

EMERGING UNCONVENTIONAL SHALE PLAYS IN WESTERN AUSTRALIA

INTRODUCTION

This is a summarized version of accompanying paper: "EMERGING UNCONVENTIONAL SHALE PLAYS, WESTERN AUSTRALIA".

- Advances in geological techniques, drilling and production technologies improve exploration and production from challenging conventional and unconventional reservoirs (Fig. 1).
- Since 2005, production from shale self-sourcing reservoirs has rapidly increased in the USA, game changer from importer to potential exporter (Figs 2, 3).
- Estimated shale-gas resources of Australia are rated after Argentina, and Mexico, with China then USA having the highest estimated resources (Fig. 4).
- Estimated shale petroleum resources are the highest for the Canning Basin, followed by the Perth, Carnarvon, and Officer basins (Figs 5, 6).
- WA is vastly underexplored and emerging self-sourcing shale plays have revived onshore exploration in the Canning, Carnarvon, and Perth basins.

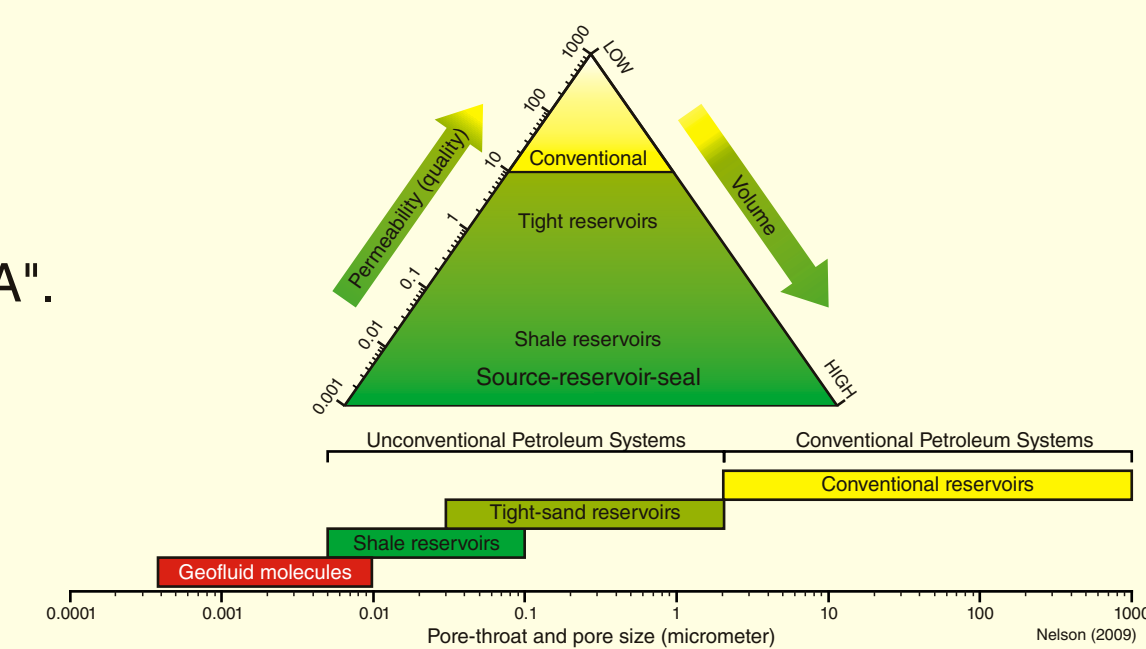


Figure 1. Conventional and unconventional petroleum reservoirs and resources.

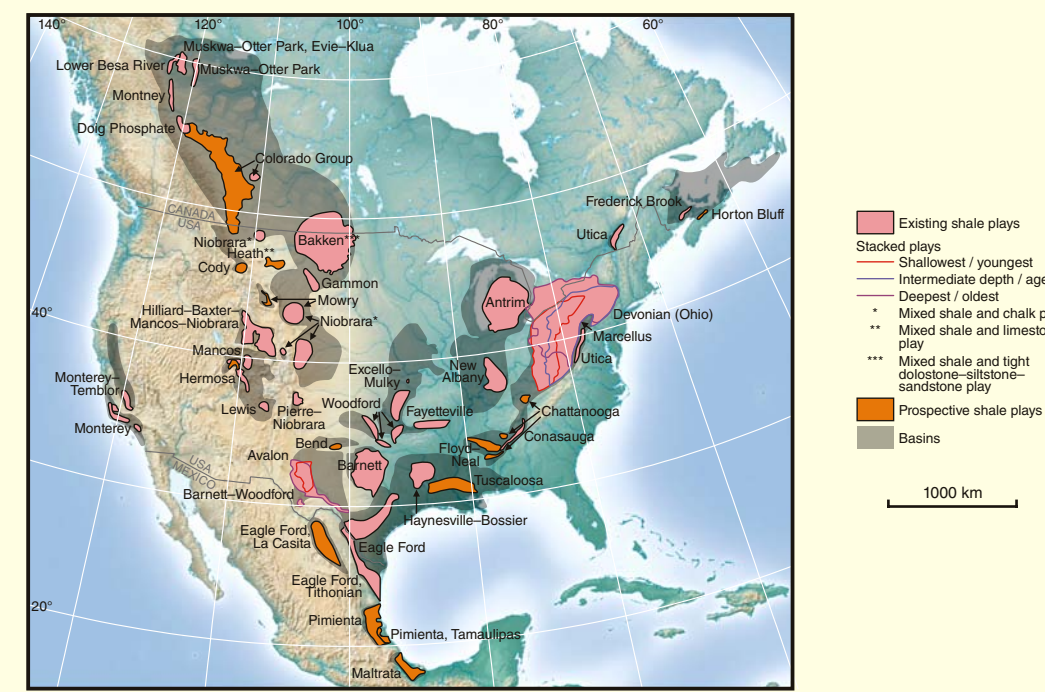


Figure 2. Map of North American shale plays identified up to May 2011.

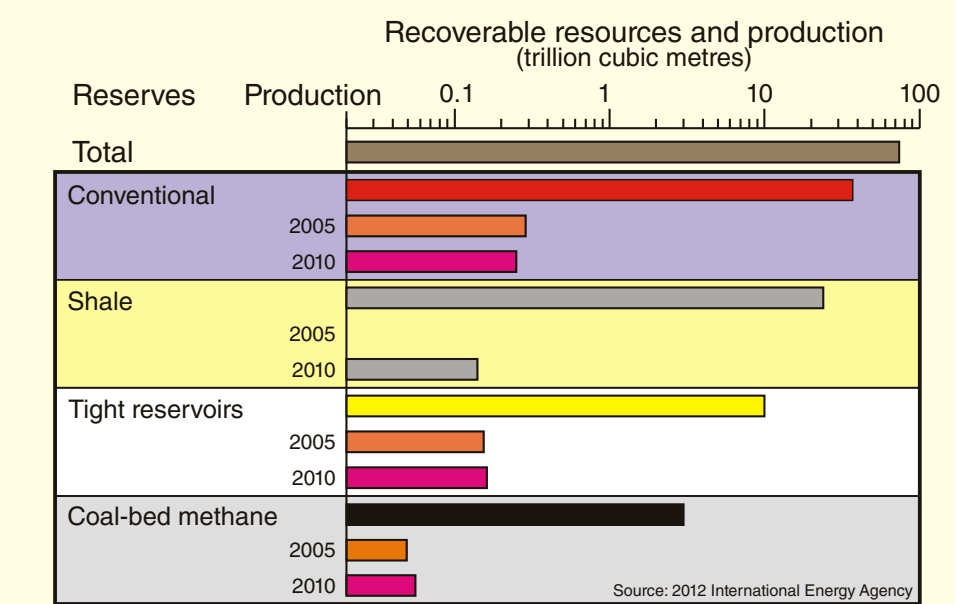


Figure 3. Recoverable resources and production for USA since 2005.

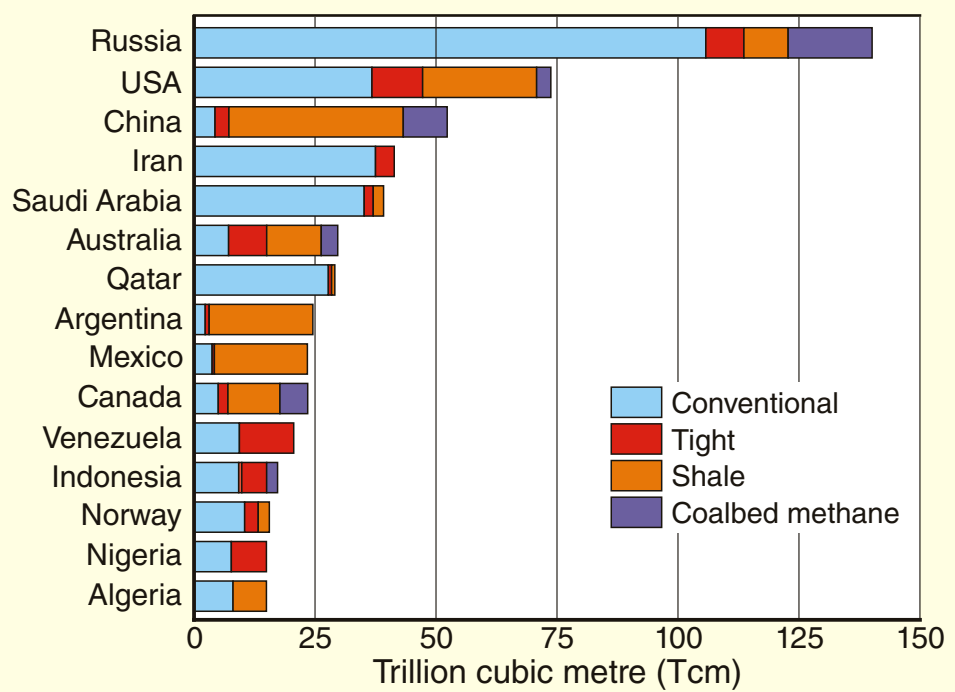


Figure 4. Estimated recoverable gas resources of the top 15 countries.

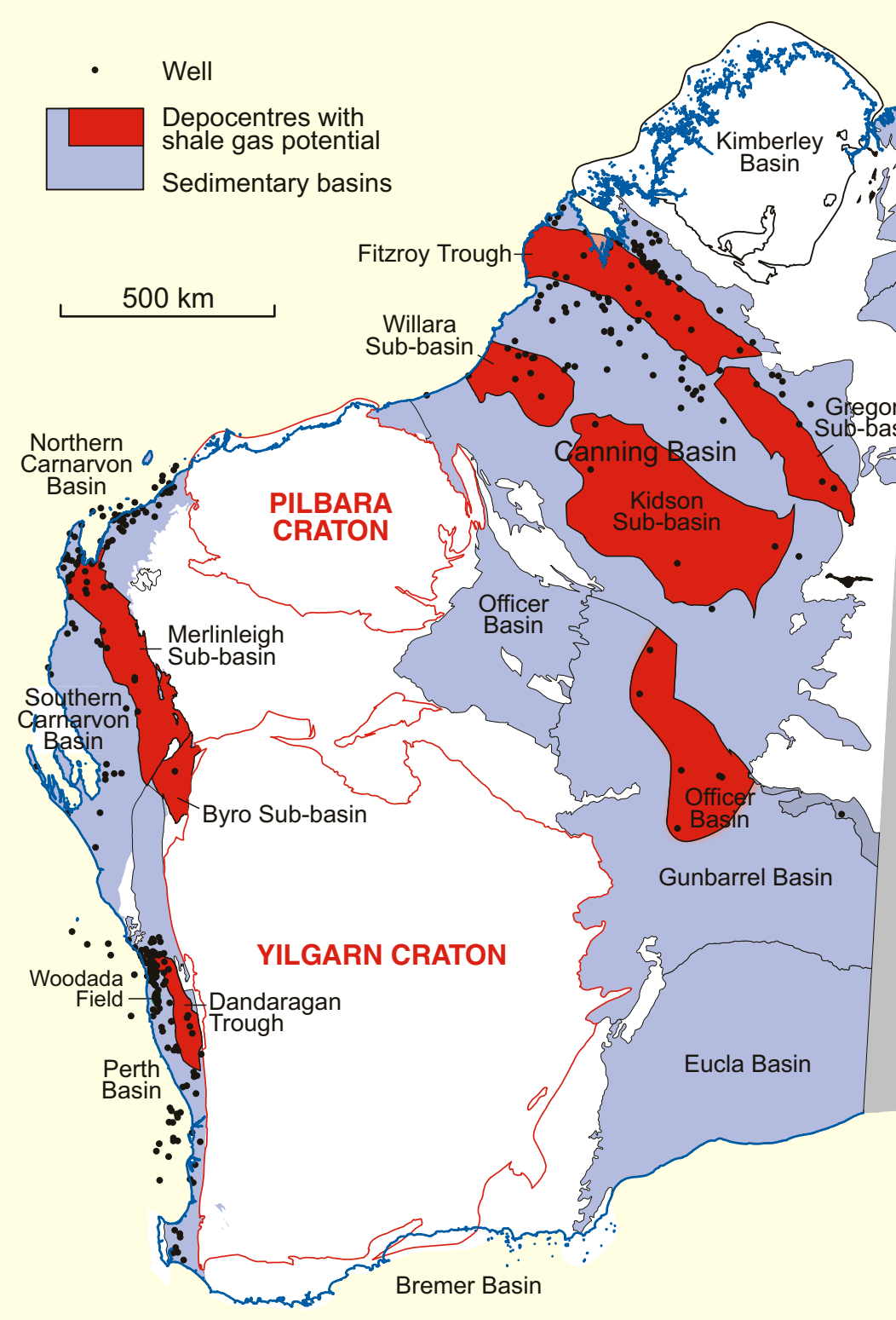


Figure 5. Map of Western Australian sedimentary basins showing deep depocentres within the Canning, Carnarvon, Officer, and Perth basins.

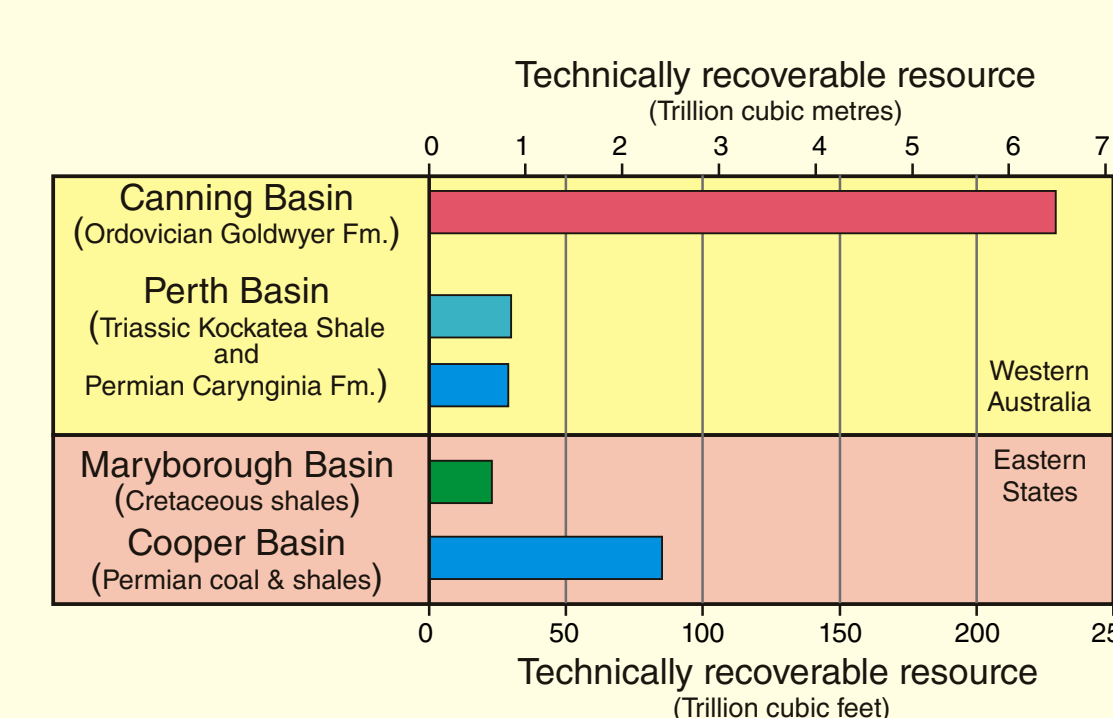


Figure 6. Estimated recoverable shale-gas resources for Australian basins. Source: 2011 US Energy Information Administration

CANNING BASIN

The Ordovician–Lower Cretaceous Canning Basin, the largest onshore basin in Western Australia, covers about 500 000 km², with highest estimated shale-gas resources. Its structural units, stratigraphy, exploration history, source and petroleum systems are summarized in Figures 7–14. The Ordovician, Upper Devonian, and Lower Carboniferous oils and sources have comparable ages and source types to the Ordovician Utica Shale, Devonian Marcellus Shale, and Carboniferous Barnett Shale of the USA; however, Canning Basin shales are untested and may have different petroleum-richness as compared to the petroleum-rich shales of the USA.

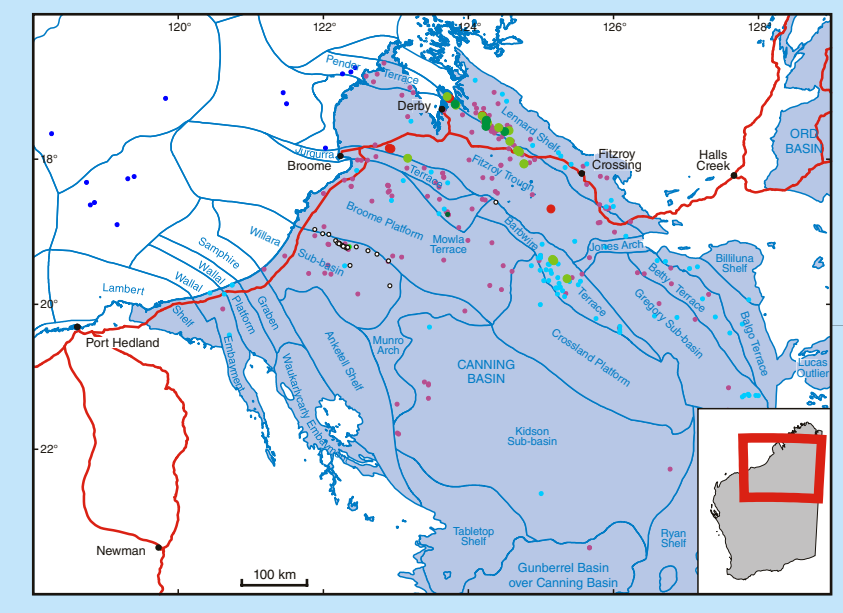


Figure 7. Map showing tectonic units, exploration wells, and petroleum discoveries (after Hocking, 1994).

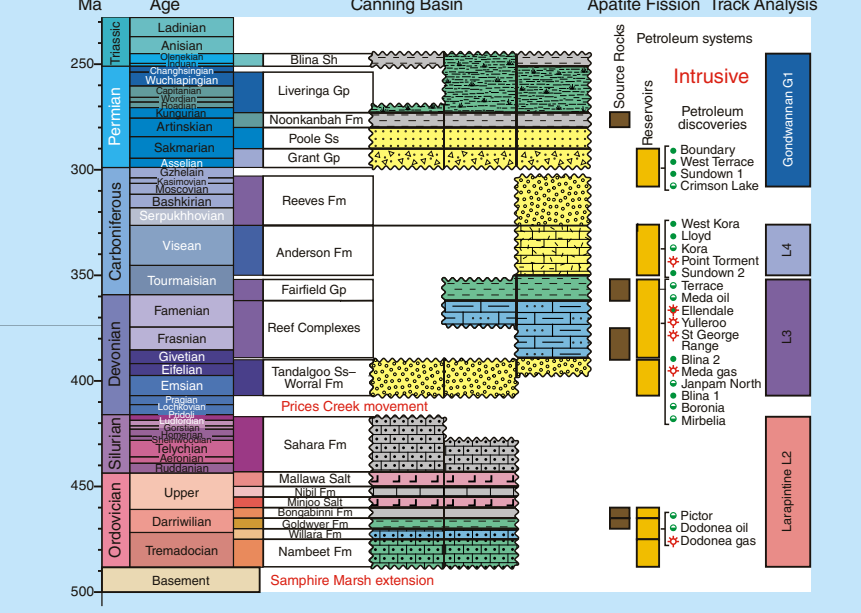


Figure 8. Stratigraphic distribution of source and reservoir rocks, petroleum discoveries and systems.

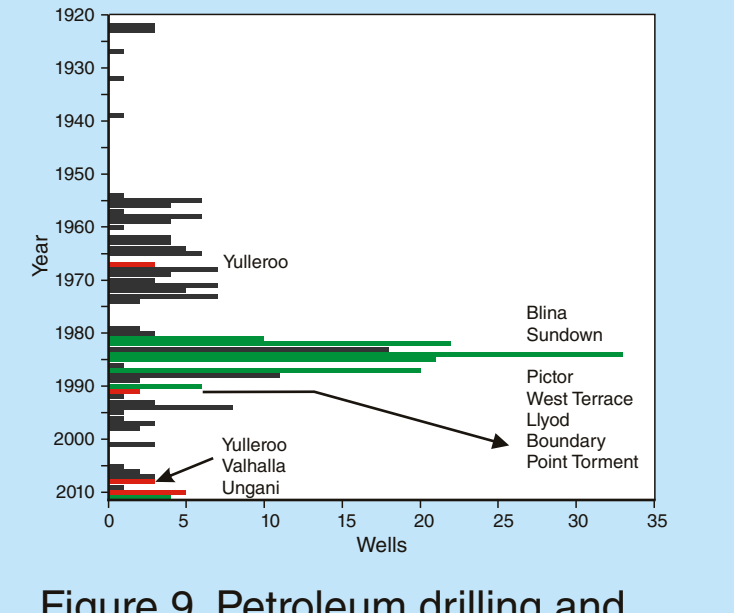


Figure 9. Petroleum drilling and discovery history.

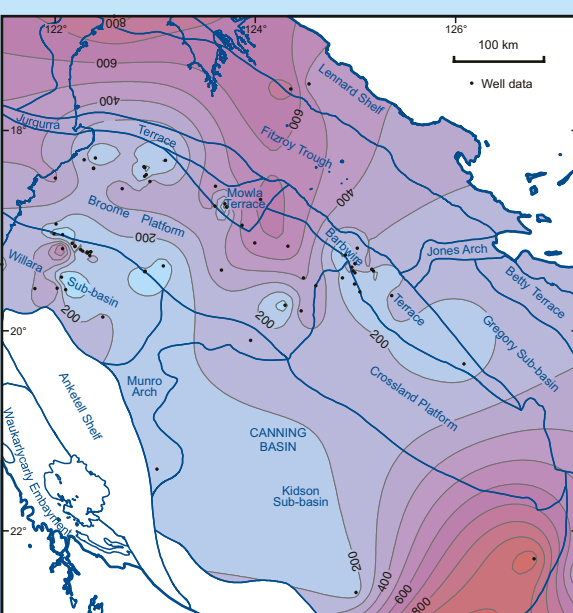


Figure 10. TOC and Rock-Eval pyrolysis evaluation of the Ordovician, Devonian, Lower Carboniferous, and Permian source rock samples: a) generating potential, b) kerogen type, and c) thermal maturity.

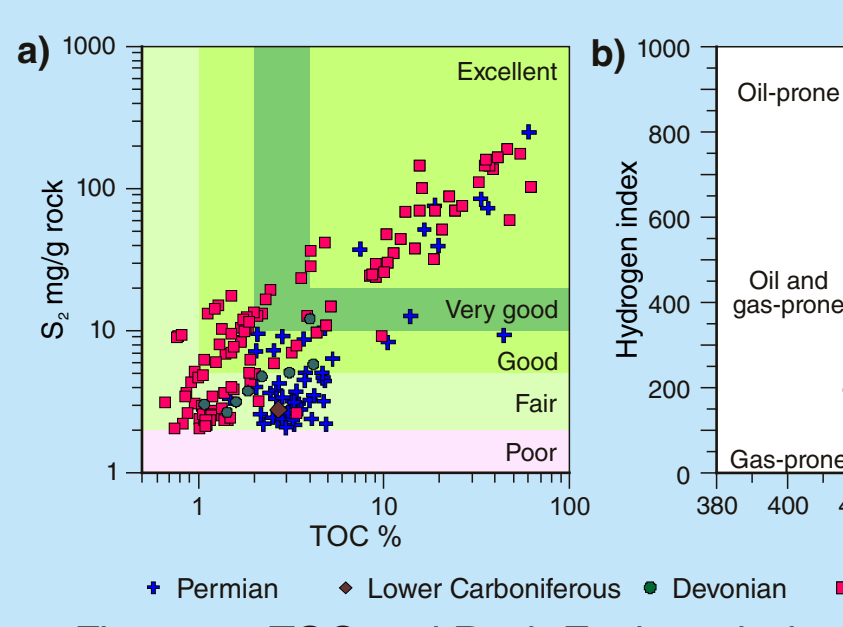


Figure 11. Gas-chromatography biomarker characterization of the Ordovician, Devonian, and Carboniferous crude oil and rock extract, analysed by GSWA.

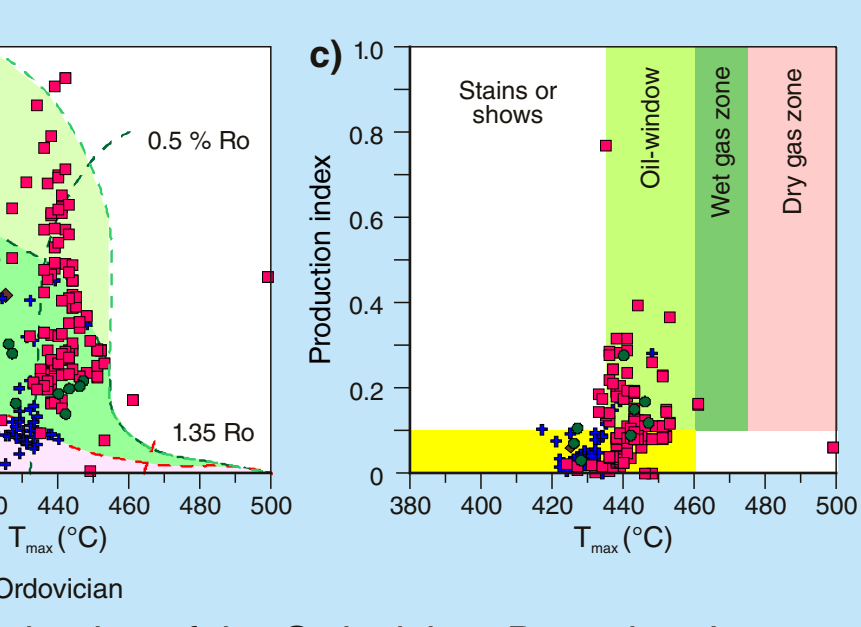


Figure 12. Oil characterization based on multivariate analysis. Modified from GeoMark and AGSO (1996).

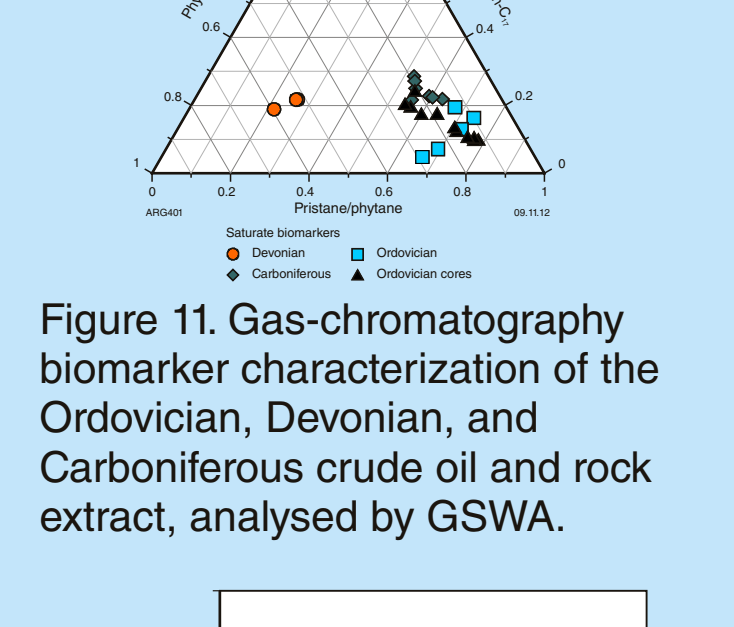


Figure 13. Map showing thickness of the Goldwyer Formation.

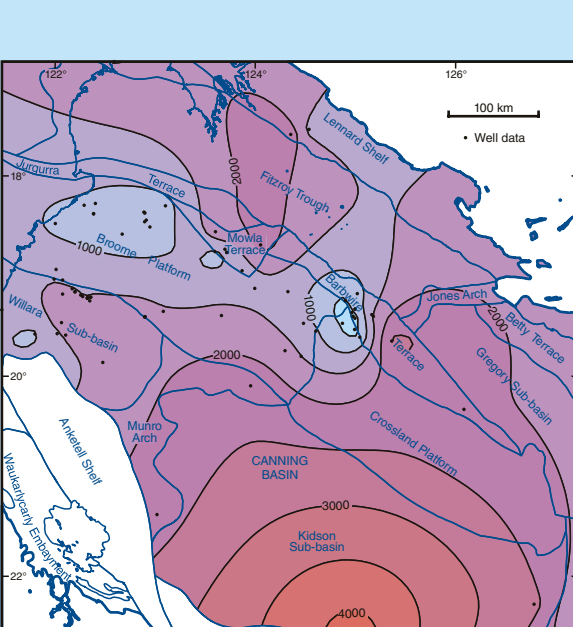


Figure 14. Map showing depth of the Goldwyer Formation.

CARNARVON BASIN

The onshore Carnarvon Basin is predominantly Paleozoic, its structural units, stratigraphy, source potential and petroleum systems are summarized in Figures 15–18. Petroleum geochemistry indicates best source potential within the Lower Permian of the Merlinleigh Sub-basin. These source rocks have analogy with predominantly gas-prone source rocks deposited worldwide, and are the important source rocks in the Cooper Basin.

New Standard Energy is evaluating shale-gas potential of the Merlinleigh Sub-basin for the Lower Permian Wooramel Group as primary resource play, their estimated unconventional resource are up to 33 Tcf and a mature source rock area of about 1100 km².

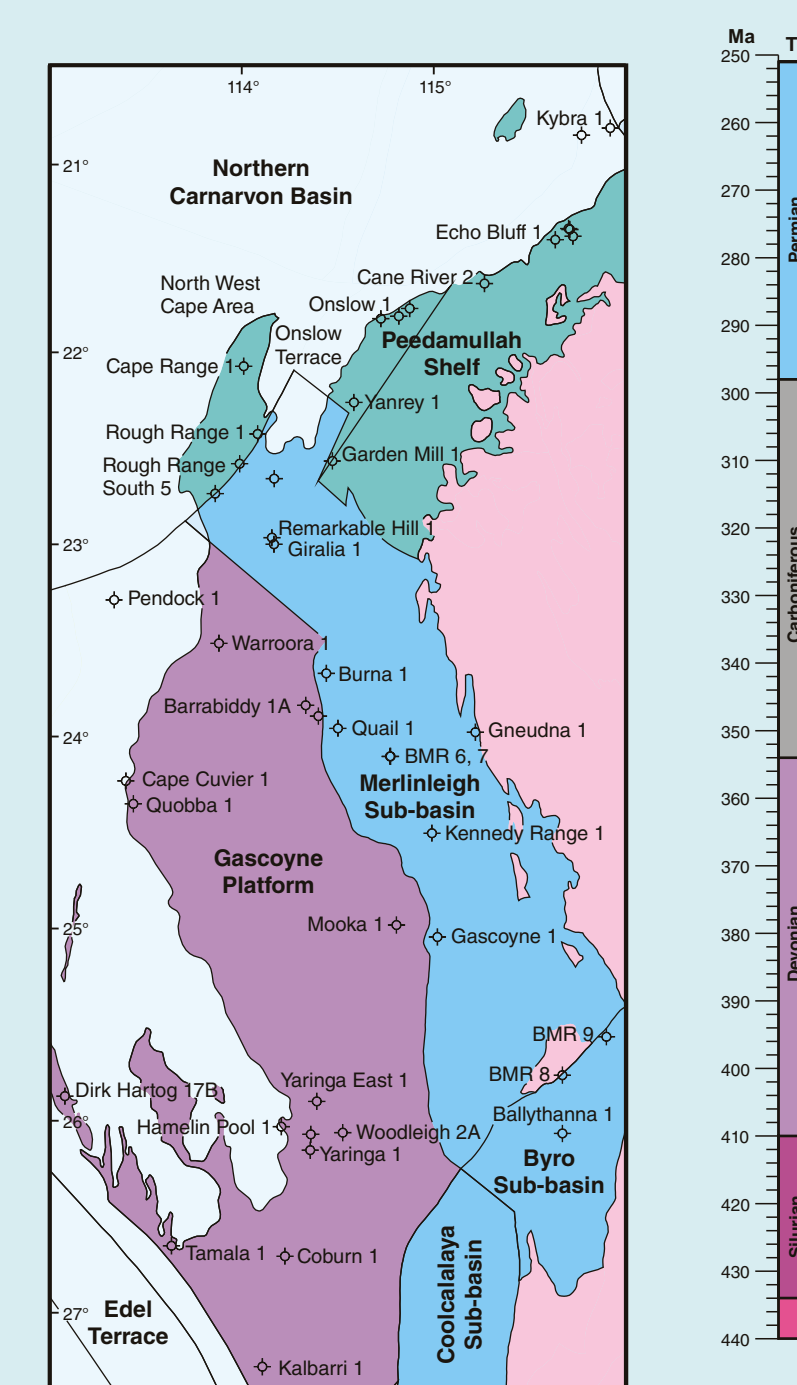


Figure 15. Map showing tectonic units of the onshore Carnarvon Basin.

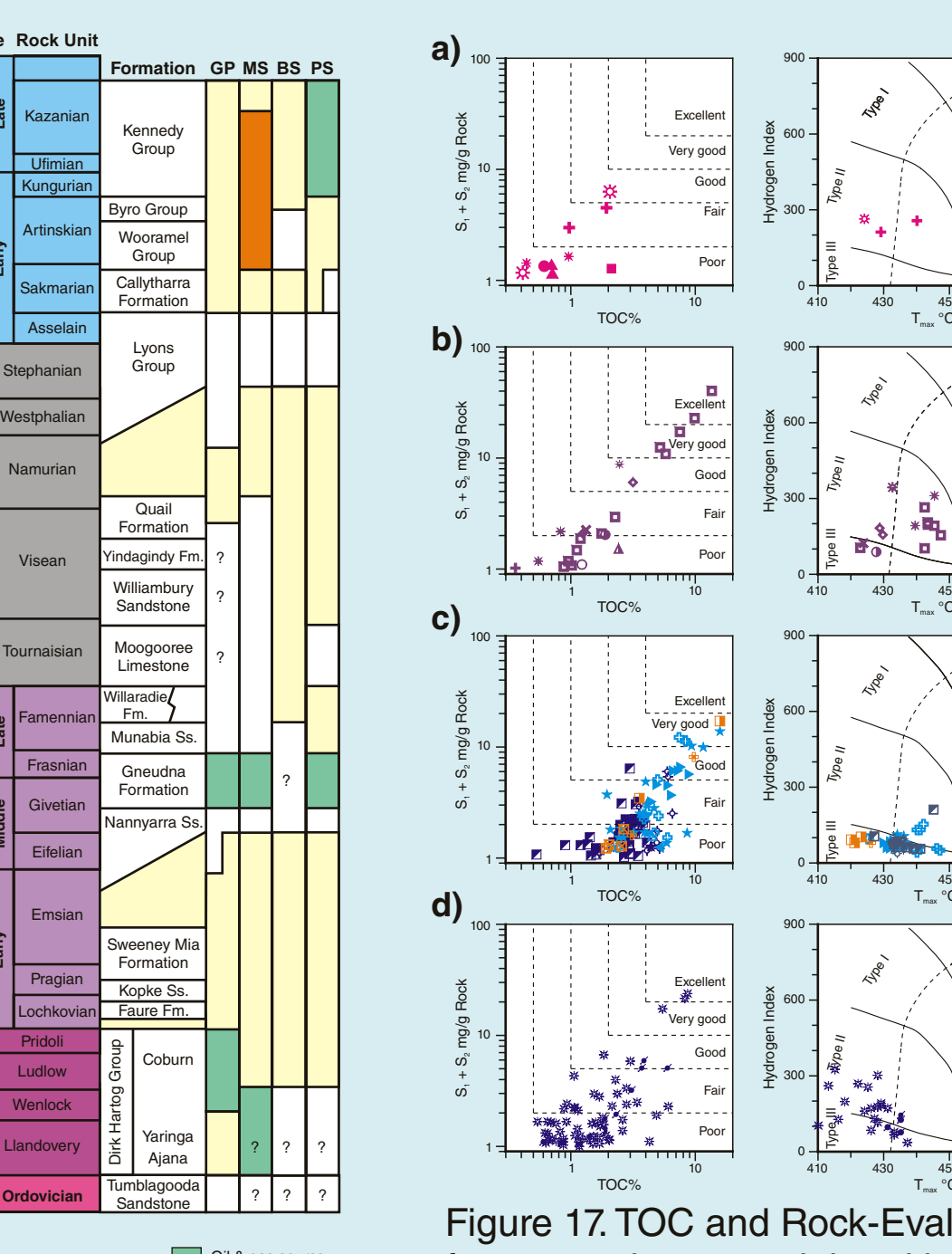


Figure 16. Generalized stratigraphy of the onshore Carnarvon Basin.

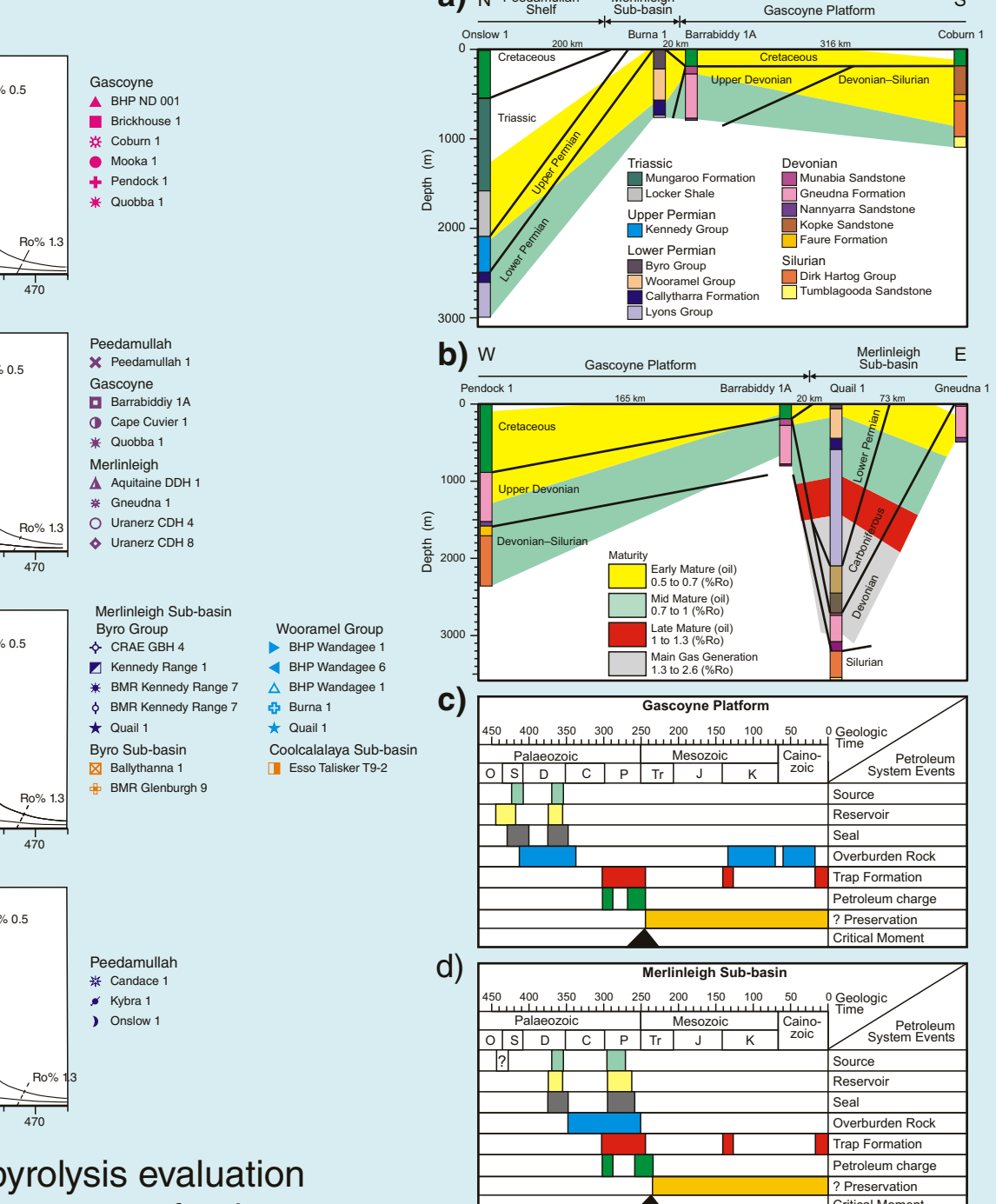


Figure 17. TOC and Rock-Eval pyrolysis evaluation for generating potential and kerogen type for the: a) Silurian; b) Upper Devonian; c) Lower Permian and d) Upper Permian source rock samples.

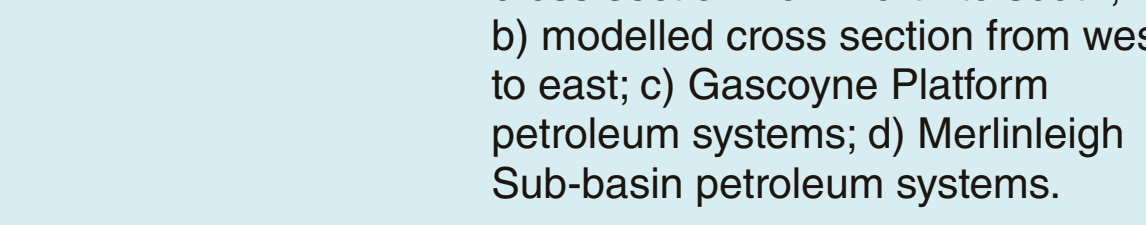


Figure 18. Thermal maturity and petroleum systems: a) modelled cross section from north to south; b) modelled cross section from west to east; c) Gascoyne Platform petroleum systems; d) Merlinleigh Sub-basin petroleum systems.

PERTH BASIN

The Perth Basin covers an area of about 100 000 km², contains mainly continental clastic rocks of Permian and younger age. Its estimated total shale-gas resources are about 59 Tcf, for the Permian Carynginia Formation and Triassic Kockatea Shale. Structural units, stratigraphy, drilling history, source potential, and petroleum systems are summarized in Figures 19–23. AWE's Woodada Deep 1 (2010) and Northwest Energy's Arrowsmith 2 (2011) were successfully fractured and flowed gas, estimated gas-resource in place are about 13–20 Tcf, further study is underway. Tight-sand gas resources are estimated at over 12 Tcf. Corybas is the first gasfield in Western Australia to produce from tight-sand reservoir.

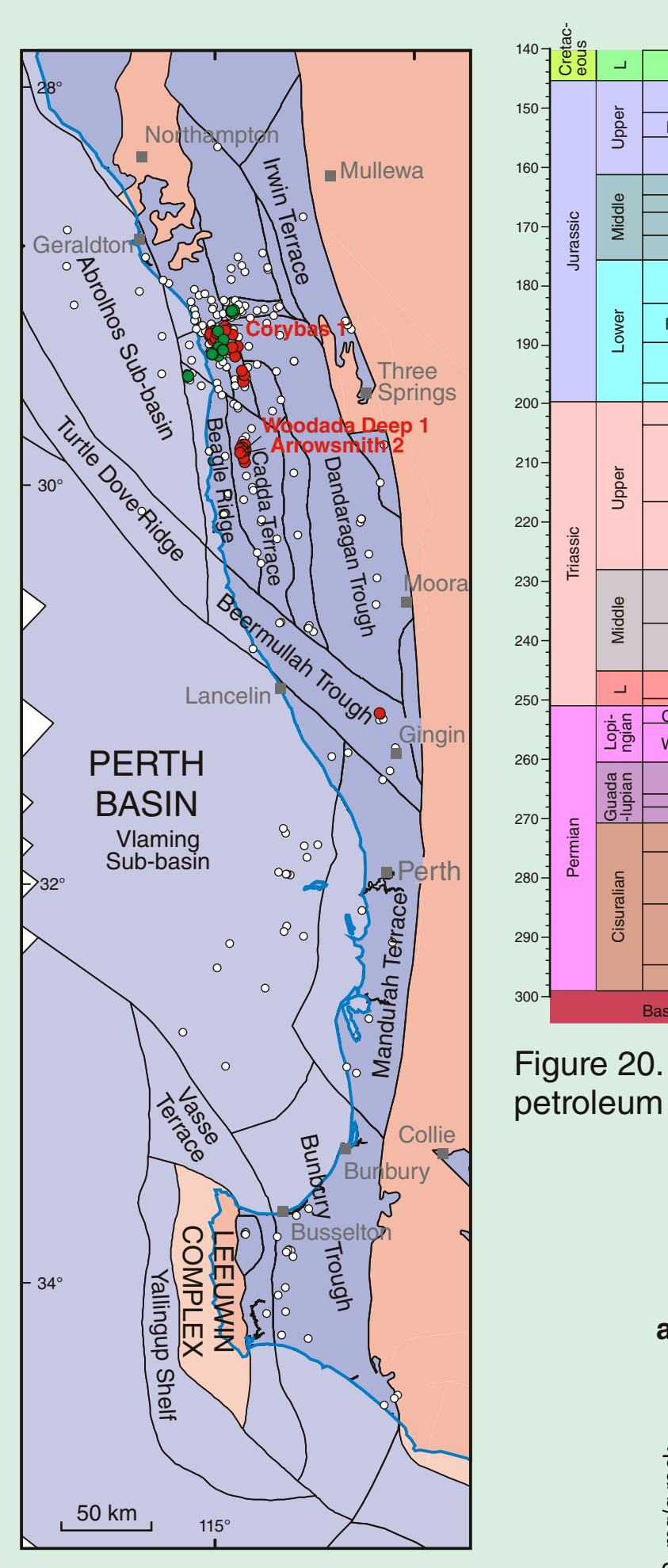


Figure 19. Map showing tectonic units, wells, oil and gas field.

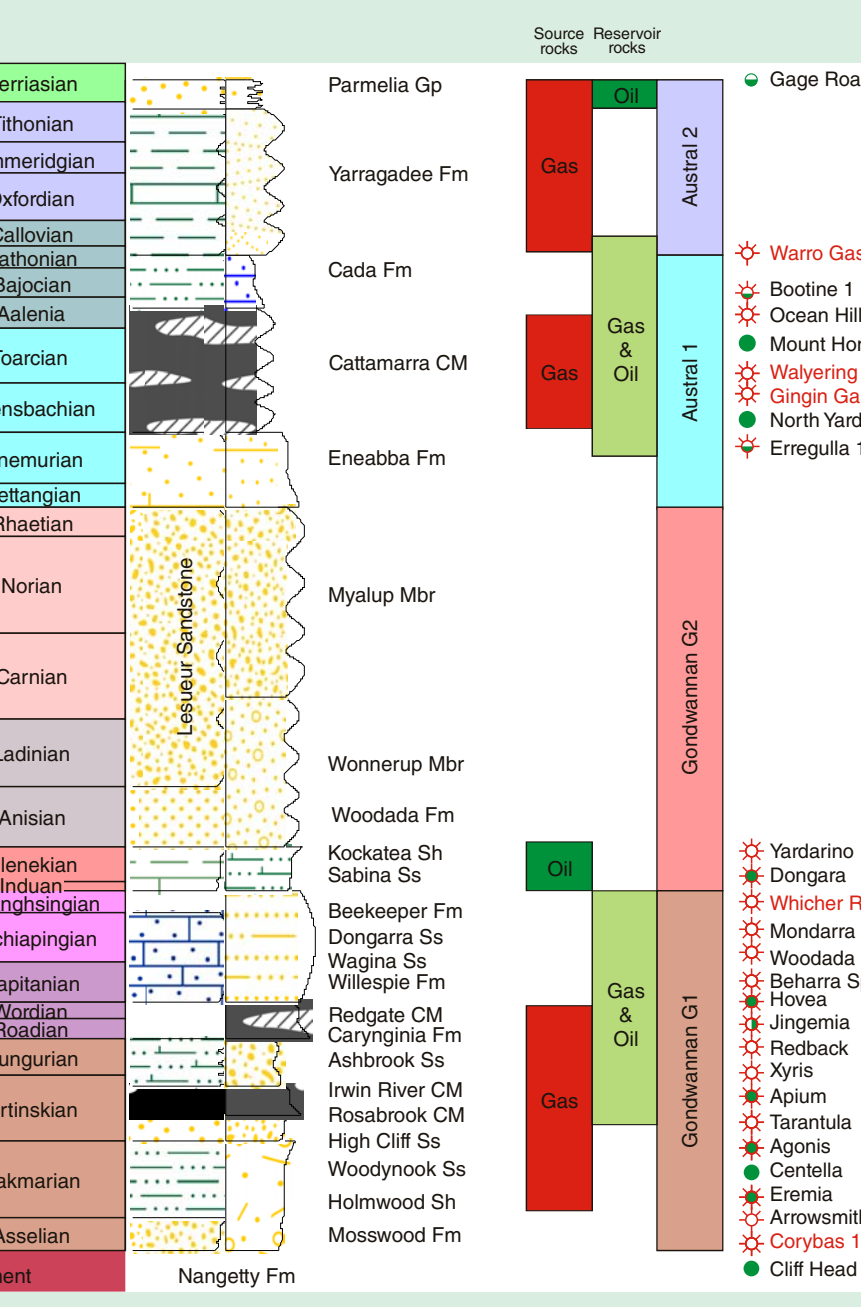


Figure 20. Stratigraphic distribution of source and reservoir rocks, petroleum discoveries and systems.

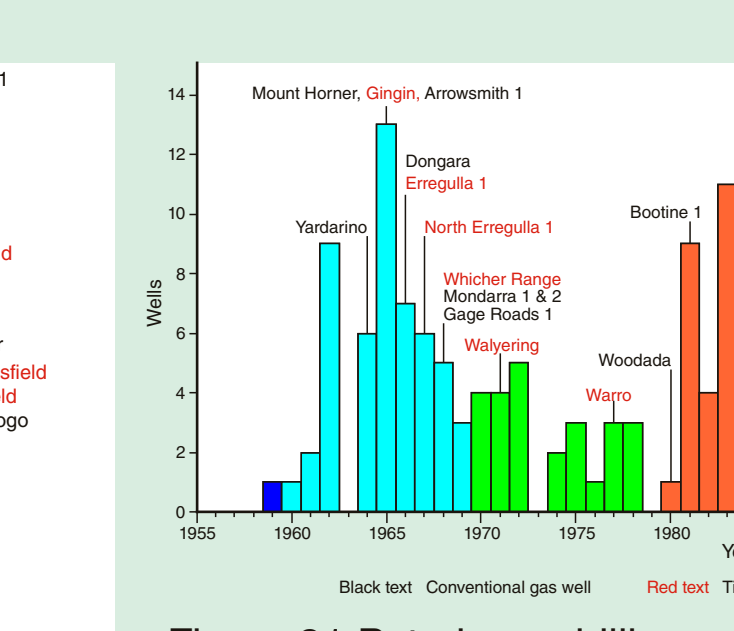


Figure 21. Petroleum drilling and discovery history.

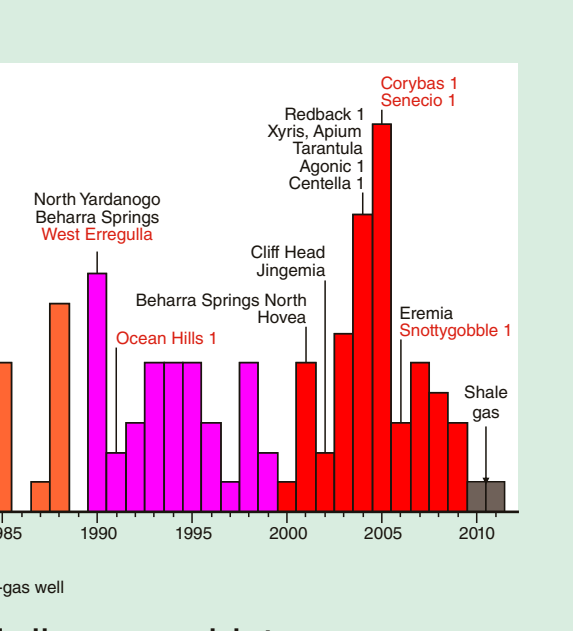


Figure 22. TOC and Rock-Eval pyrolysis evaluation: a) generating potential; b) kerogen type; c) thermal maturity.

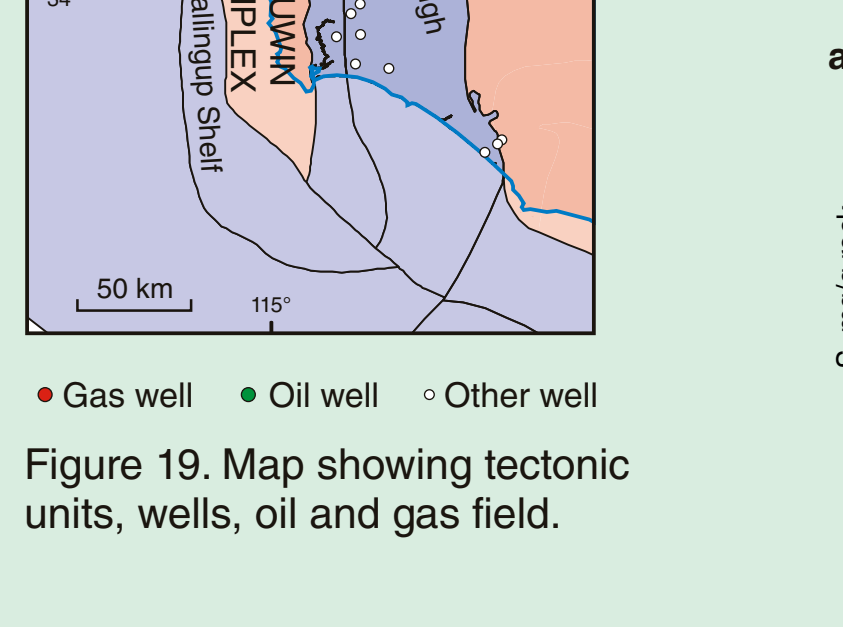


Figure 23. Oil characterization based on multivariate analysis (GeoMark and AGSO, 1996).

OFFICER BASIN

The Officer Basin is a part of the Centralian Superbasin, filled with the Neoproterozoic (840–541 Ma) rocks. Organic rich rocks and numerous oil, gas, bitumen shows, and a significant gas accumulation at Dingo in the Amadeus Basin indicate the existence of Neoproterozoic petroleum systems. Its structural units, stratigraphy, and source potential are summarized in Figures 24–27. The petroleum potential of this vast with limited data, under-explored basin remain unverified.

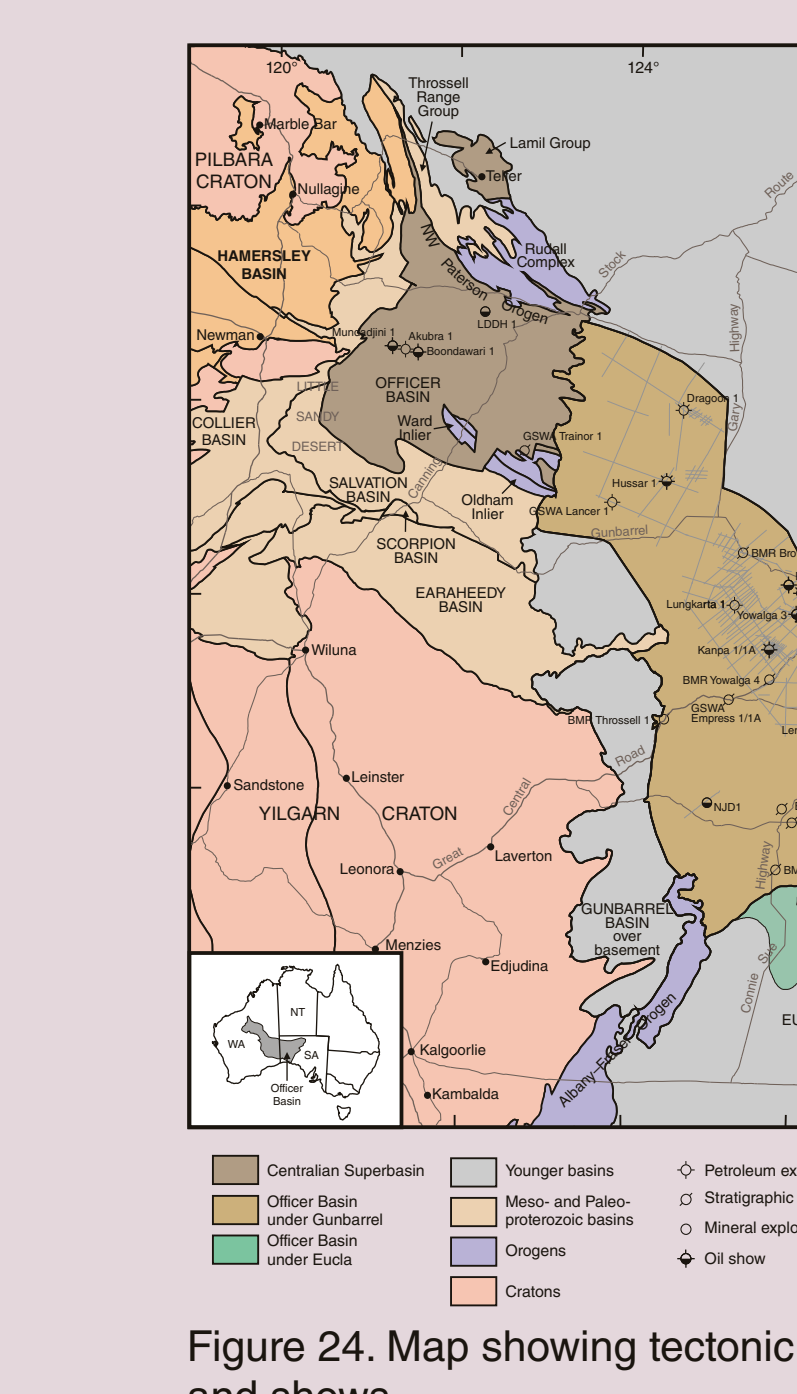


Figure 24. Map showing tectonic units, wells, and shows.

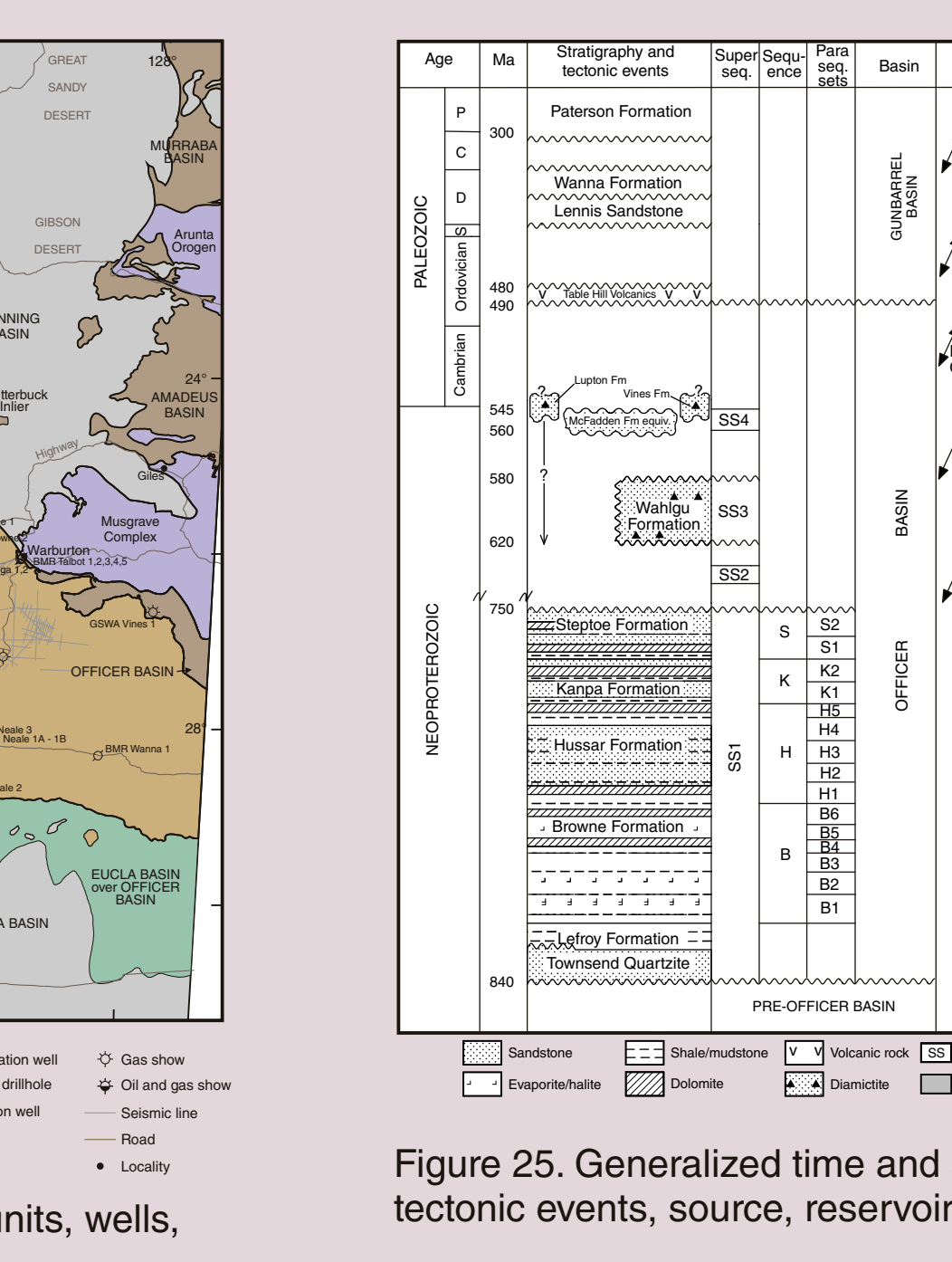


Figure 25. Generalized time and seismic stratigraphy, tectonic events, source, reservoir, and seal rocks.

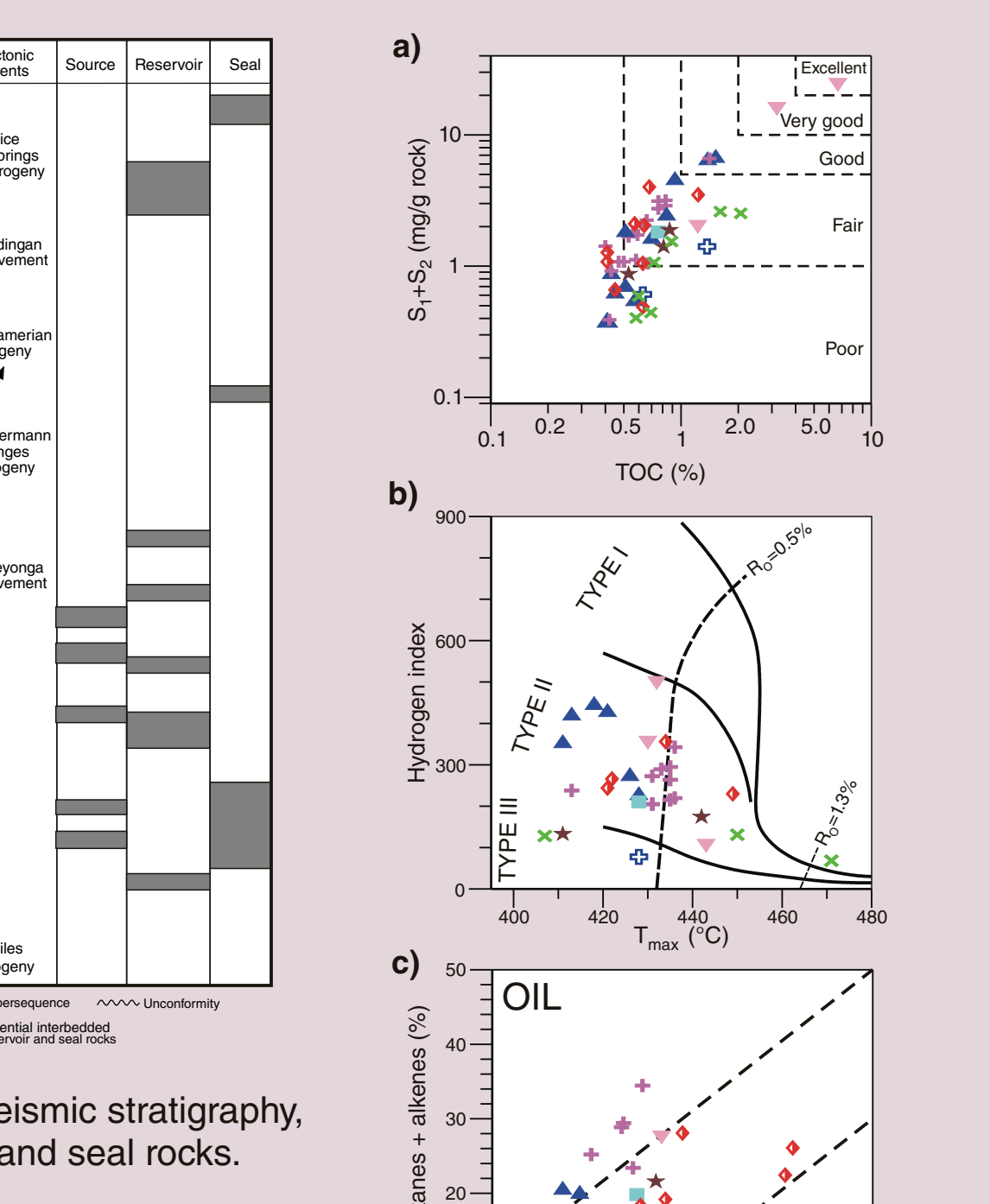


Figure 26. Composite seismic section of the Yowalga 3 and Brown 2 wells and erosion of Supersequence 1 strata between salt emplacements in the Yowalga area.

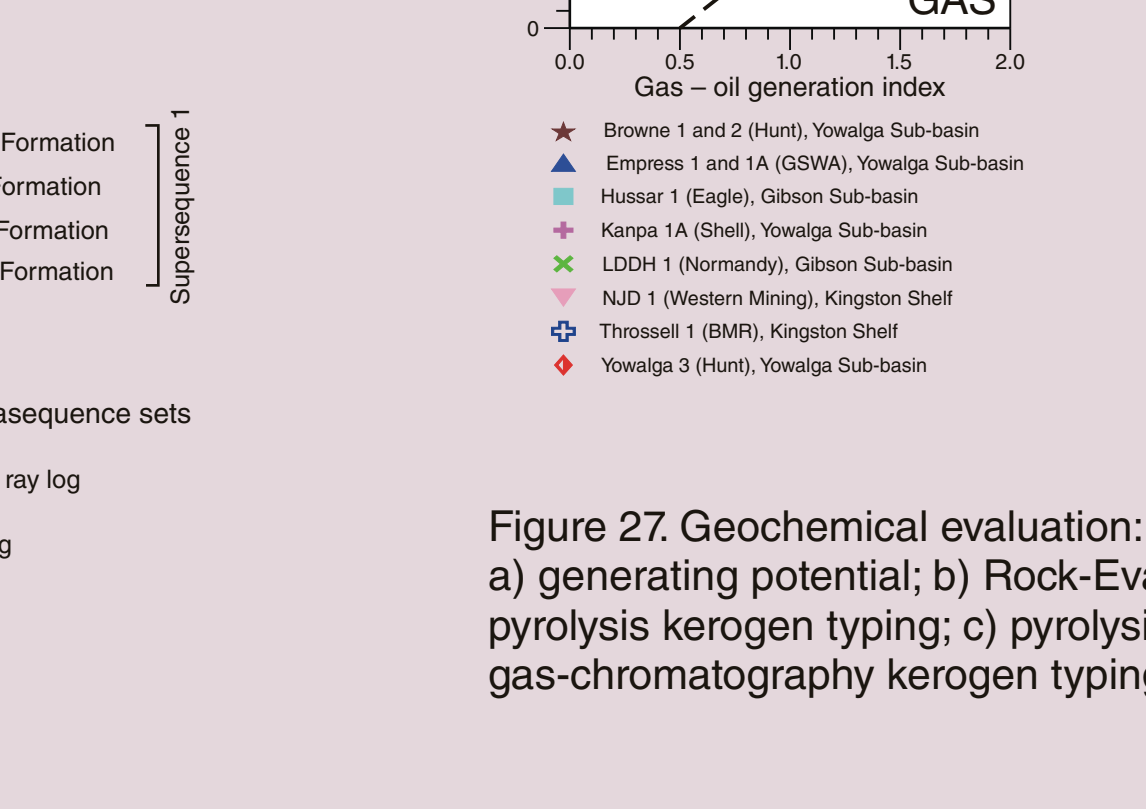


Figure 27. Geochemical evaluation: a) generating potential; b) Rock-Eval pyrolysis kerogen typing; c) pyrolysis gas-chromatography kerogen typing.

CONCLUSIONS

- The Canning Basin has the largest estimated shale-gas resource in Australia; with about 229 Tcf in the Ordovician Goldwyer Formation. New Standard Energy's Nicolay 1 (2011) is the first foundation well to verify shale-gas resources. The Perth Basin's estimated shale-gas resources are 29 Tcf for the Permian Carynginia Formation and 30 Tcf for the Triassic Kockatea Shale. AWE's Woodada Deep 1 (2010) and Arrowsmith 2 (2011) are the first wells of Western Australia to successfully produce shale-gas from the Carynginia Formation. Further studies are under way.
- The Ordovician Bongabinni Formation, the Devonian Gogo Formation, the Lower Carboniferous Laurel Formation, and the Lower Permian Noonkanbah Formation of the Canning Basin; the Lower Permian Wooramel and Byro groups of the Merlinleigh Sub-basin, Carnarvon Basin, and the Neoproterozoic shale of the Officer Basin, may also host shale-gas resources, in addition to the Goldwyer and Carynginia formations and the Kockatea Shale.
- All these source rocks are untested for petroleum richness as compared to petroleum-rich shale of the United States; they may have different petroleum richness, geological and fracturing characteristics for unlocking its reservoir petroleum.
- In the United States, shale-plays takes up to five years to convert to commercial-plays, where infrastructure is well developed with all necessary facilities and expertise for geological evaluation, drilling, fracturing, and production.
- These facilities are currently lacking in Western Australia and need to be developed. Four vertical shale-gas wells have been completed and successfully fractured, and are under geological studies to understand how shale-petroleum is stored and can be effectively produced.
- These wells laid the foundation to expand facilities and expertise for shale-petroleum exploration and development in Western Australia.
- Exploration is at a very early stage and much more work is needed to estimate and verify the shale-petroleum resources of the vastly underexplored onshore Western Australian basins.