

Australian Palaeogeographic Studies - Outcomes and Future Opportunities*

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Abstract

Palaeogeographic maps are a key tool for integrating geological information and expanding interpretations into areas between and beyond data control using depositional, sequence stratigraphic, plate tectonic, and other models. In Australia a major continent-wide palaeogeographic mapping program was undertaken in the 1980s as a co-operative endeavor between government, universities, and the petroleum and minerals industries. The BMR-APIRA Palaeogeographic Maps Project produced data and interpretative maps for 70 biostratigraphically controlled time-slices from the Cambrian to the Quaternary at a regional scale of 1:5 million. The overlap of source, reservoir, and seal facies with structural trends mapped petroleum plays. New plays were identified in the Surat Basin and on the North West Shelf. Relationships revealed between organic geochemistry, depositional environments, and paleogeography were especially powerful in predicting source rock distribution. This approach married with detailed oil family correlations matured to establish a framework of Australian petroleum supersystems. Other significant outcomes were the development of public access well databases and educational products. The Australian maps were integrated into global map series and provided evidence for new concepts such as the Pangean Monsoon and Dynamic Topography. Advances in technology, geological concepts and in knowledge of Australian basins in the past 30 years provide opportunities for producing new, more sophisticated palaeogeographic maps to underpin future exploration. For example, the original maps that were largely based on well information, could be updated with thousands of wells drilled in the past decades and extensive high quality seismic information that images entire new sedimentary basins discovered around Australia's continental margin. New seismic technologies also provide visualisations of ancient geomorphologies extracted from 3D data volumes that can be then nested within more generalised time-slice maps. Also beyond the scope of the original maps, were Proterozoic sequences that are now targeted for petroleum exploration. Advances in biostratigraphy, chemostratigraphy, and isotopic dating provide improved time control for constructing new palaeogeographic maps back into the Neoproterozoic Centralian Superbasin sequences across much of inland Australia.

Selected References

Barrett, A.G., A.L. Hinde, and J.M. Kennard, 2004, Undiscovered Resource Assessment Methodologies and Application to the Bonaparte Basin, *in* G.K. Ellis, P.W. Baillie, and T.J. Munson (eds.), Timor Sea Petroleum Geoscience, Proceedings of the Timor Sea Symposium, Darwin, Northern Territory, 19-20 June 2003, Northern Territory Geological Survey, Special Publication 1, p. 353-372.

Edwards, D.S., J.C. Preston, J.M. Kennard, C.J. Boreham, B.G.K. Van Aarssen, R.E. Summons, and J.E. Zumberge, 2004, Geochemical Characteristics of Hydrocarbons from the Vulcan Sub-basin, Western Bonaparte Basin, Australia, *in* G.K. Ellis, P.W. Baillie, and T.J. Munson (eds.), Timor Sea Petroleum Geoscience, Proceedings of the Timor Sea Symposium, Darwin, Northern Territory, 19-20 June 2003, Northern Territory Geological Survey, Special Publication 1, p. 169-201.

Rullkötter, J. R. Littke, M. Radke, U. Disko, B. Horsfield, and J.W. Thurow, 1992, Petrography and Geochemistry of Organic Matter in Triassic and Cretaceous Deep-sea Sediments from the Wombat and Exmouth Plateaus and Nearby Abyssal Plains off Northwest Australia, *in* U. von Rad, B.U. Haq, R.B. Kidd, and S. O'Connell (eds.), Proceedings of the Ocean Drilling Program, Scientific Results, College Station, TX (Ocean Drilling Program), v. 122, p. 317-333.

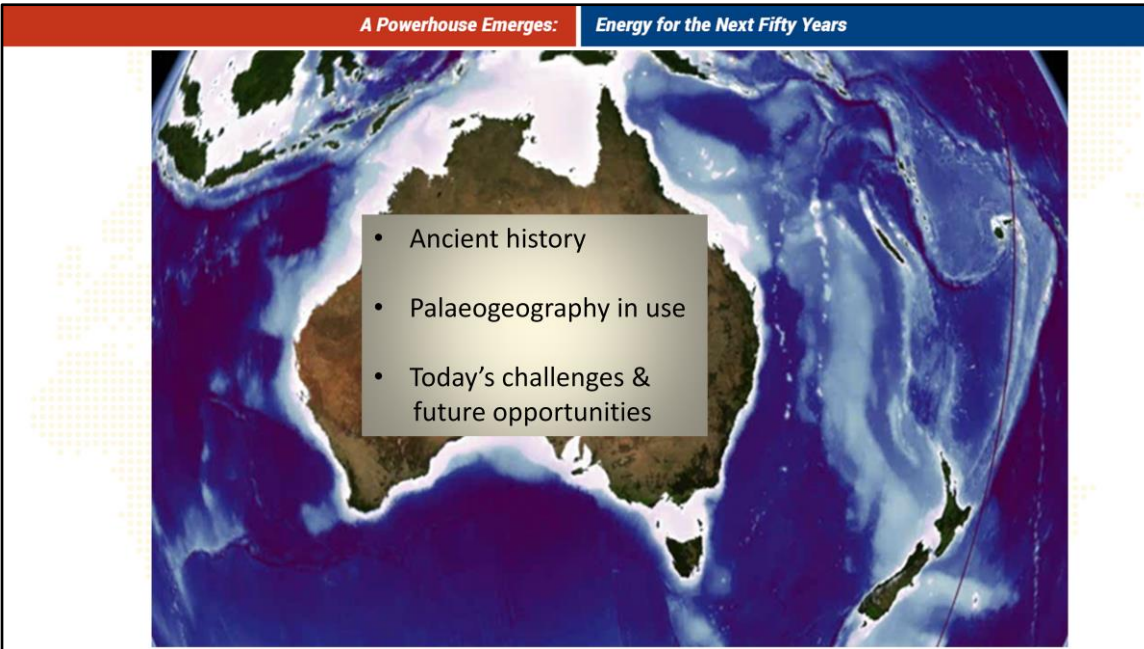


Australian palaeogeographic studies – outcomes & future opportunities

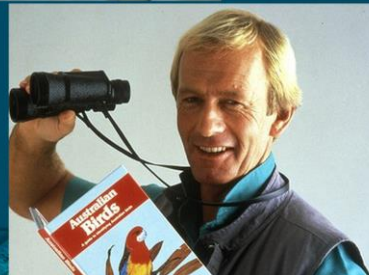
Marita Bradshaw, Peter Cook, Rob Langford, Jennie Totterdell, Monica Yeung and many more

AAPG ICE Melbourne 2015
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- 
- A satellite image of the Pacific Ocean, showing the western coast of North America on the left and the eastern coast of Asia on the right. The ocean is a deep blue, and the landmasses are green and brown. A semi-transparent grey rectangular box is centered over the Pacific Ocean, containing a bulleted list. The background of the slide features a faint, stylized world map with yellow dots on a white background.
- Ancient history
 - Palaeogeography in use
 - Today's challenges & future opportunities

Ancient history – Australia in the 1980s



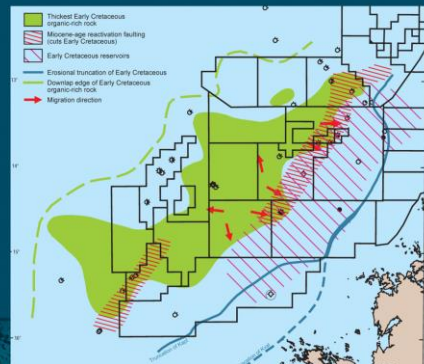
Esso Australia

- applied approach used to assess petroleum potential in the Arctic to Australia
- Time slice palaeogeographic maps to stack source, reservoir and seal facies

Where is the next Gippsland ?

What is Australia's YTF ?

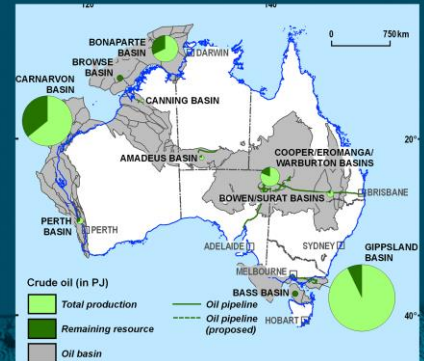
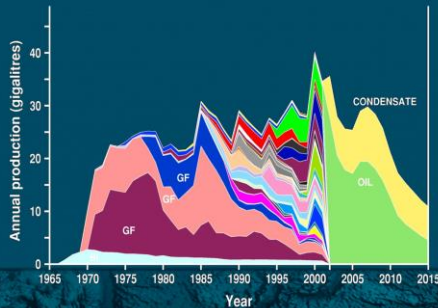
Answer: 4.2 BBO (P50)



Esso Australia

- applied approach used to assess petroleum potential in the Arctic to Australia
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Where is the next Gippsland ?

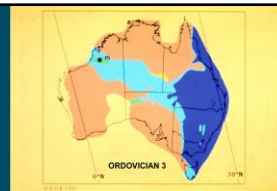


From industry to government

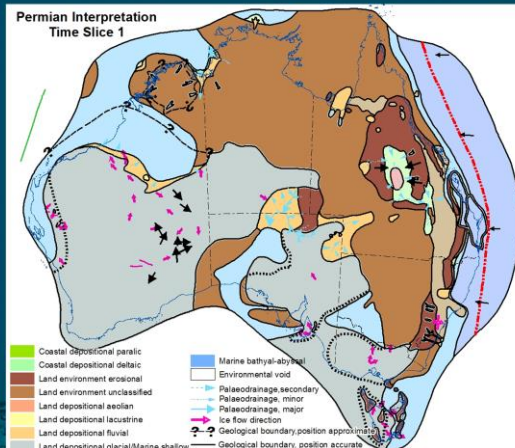
- BMR APIRA Project 1 1984-87
- Industry, universities federal and state government *collaboration*
- 70 timescale palaeogeographies for the continent, Cambrian to Holocene

Rapid input once confront someone with a map

- New petroleum plays – NWS, Surat
- How does the continent behave?
- Educational products
 - *the narrative of Australia's story*

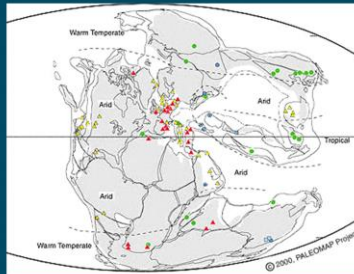


Permian Interpretation
Time Slice 1



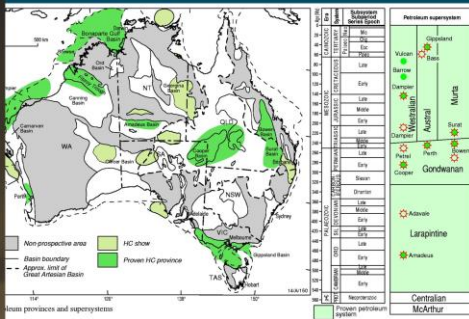
BMR APIRA Project 2 1987-91

- Plate wide view
- Mz and Cz only
- International links

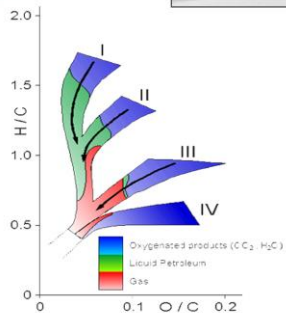
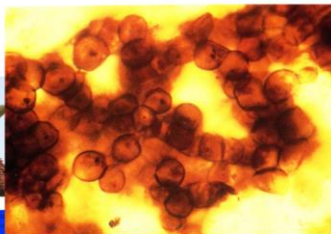
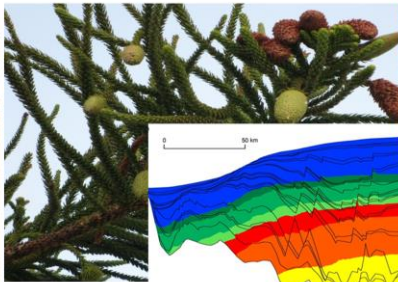


Project 3 1992-96 Petroleum Systems

- Focus on North West Shelf
- link geochem to palaeoenvironments
- Oil families validated petroleum systems

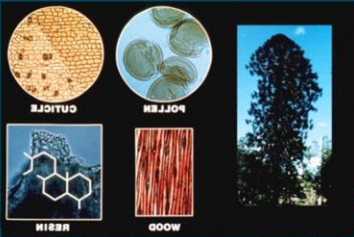


Message in a bottle.....

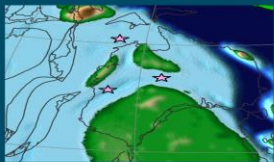


Oil Family: Controlling Factors

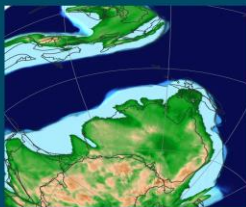
- Age: evolution of biota
- Organic matter type: algal, bacterial, plant
- Depositional environment: geographic location, climate, lithofacies
- Oil Family = common origin
- Petroleum systems & supersystems



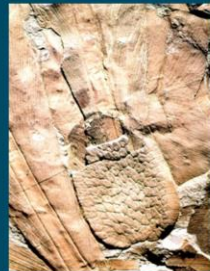
Australian Petroleum Supersystems



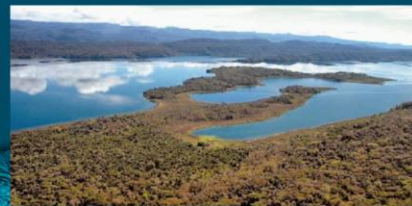
- Early Palaeozoic – LARAPINTINE
 - tropical seaways, marine source rocks
 - Australia to China



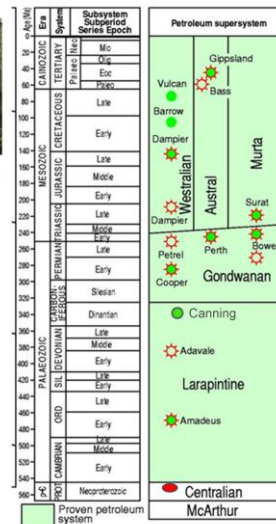
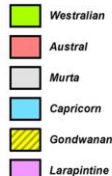
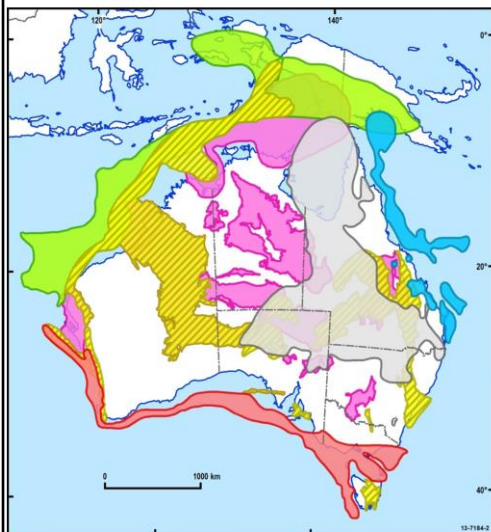
- Late Palaeozoic – GONDWANAN
 - mountain building, glaciation,
 - coal deposition



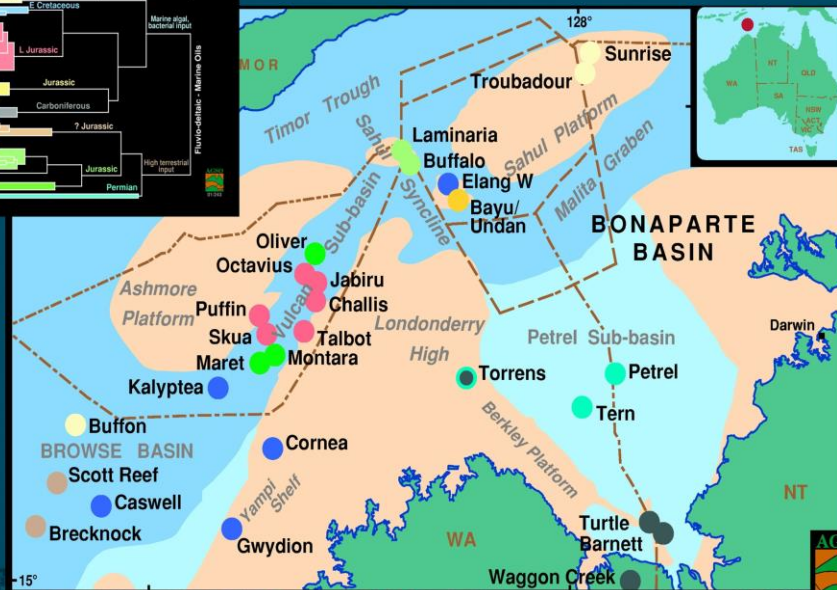
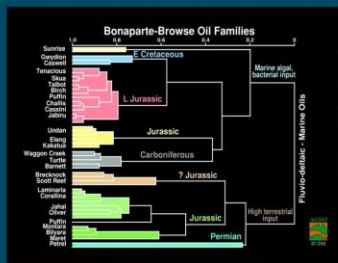
- Mesozoic – WESTRALIAN, AUSTRAL
 - Gondwana break up
 - oil & gas in rifted margins



Distribution of Australia's petroleum systems

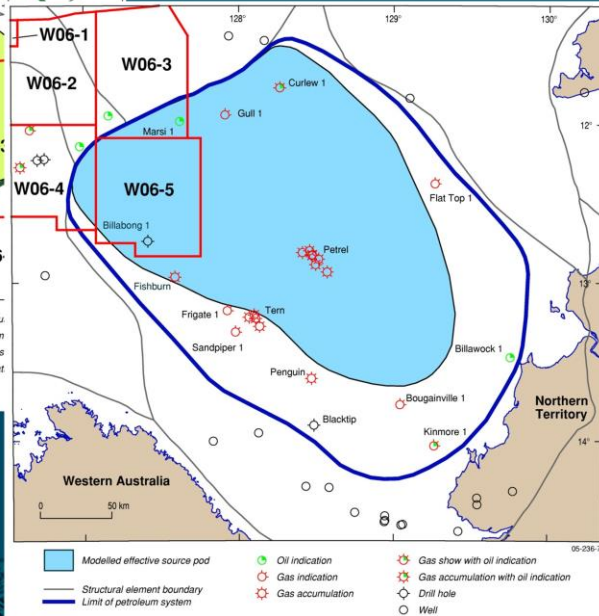
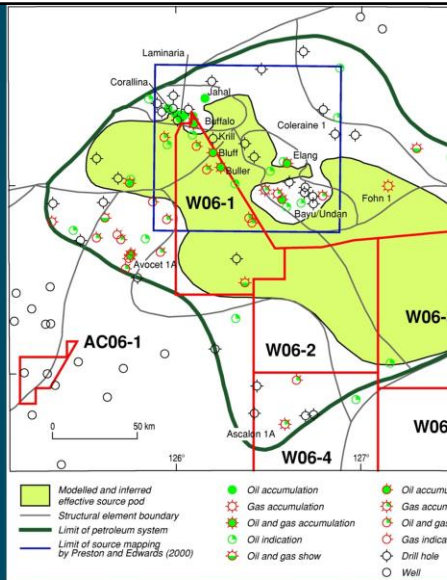


Browse-Bonaparte Oil Families




Edwards et al., 2004

Mapping Petroleum systems for resource assessment



Presenter's notes: The Jurassic Elang-Elang(!) petroleum system in the Sahul and Flamingo Synclines and Laminaria and Flamingo highs (Barrett et al., 2004) is active in the region.

- 
- Ancient history
 - ***Palaeogeography in use***
 - Today's challenges & future opportunities

- ***Palaeogeography in use***

Petroleum exploration

Mineral exploration

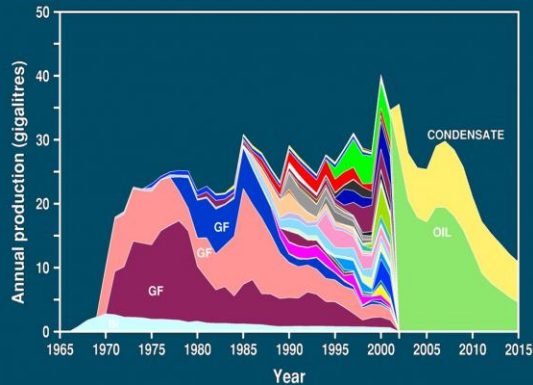
Australia in the global context

Continental processes

Unexpected outcomes

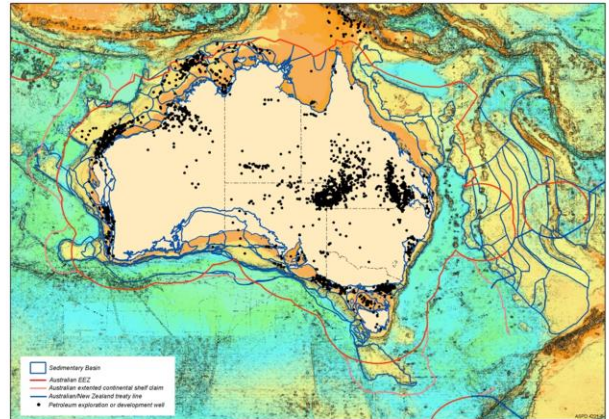
petroleum systems & oil
families

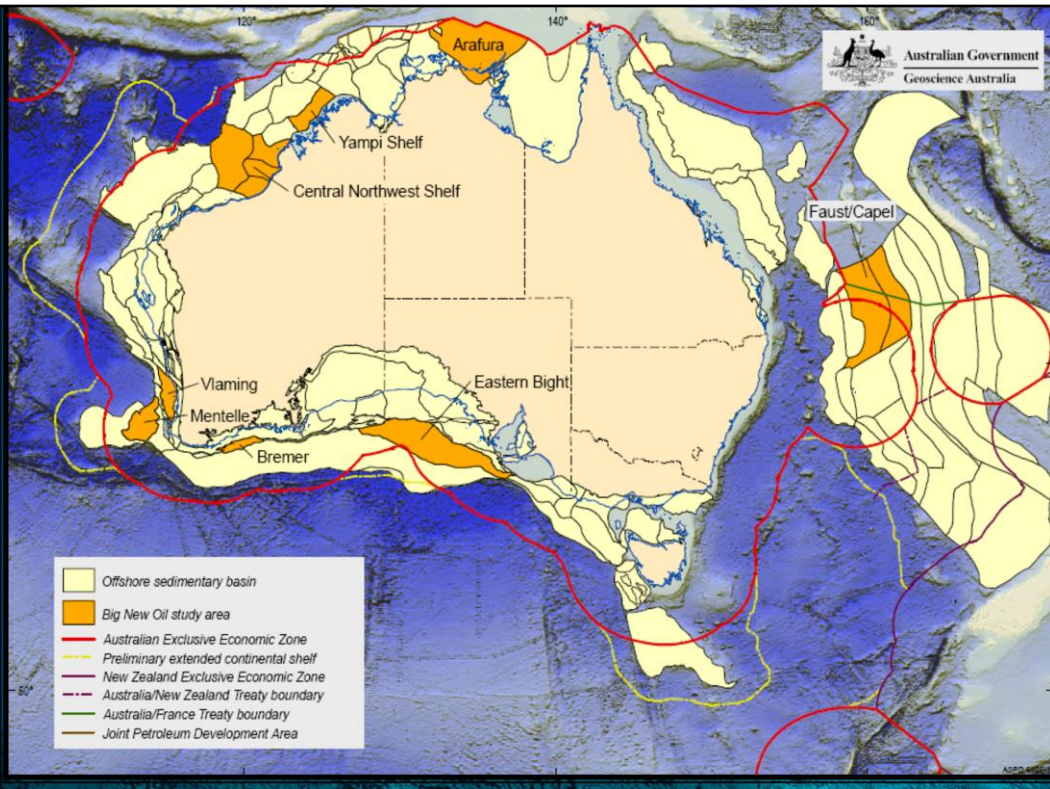
Data bases



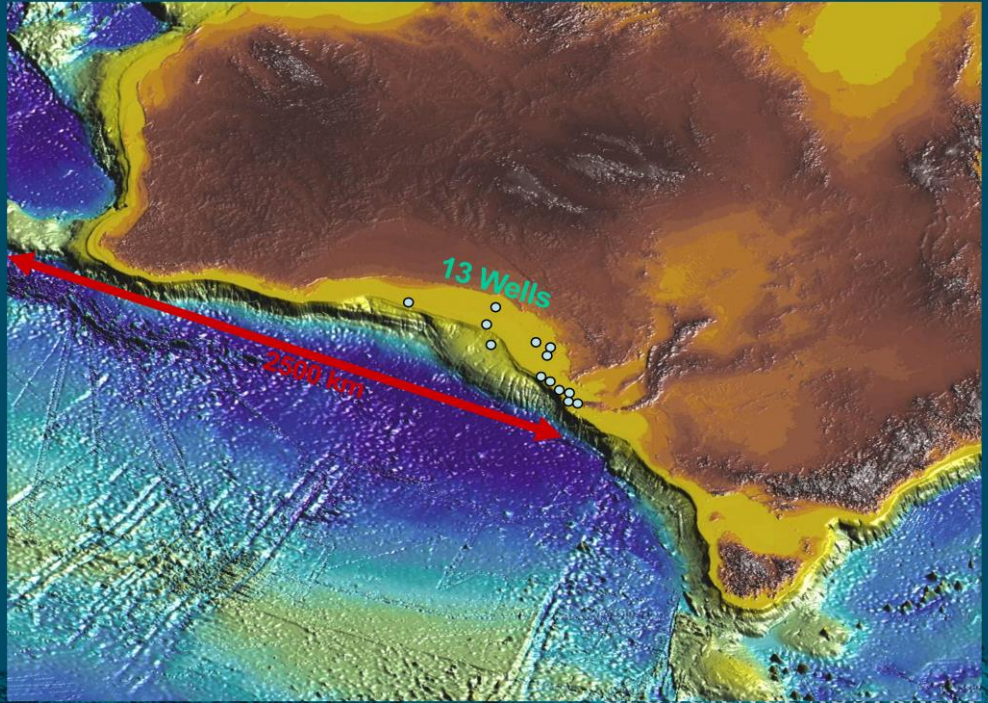
**The challenge –
decline in Australia's
oil production**

**The opportunity –
Australia is
vastly unexplored**





Presenter's notes: Geoscience Australia's study of frontier basins along the southern margin has focussed on three main areas. Firstly, the Mentelle Basin, which is a strike slip basin that formed during break-up of Australia, Antarctica and Greater India. It contains over 5 km of Jurassic and Cretaceous age strata, and has had no previous exploration. However, there is significant potential for hydrocarbons to have generated in the deep western depocentre, and for these to have migrated updip to structural and stratigraphic traps on the eastern flanks.

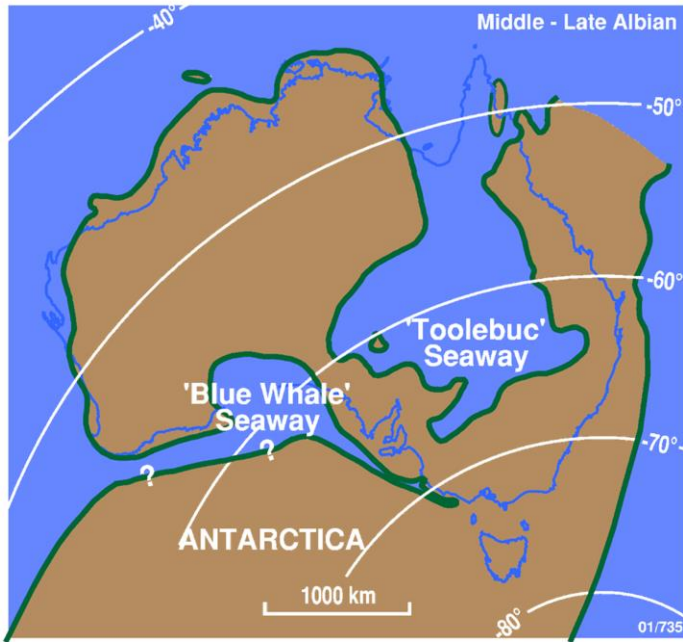


Presenter's notes: For this presentation, I'm going to use case studies from work on the Southern Australian Margin, which will show quite nicely the different approaches we use when undertaking basin studies in frontier areas.

This is a very deep water frontier region, as you can see on this 3-D bathymetry image, with the main basin areas extending over water depths of 100 to 5000 metres.

It is also a vast, very unexplored area, with only 13 offshore wells drilled, most around the proximal margins of a Late Cretaceous delta system in the eastern Great Australian Bight that forms a prominent bathymetric terrace.

Mid-Cretaceous Marine Source Rock



Asphaltites

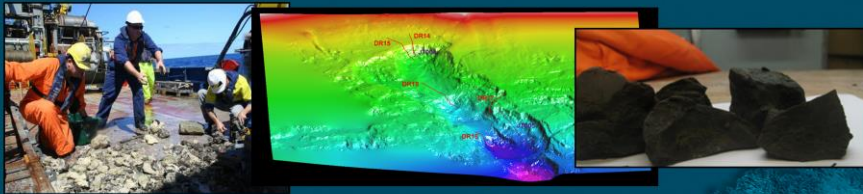
Albian?

2003
Gnarlyknots 1

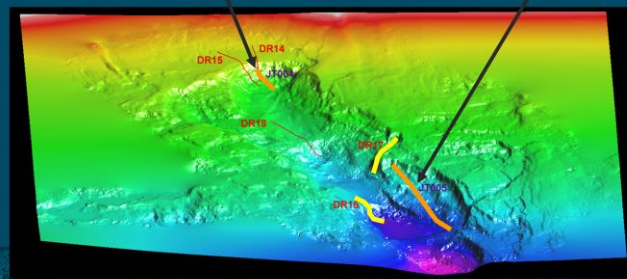
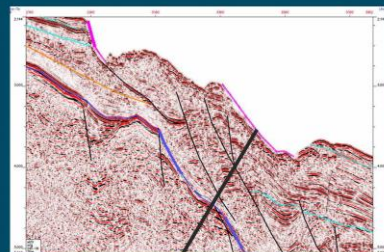
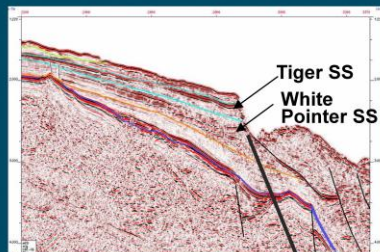


Bight Basin source rock study

- Predicted source rocks
- Survey
- Analysis



Bight Basin Survey SS01/2007



CIENCE AUSTRALIA

Cenomanian-Turonian organic-rich rock and asphaltites

- Close geochemical relationships
 - molecular composition indicating a marine, anoxic environment
 - oil type: low wax paraffinic-naphthenic-aromatic crude
 - isotopes (H, Re/Os)
 - evidence of anoxia: photic zone for asphaltites



Dredge sample – C-T ORR



Asphaltite – coastal bitumen

Asphaltites: product of source rocks that include basinal correlatives of the Cenomanian-Turonian dredge samples

GEOSCIENCE AUSTRALIA

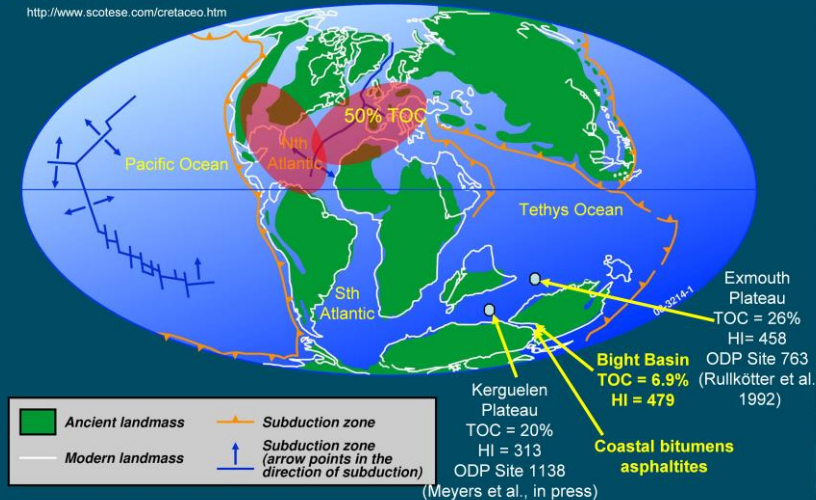
Presenter's notes: The identification of an oil-prone source rock in the basin of course invited comparison with the best evidence we had of the generation of liquids in the region – asphaltites from the bitumens washed up along the coast of southern Australia. Previous work on these asphaltites had identified them as being the product of a marine Cretaceous source rock.

Analyses undertaken by GA have demonstrated close geochemical relationships between the dredged source rock and the asphaltites suggesting genetic and depositional relationships. They have a similar molecular composition indicative of a marine anoxic environment. Both have a similar oil type – a low wax paraffinic-naphthenic-aromatic crude. They also share a number of isotopic similarities. Both have biomarker evidence of anoxia – photic zone anoxia in the case of the asphaltites, with the oxic-anoxic boundary being close to the sediment-water interface in the dredge samples. Taken together, these results suggest that the asphaltites are the product of source rocks that include a basinal correlative of the Cenomanian-Turonian dredge samples.

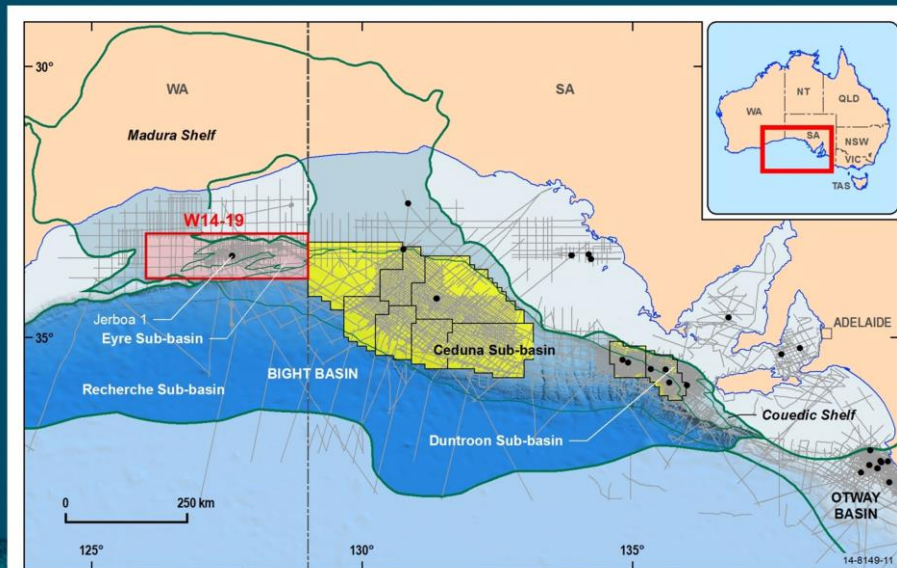
Oceanic Anoxic Event (OAE) 2 Cenomanian–Turonian boundary


Late Cretaceous - 94 Ma

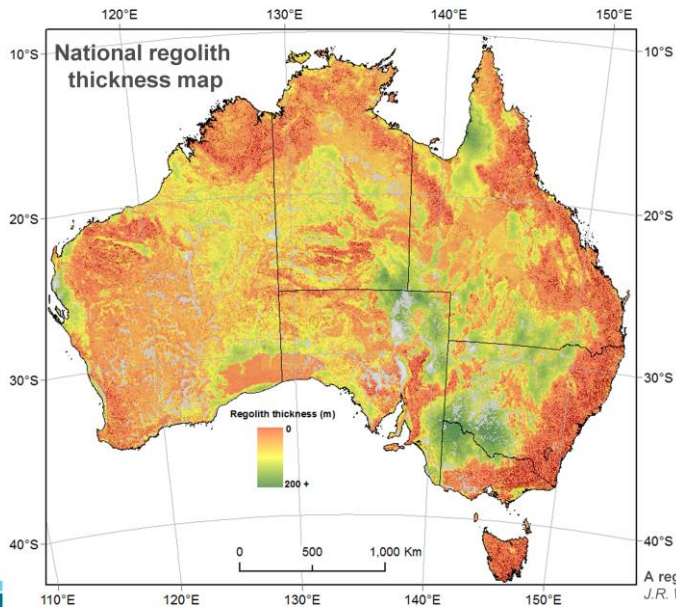
<http://www.scotese.com/cretaceo.htm>



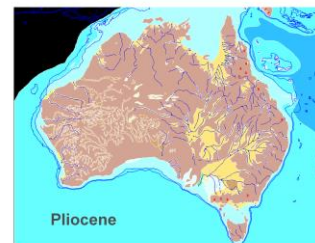
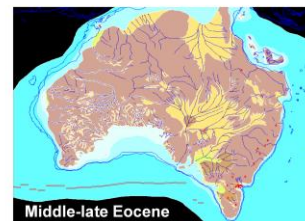
Presenter's notes: The geochemical characteristics of the Cenomanian-Turonian shales and their relationship to the asphaltites also raises the question of whether we might be seeing evidence of Oceanic Anoxic Event 2 in the Bight. The dredged rocks that show enhanced preservation of organic carbon and the best oil potential come from a very specific time interval equivalent to the Cenomanian-Turonian boundary. That combined with the evidence of photic zone anoxia in the asphaltites give a strong indication that we may be looking at that event, which has also been identified at locations on the Exmouth and Kerguelen Plateaus. This means that there is potential in the basin for even better source rocks than those that we sampled.



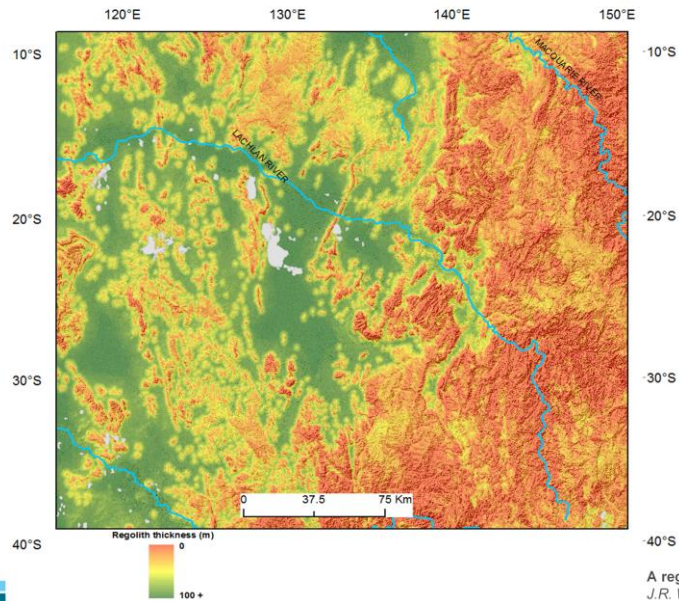
- 
- Ancient history
 - Palaeogeography in use
 - ***Today's challenges & future opportunities***
 - *unconventional gas*
 - *carbon storage*



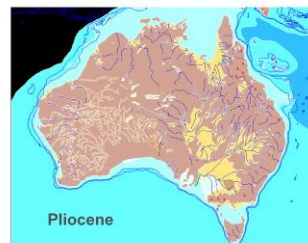
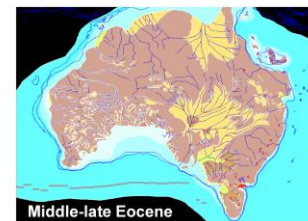
Cenozoic time periods



A regolith depth map of the Australian continent. In prep
J.R. WILFORD, R. SEARLE, M. THOMAS, D. PAGENDAM, M.J. GRUNDY

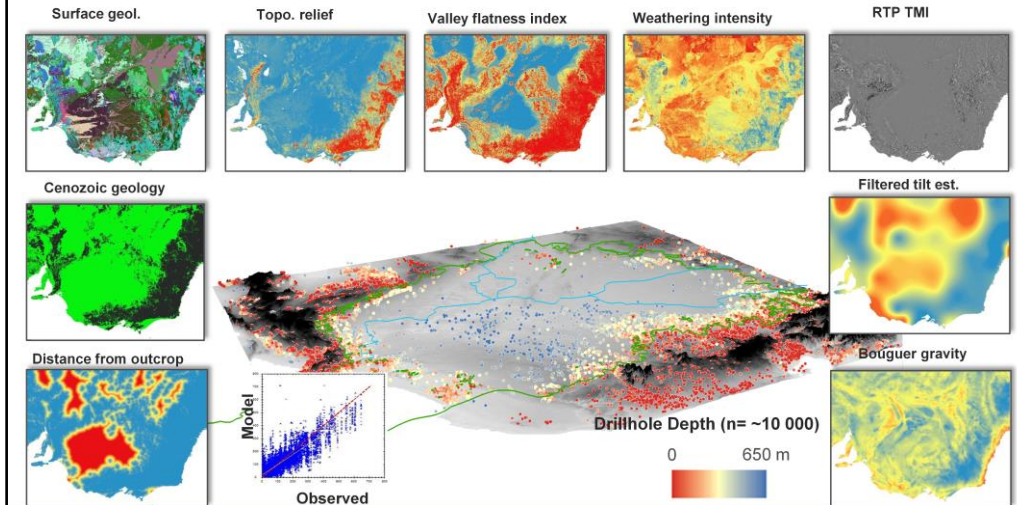


Cenozoic time periods



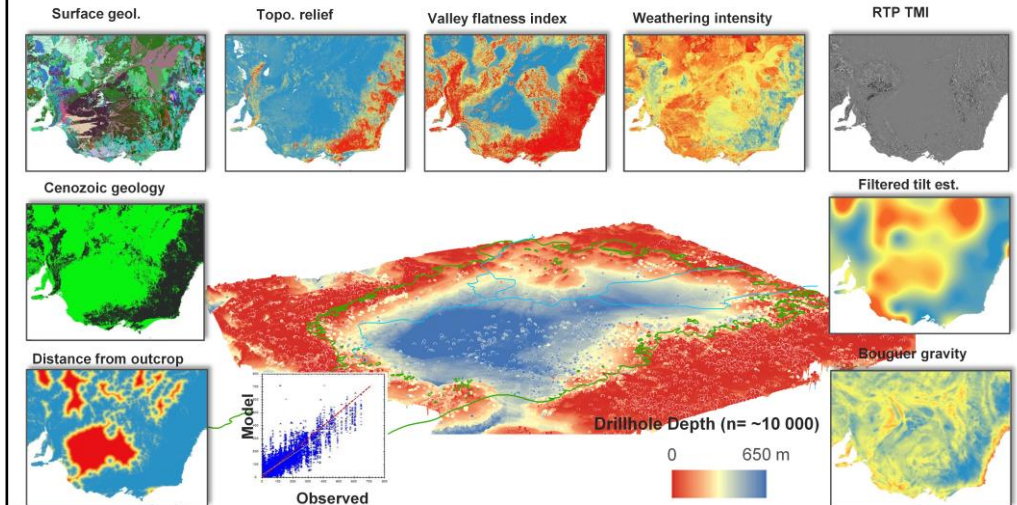
A regolith depth map of the Australian continent. In prep
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Predictive maps of cover thickness – Murray Basin



Presenter's notes: This map is not based on kriging between drillhole basement depths but generate by establishing correlations between drillhole depths (shown by the white dots) and a suite of predictive datasets including for example, gravity, magnetics and terrain attributes. Depth uncertainties are also generated as part of the process. The approach allows us to predict into areas with limited drillhole coverage. Results are preliminary at this stage and the approach is still being evaluated.

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4D Palaeogeography

- from flat maps to a 3D view of the earth through time
- From a static view to the dynamic processes – *rates and volumes*
- What's possible?
- *Still need high quality data with robust time control*

