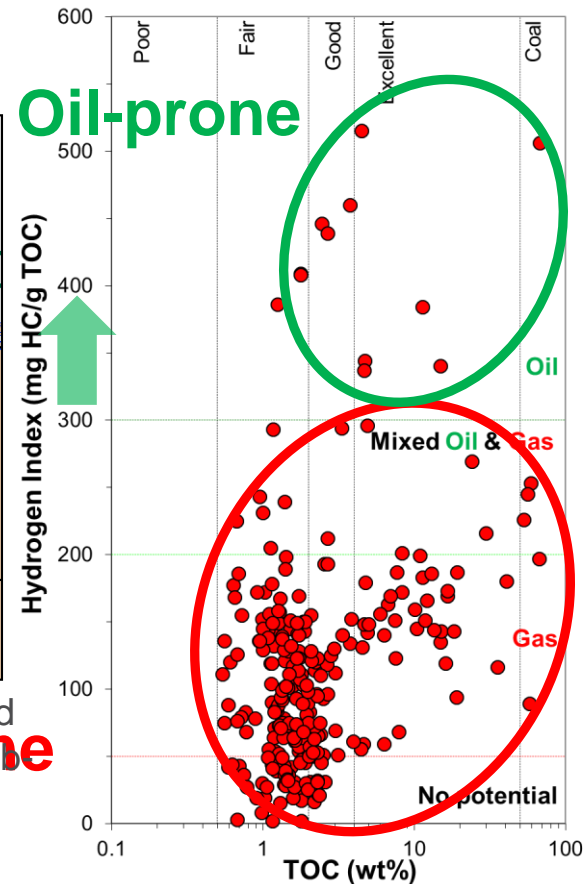
Source Rocks: J10–J20 supersequences (Plover Fm)



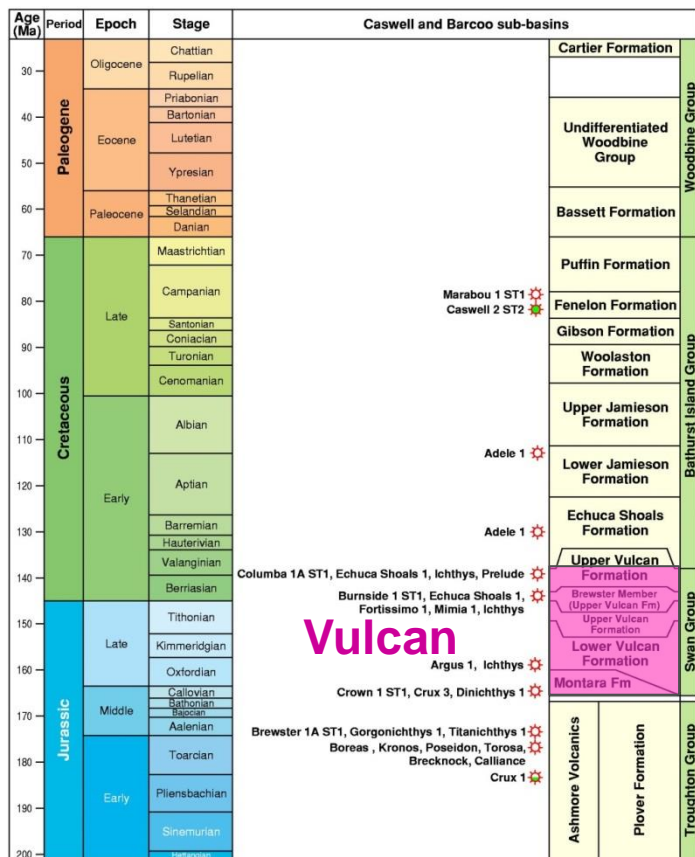
Estimated shale thickness



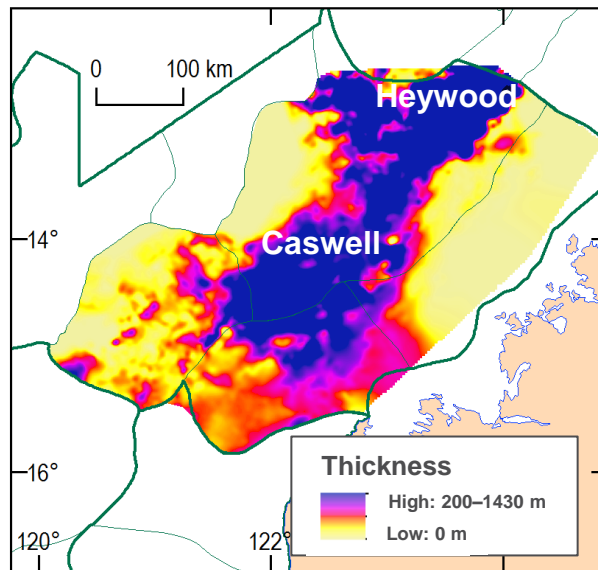
- Thickest in Heywood Graben and southern Caswell and Barcoo sub-basins
- Potential for oil and gas



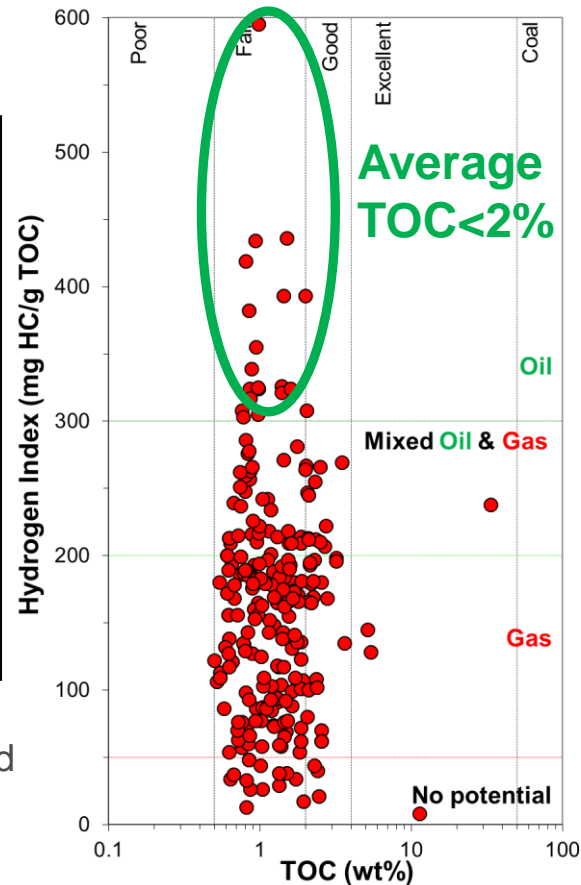
Source Rocks: J30–K10 supersequences (Vulcan Fm)



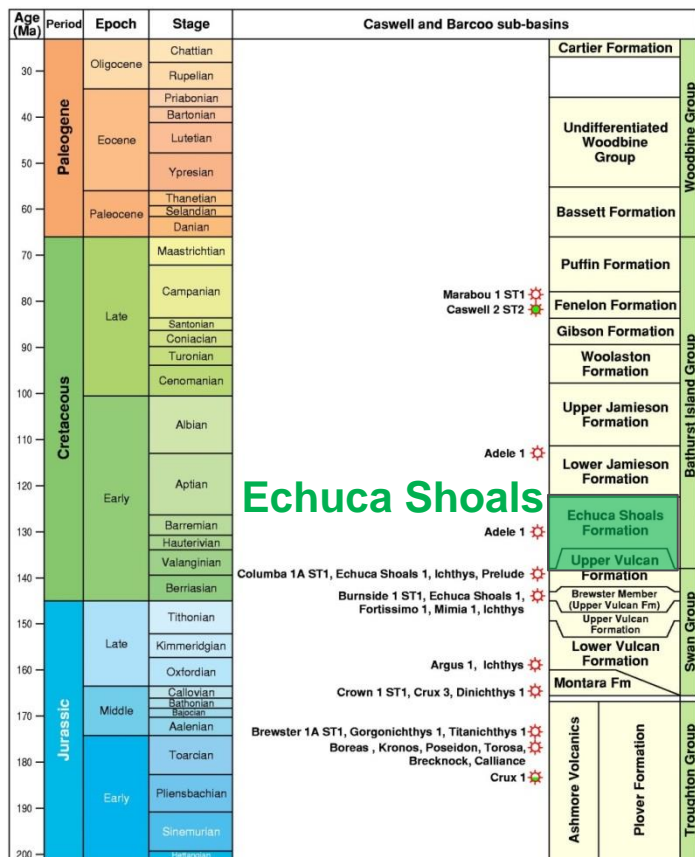
Estimated shale thickness



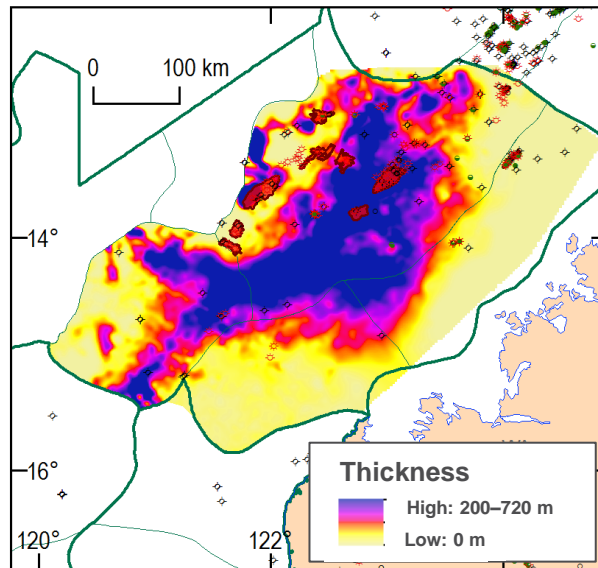
- Thickest in Heywood Graben and southern Caswell Sub-basin
- Potential for oil and gas



Source Rocks: K20–K30 supersequences (Echuca Shoals Fm)



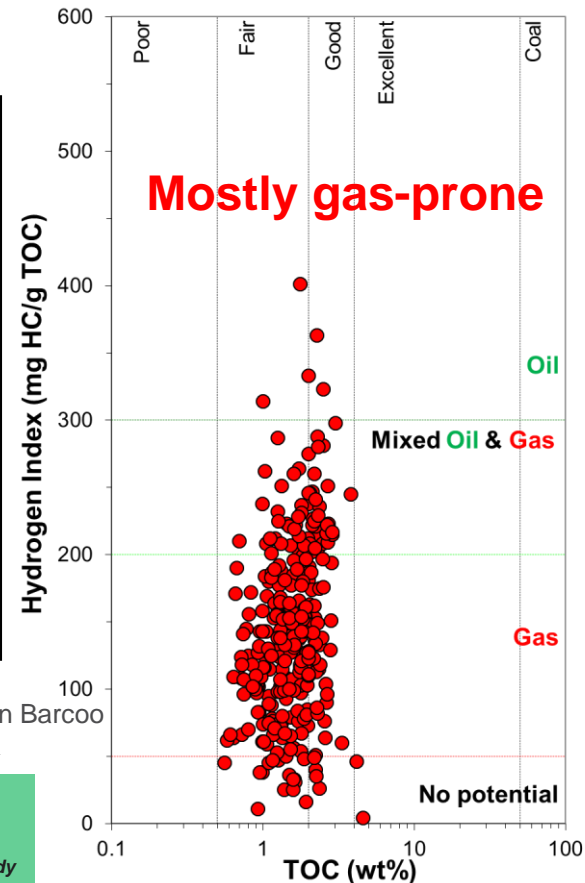
Estimated shale thickness



- Thickest in central Caswell Sub-basin & northern Barcoo
- TOC mostly < 4%; Fair to good gas source rock

Source of oils in the Browse Basin (based on biomarkers and light carbon isotopic signatures)

Blevin et al., 1998 BBHR study



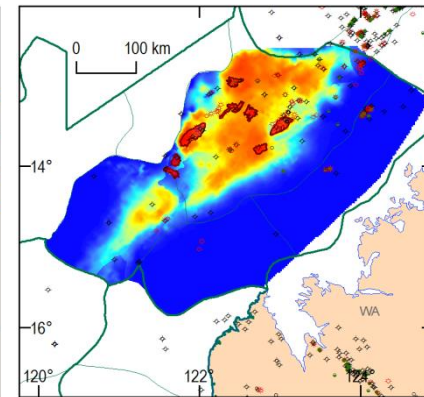
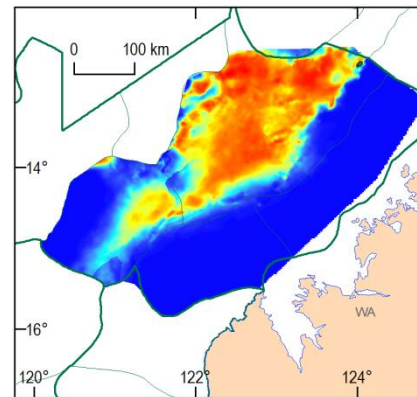
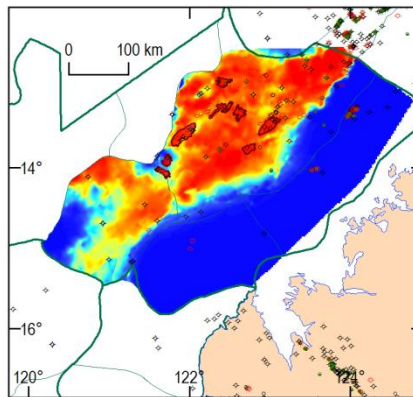
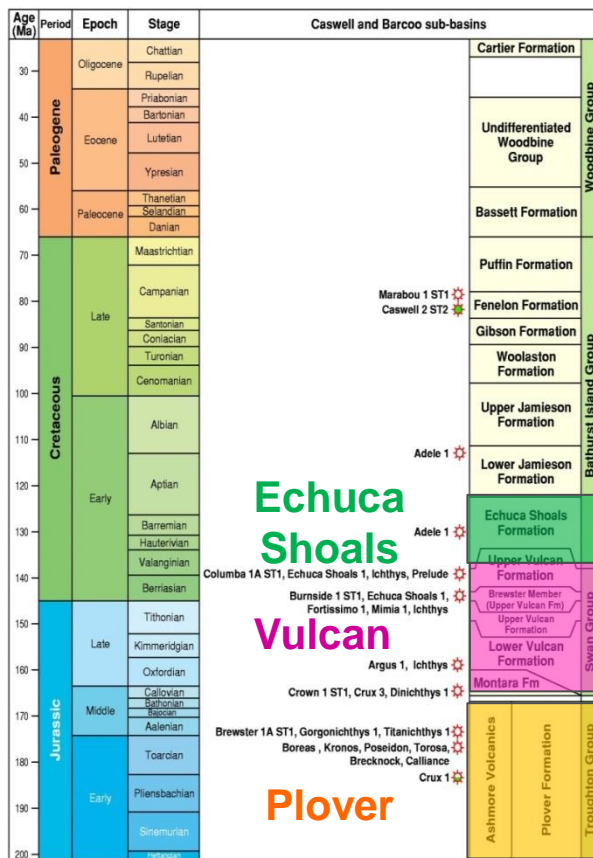
Source rocks: Transformation ratio

Transformation ratio = The proportion of kerogen converted to hydrocarbons

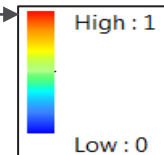
J10–J20
Plover

J30–K10
Vulcan

K20–K30
Echuca Shoals



- 1 = most kerogen has been converted to hydrocarbons
- High transformation ratios in the Caswell Sub-basin
- Plover source rock is mature in the Barcoo Sub-basin

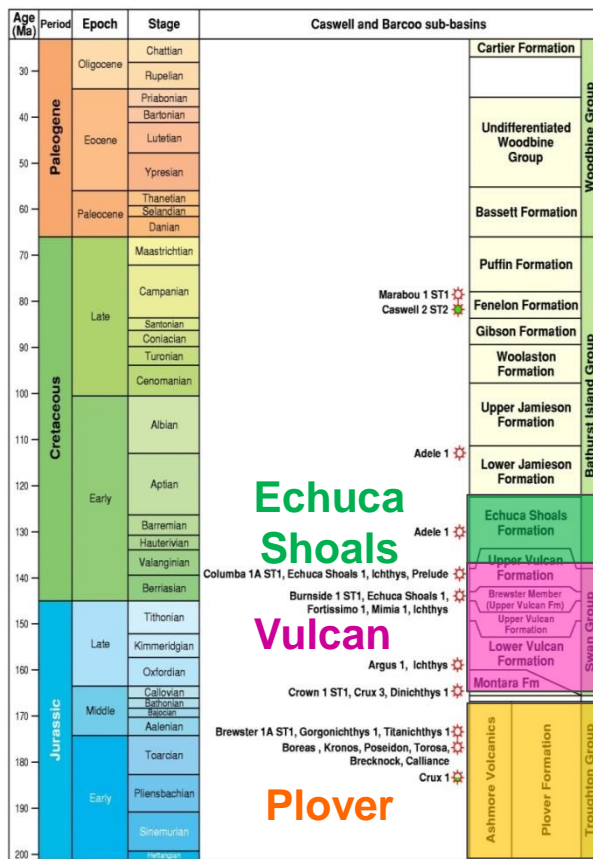


Modelled hydrocarbons expelled

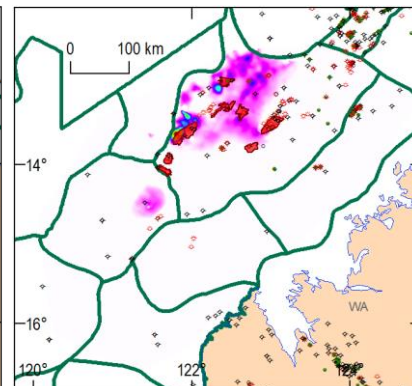
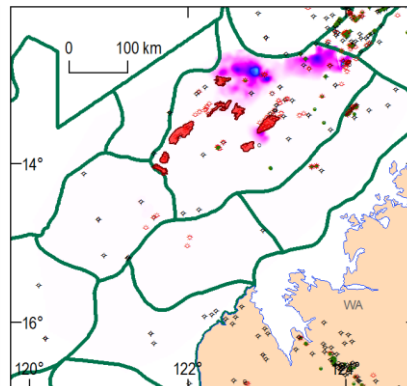
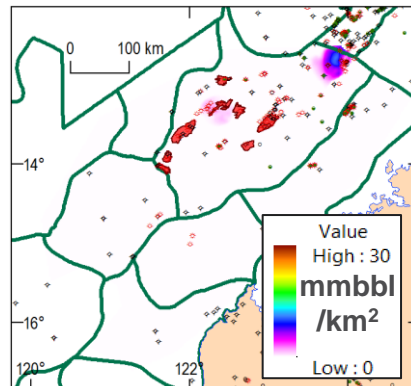
J10–J20
Plover

J30–K10
Vulcan

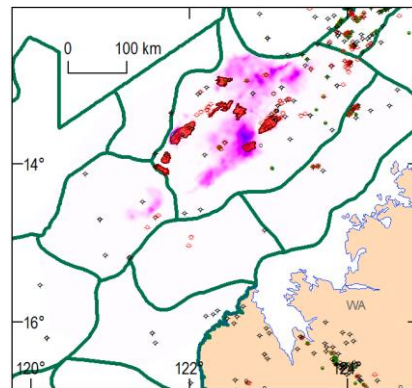
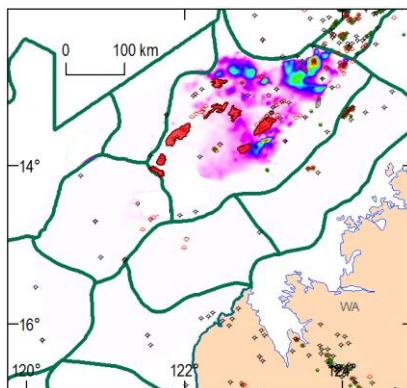
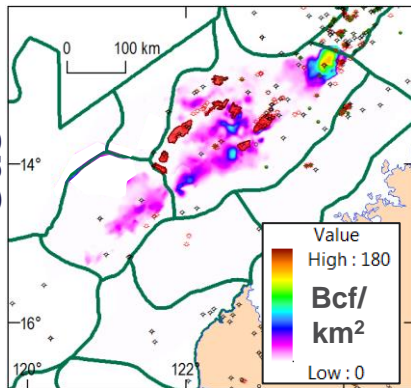
K20–K30
Echuca Shoals



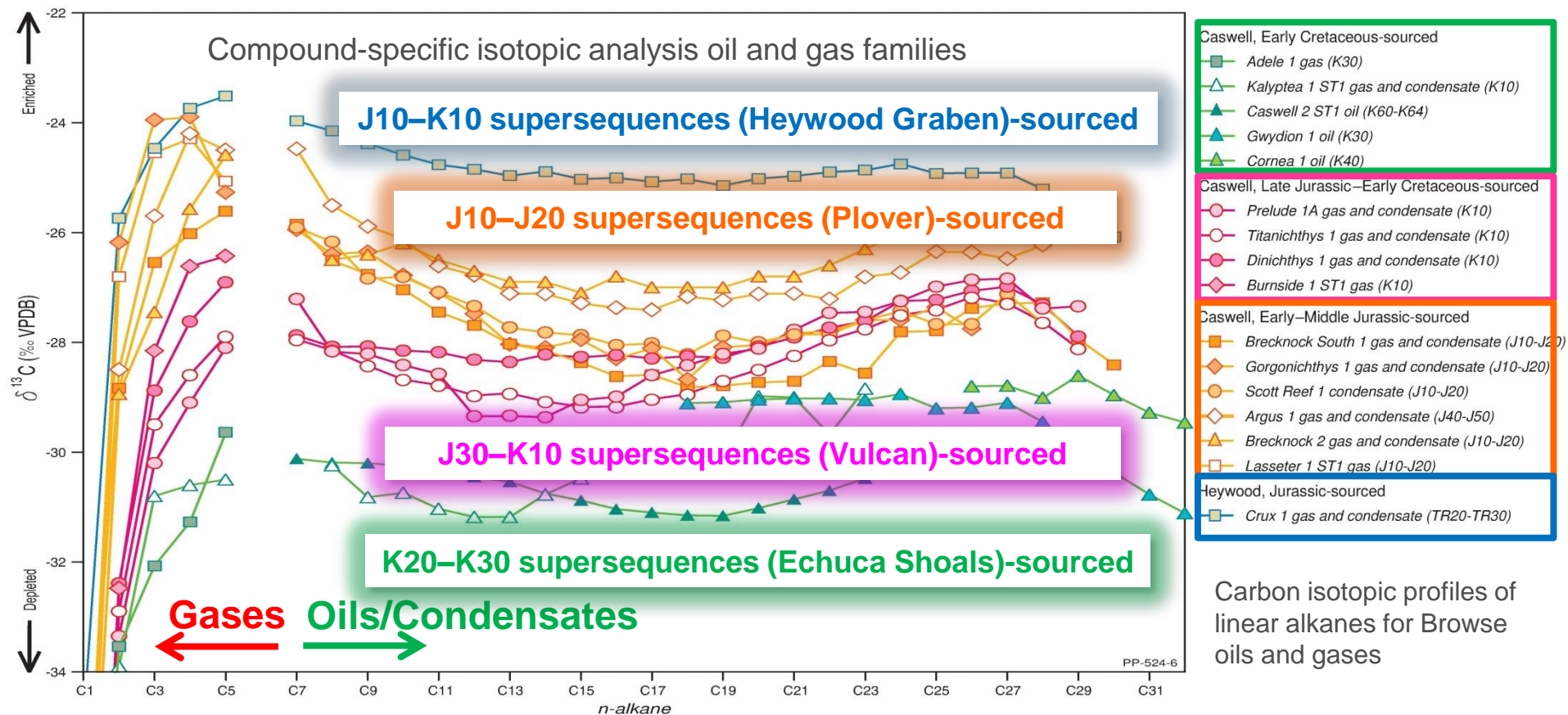
Oil



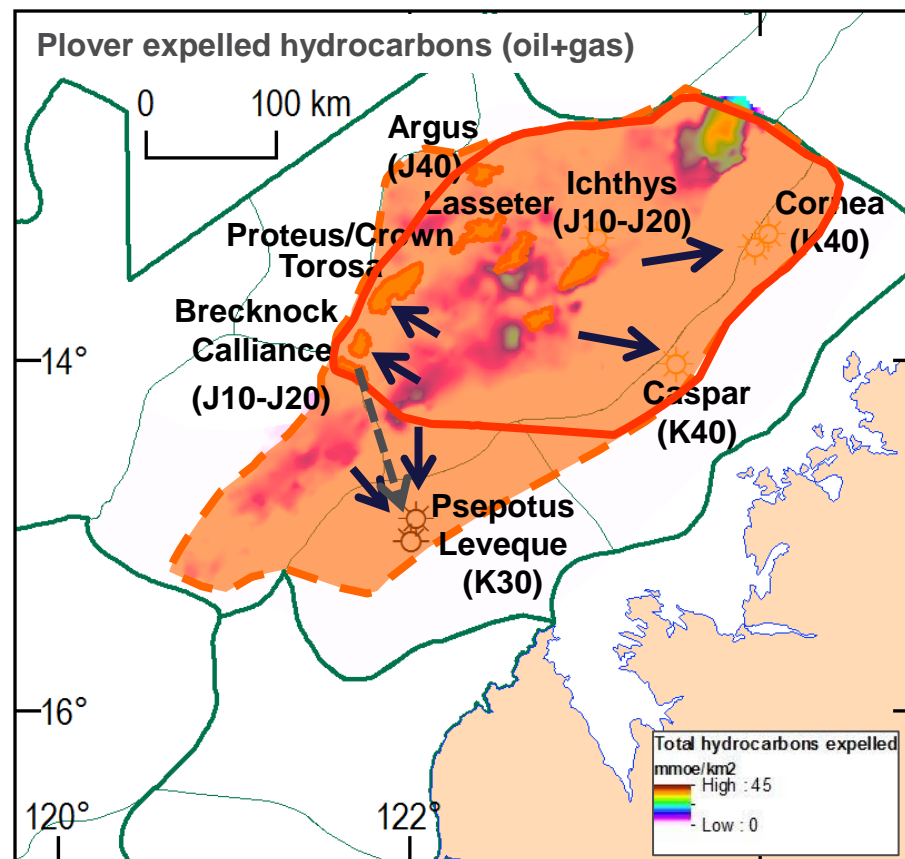
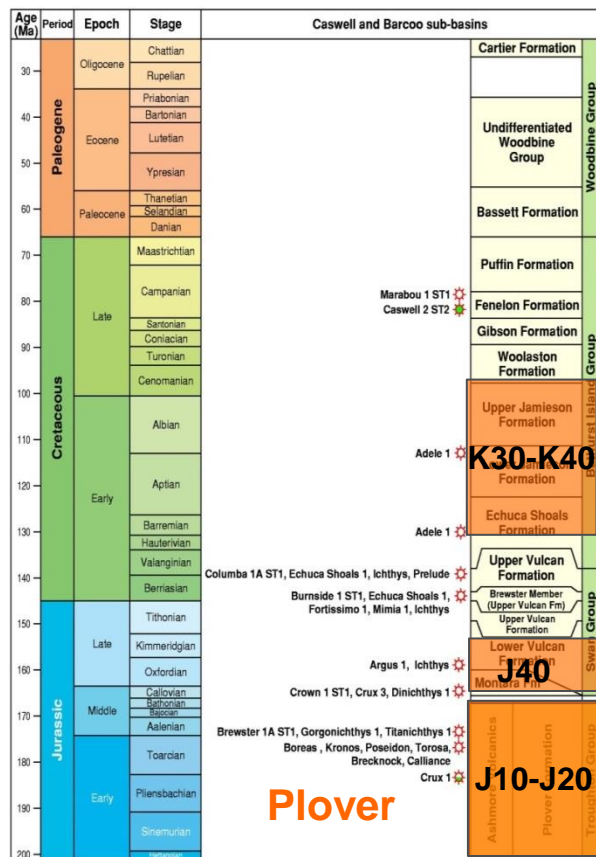
Gas



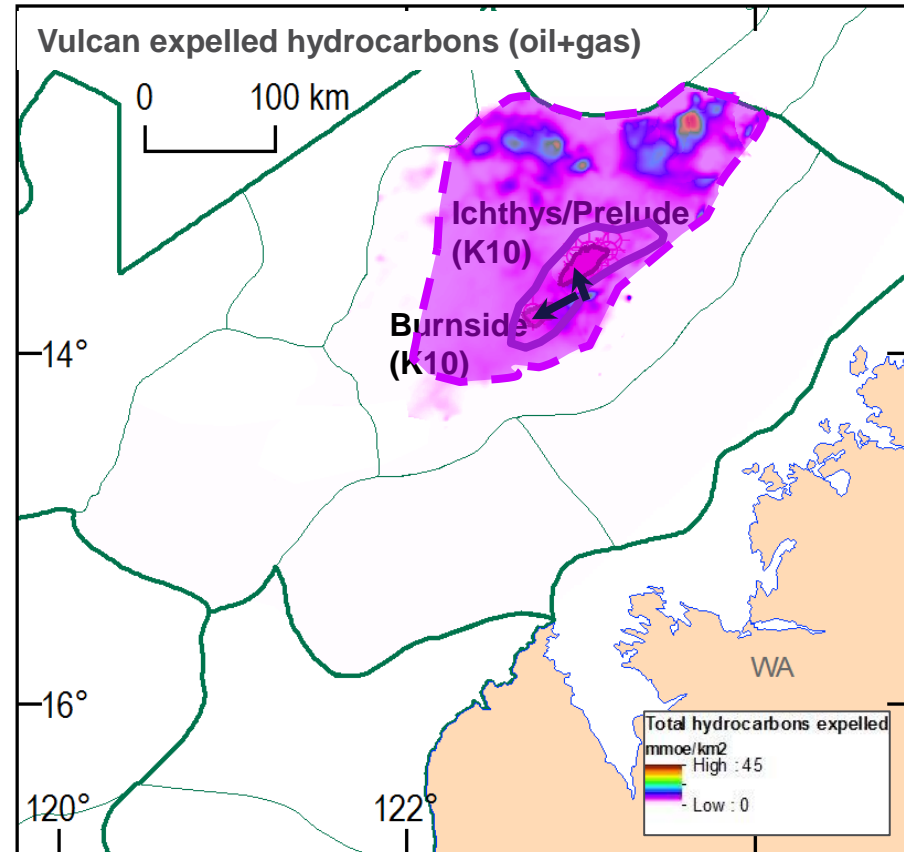
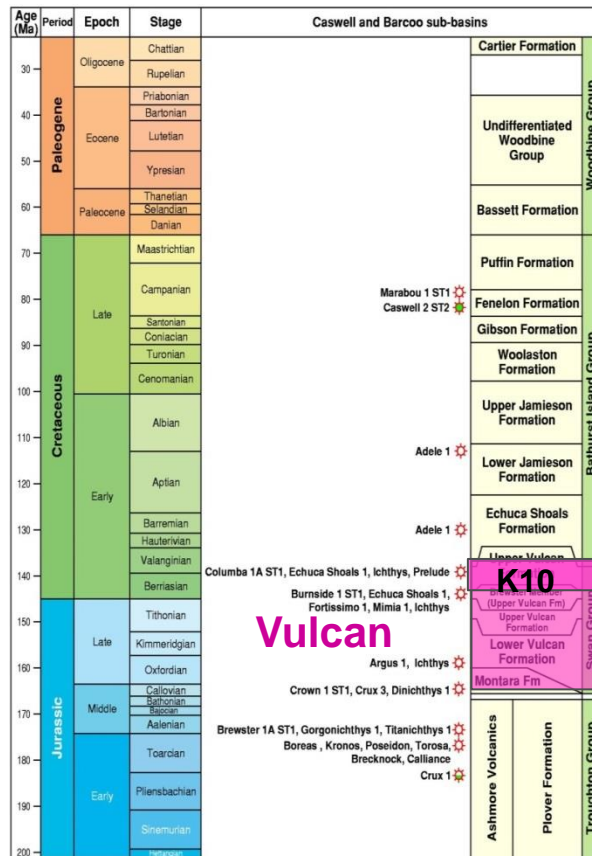
Oil and gas families source rock correlation



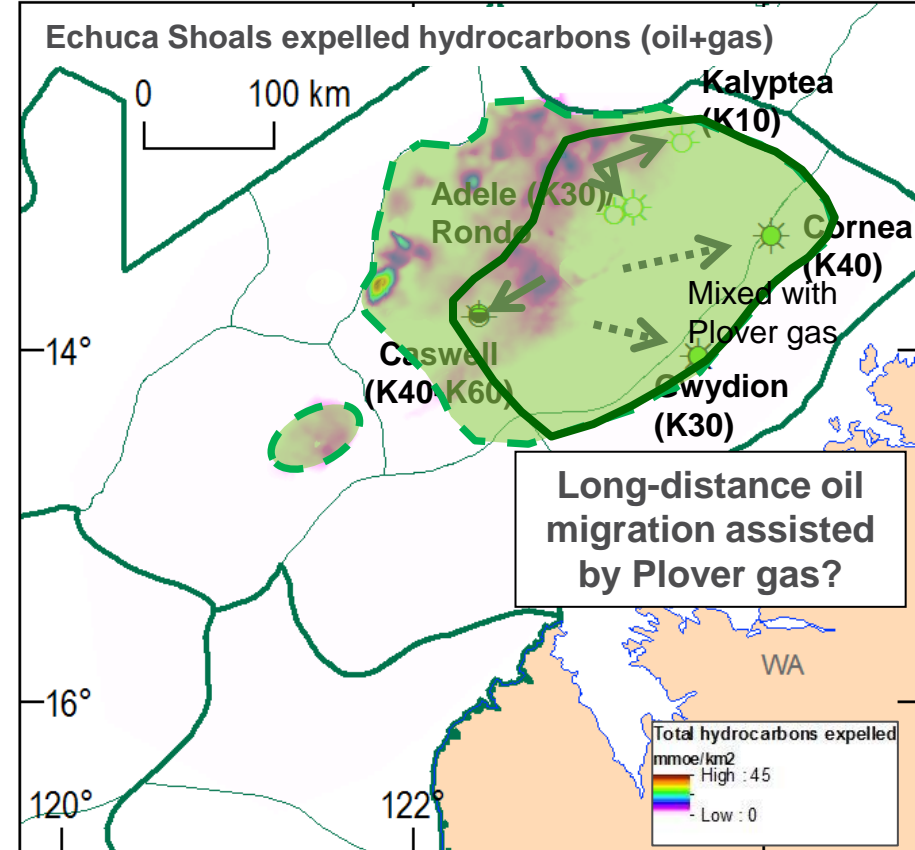
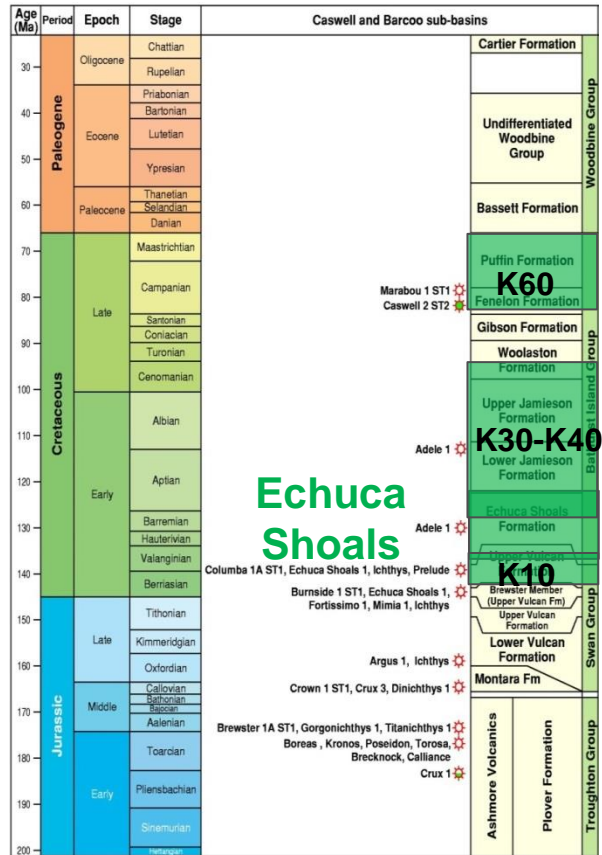
J10–J20 Plover-sourced hydrocarbons



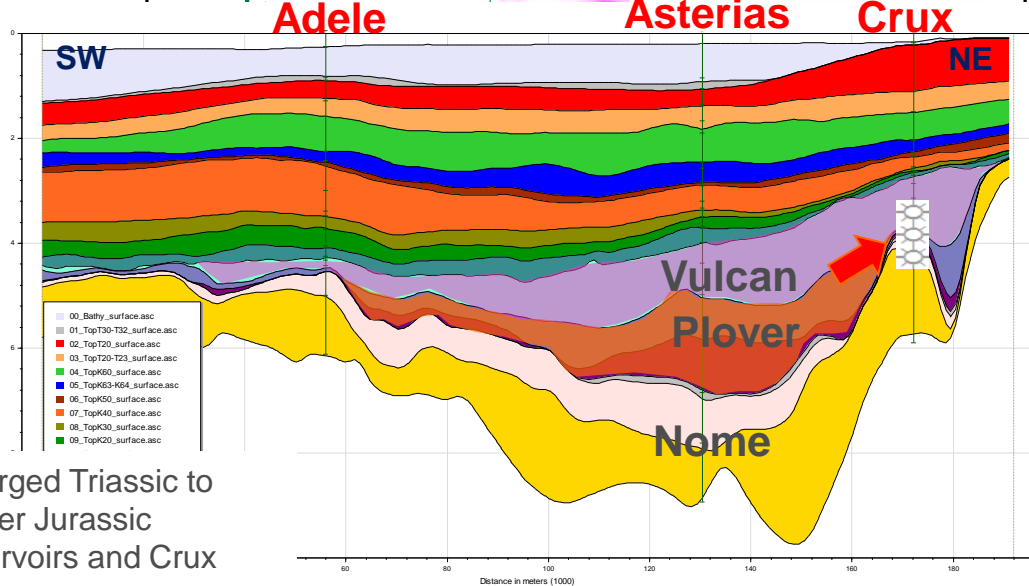
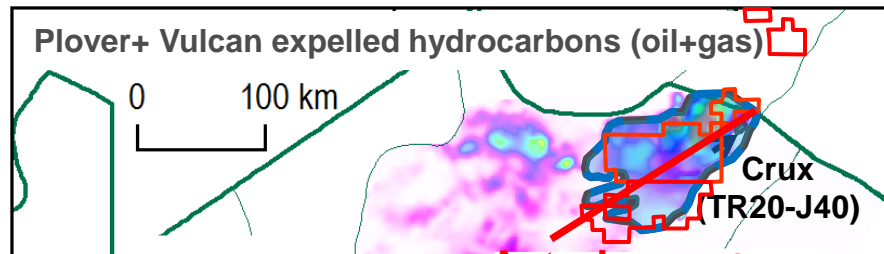
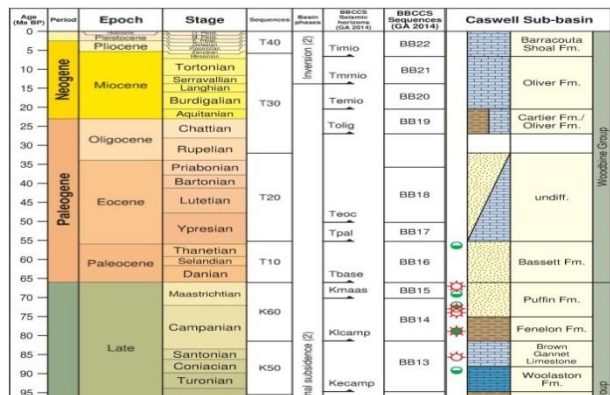
J30–K10 Vulcan-sourced hydrocarbons



K20–K30 Echuca Shoals-sourced hydrocarbons

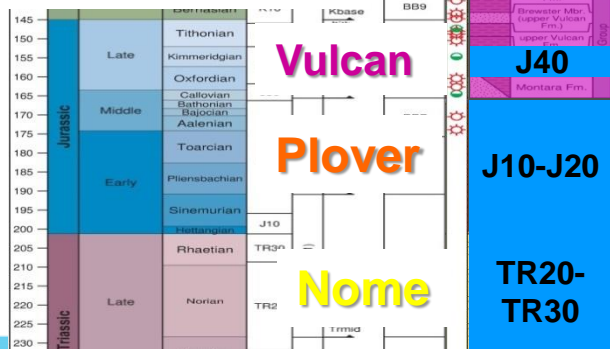


J10–K10 supersequences (Heywood Graben)-sourced

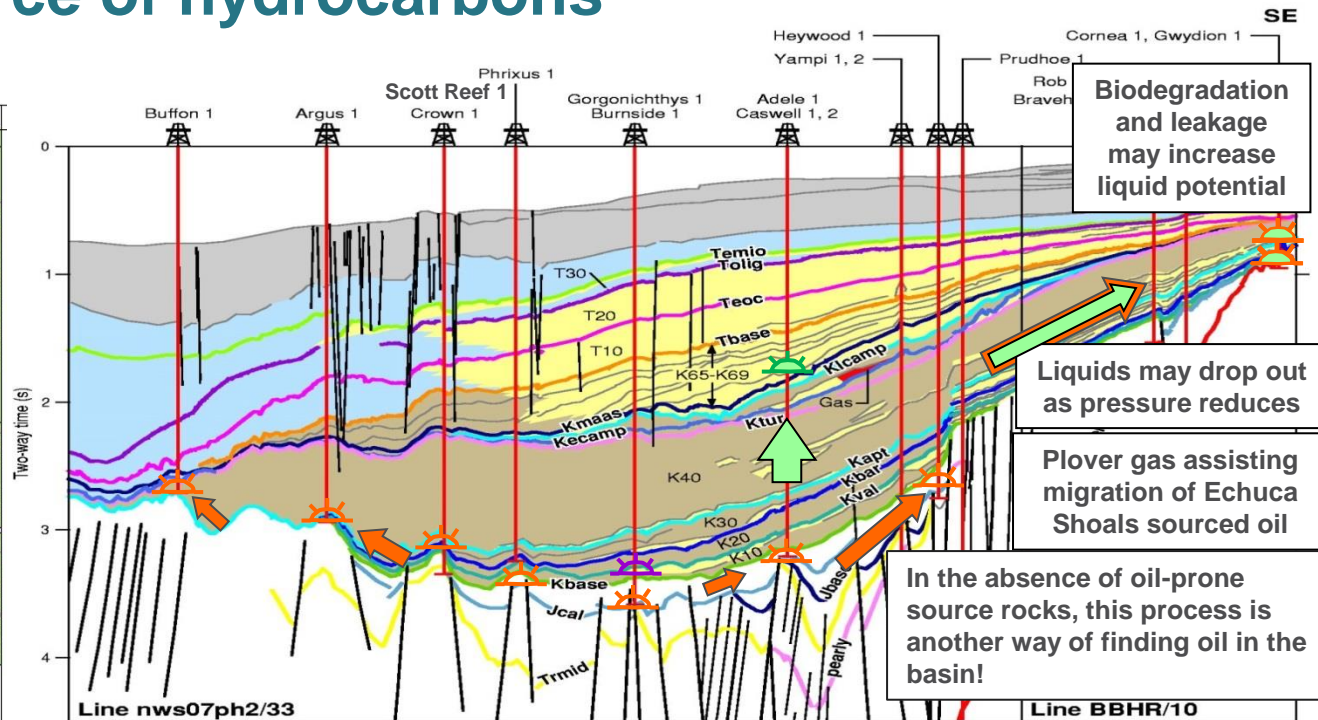
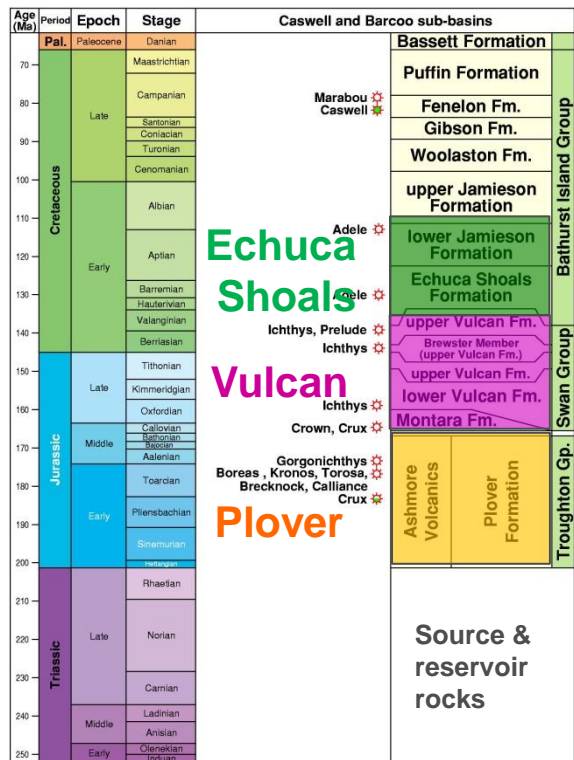


Charged Triassic to Upper Jurassic reservoirs and Crux

Sources likely terrestrially derived organic matter within the thick Jurassic supersequences



Summary: Source of hydrocarbons



Plover-sourced
E-M Jurassic gas
Plover-Plover Fm

Vulcan-sourced
Jurassic wet gas
Vulcan-Brewster Mbr

Echuca Shoals-sourced
E Cret oil & gas
Echuca Shoals-Echuca S./Jamieson

Biodegradation and leakage may increase liquid potential

Liquids may drop out as pressure reduces

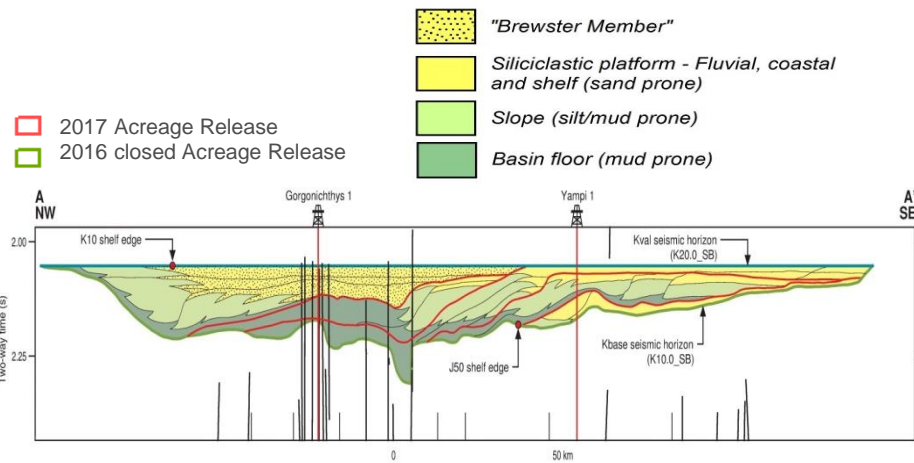
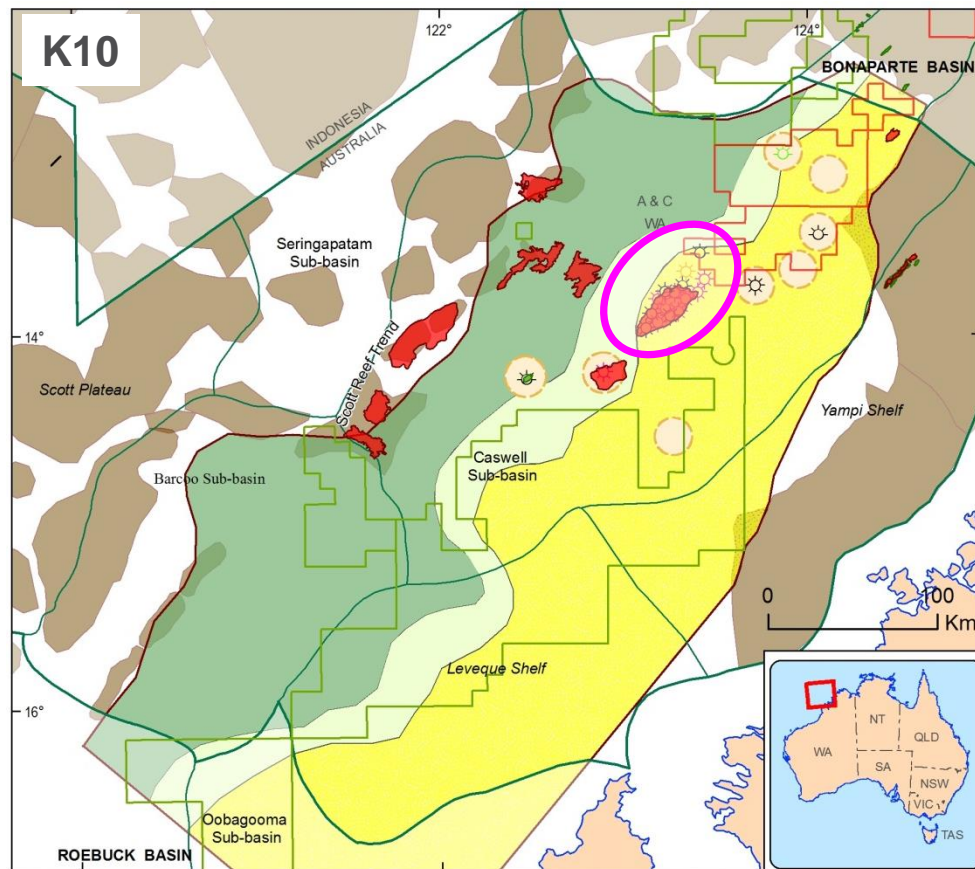
Plover gas assisting migration of Echuca Shoals sourced oil

In the absence of oil-prone source rocks, this process is another way of finding oil in the basin!

Redefining play concepts – K10 example

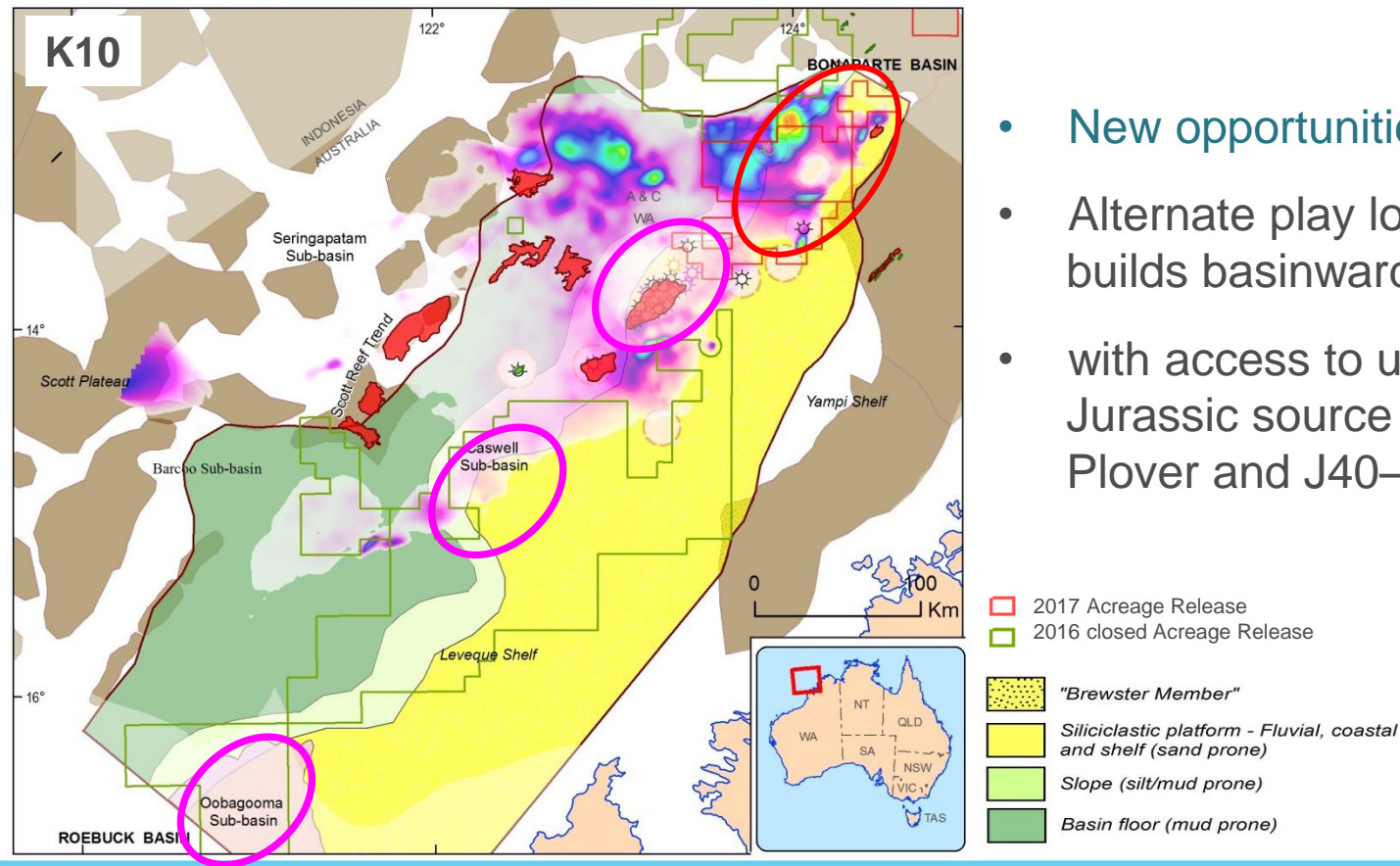
Ichthys Field – Brewster Member

New model: suggests siliciclastic platform sediments related to deltaic lobes which may be present elsewhere



From Abbott et al., 2016

Redefining play concepts – K10 example



- New opportunities?
- Alternate play locations where shelf builds basinward
- with access to underlying potential Jurassic source kitchens (J10–J20 Plover and J40–K10 Vulcan)

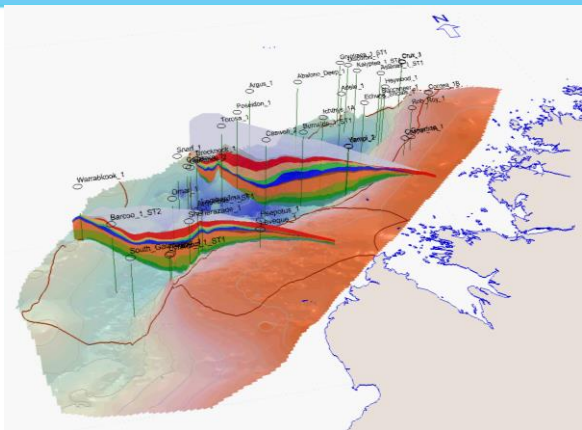
Conclusions

New insights into petroleum prospectivity of the Browse Basin:

- Palaeogeography, geochemistry and petroleum system analysis identified four petroleum systems
- Jurassic-sourced gas saturated dew point system may add liquids potential to shallower traps
- Integrated studies are important to predict the petroleum resource potential of Australia's sedimentary basins



Australian Government
Geoscience Australia



List of products from Browse Basin Study:

<http://www.ga.gov.au/about/projects/resources/browse-basin-petroleum-systems-study>

Email: nadege.rollet@ga.gov.au

Related Poster:

Palu, T., Hall, L., Grosjean, E., Rollet, N., Boreham, C., Buckler, T., Higgins, K., Nguyen, D., Khider, K. (2017). [Source Rocks and Hydrocarbon Fluids of the Browse Basin](#). AAPG|ICE International Conference - London, 15-18 October 2017

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