

THERMAL AND BURIAL HISTORY

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Chapter 9

INTRODUCTION

This chapter draws on preliminary results from the National Geoscience Mapping Accord (NGMA) Cooper and Eromanga Basins Project, due for completion in September 1999, and presents conclusions based on calculated maturity and source rock expulsion curves from 15 wells in the Cooper Basin, South Australia (Fig. 9.1). These wells form a subset of the overall study which encompasses 90 wells from the South Australian and Queensland portions of the Cooper Basin, and includes a number of synthetic wells in undrilled troughs.

PREVIOUS STUDIES

Kantsler *et al.* (1983) noted that higher palaeotemperatures than present were necessary to model maturities in the Nappamerri Trough but claimed that hydrocarbon generation elsewhere in the Cooper Basin was likely to post-date deposition of the Winton Formation. They did not present any maturity cross-plot validation for this claim. Similar conclusions were substantiated by Kantsler *et al.* (1986) who found that variable palaeoheatflow regimes appeared to apply in different parts of the Cooper and Eromanga Basins. Pitt (1986) reached similar conclusions and also identified a recent rise in geothermal gradient in the last 5–10 million years. Duddy (1987) and Gallagher (1988) identified rising heatflow in the last 1–2 million years using apatite fission track analysis (AFTA) and argon spectrum analysis, respectively. Gallagher *et al.* (1994) and Tingate and Duddy (1996) have confirmed the apparently widespread nature of this Plio-Pleistocene thermal event. Toupin *et al.* (1997) modelled these heatflow variations in terms of changes in aquifer flow rates in the Great Artesian Basin. Their model suggests invasion of Permian strata by hot artesian waters in the early Tertiary, locally shifting the depth of the zone of oil generation.

BURIAL HISTORY

Figure 9.2 shows the burial geohistory for Burley 2 in the Nappamerri Trough, constructed using standard decompaction techniques, a fluctuating sea level and palaeowaterdepths derived from sedimentological and fossil content. The plot indicates the main features of deposition in the Cooper and overlying Eromanga Basins — a thick (1500 m) non-marine Permian and Early Triassic sequence of sandstone, siltstone and shale is overlain disconformably by ~800 m of non-marine sandstone, siltstone and shale of mid-Jurassic to Early Cretaceous age. Rapid deposition of marine mudstone and siltstone took place in the late Early

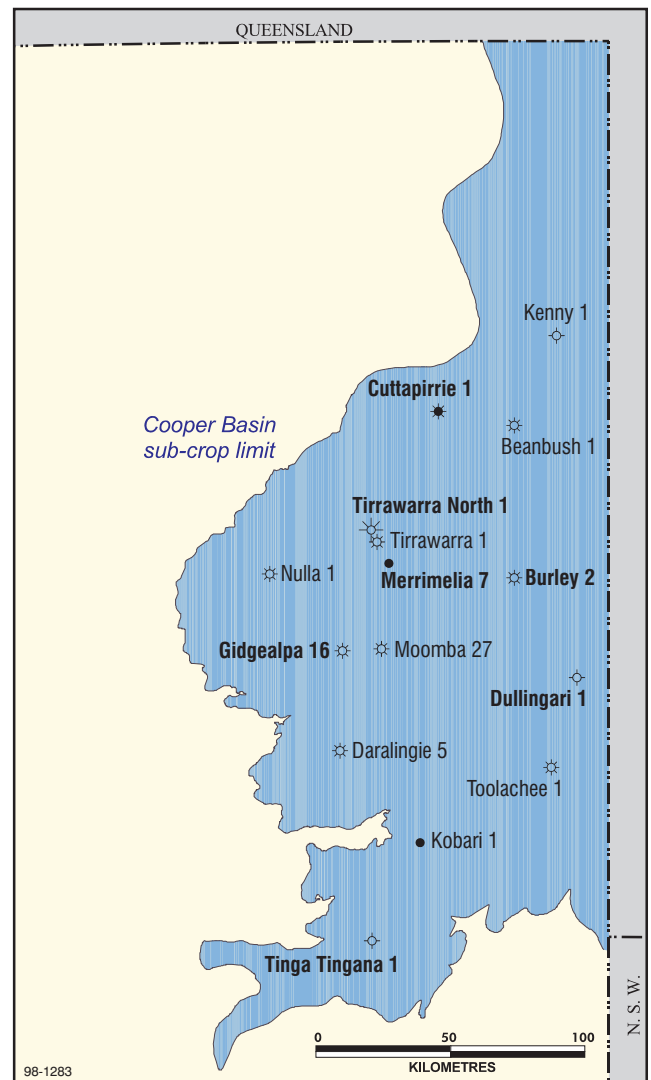


Fig. 9.1 Location of wells studied; bold indicates wells discussed in detail.

Cretaceous (shaded area in Fig. 9.2) and was followed by a thick sequence (900 m) of non-marine siltstone in the mid-Cretaceous. A minor erosional event separates this lower sequence from intermittent Tertiary deposition of thin non-marine sediments accompanied by minor compressional structuring. Interpretation of erosional events is based on Moussavi-Harami (1996b).

TECTONIC SUBSIDENCE

Previous burial history studies of the Cooper and Eromanga Basins have concentrated on explaining the apparently anomalous rapid deposition of the Winton

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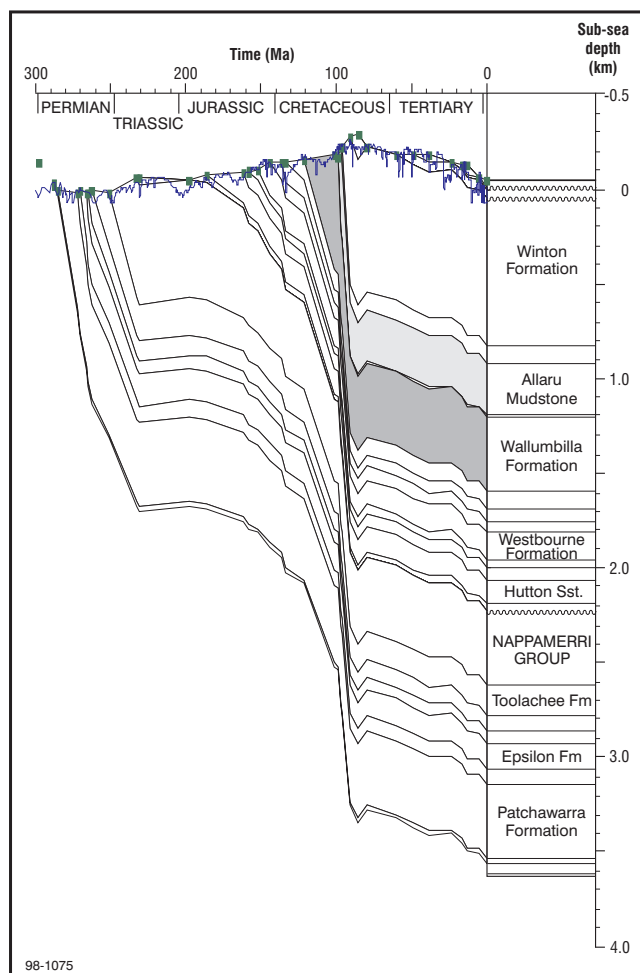


Fig. 9.2 Burial history plot, Burley 2.

Formation (Middleton, 1989; Gallagher, 1988; Zhou, 1989). In this study, the authors have modelled terrestrial compaction based on work by Nadon and Issler (1997; near-surface porosities are lower than for marine sediments; see Fig. 9.3) and palaeo-elevation some 100 m above sea level for deposition of the Winton Formation. The resultant tectonic subsidence during Winton deposition and erosion is

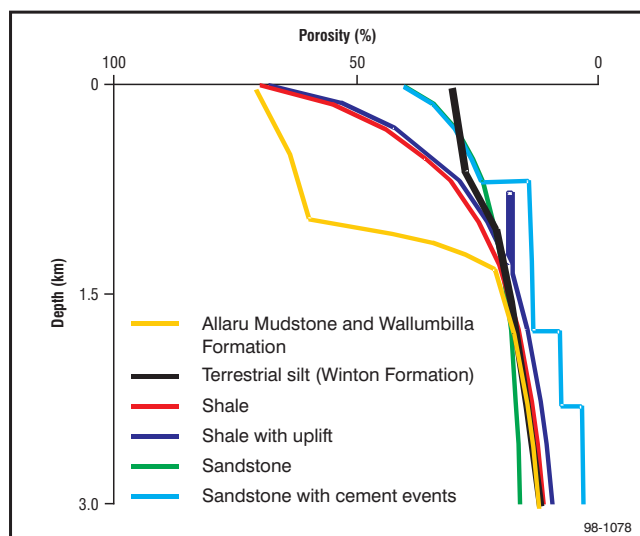


Fig. 9.3 Typical porosity versus depth profiles for various sediment types.

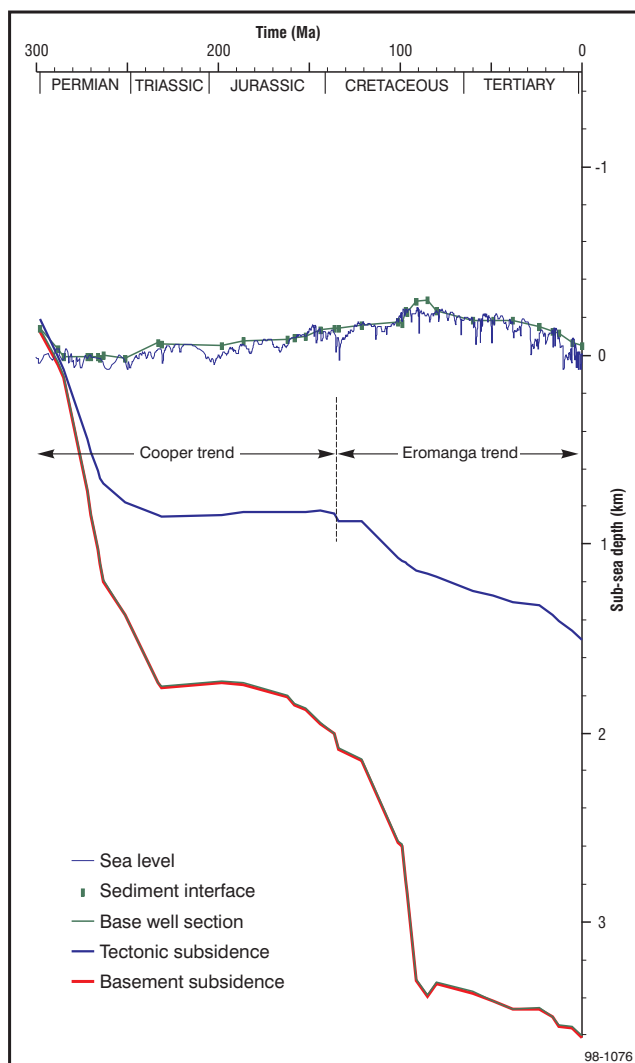


Fig. 9.4 Simplified burial and tectonic subsidence history of Burley 2. The lower curve shows subsidence of basement. The upper curves are sea-level (using the AGSO 95 sea-level curve) and the sediment interface (also showing age-control points). The middle curve is stripped-basement or tectonic subsidence. Deposition of the Winton Formation (mid-Cretaceous) was under subaerial conditions.

no different from the background Eromanga trend (Fig. 9.4). Cretaceous to Tertiary tectonic subsidence is small compared to Permian subsidence.

Figure 9.5 shows the tectonic subsidence of the wells in this study, normalised from the start of burial. Note the uniformity of mid-Cretaceous to present subsidence and the comparatively greater magnitude of Permian subsidence. Interpreted simply, in terms of the McKenzie (1978) crustal stretching model, Cooper subsidence at Burley 2 would correspond to a stretching factor of 1.2 (based on stretching subsidence of ~1 km), while Eromanga subsidence would correspond to a stretching factor of <1.1 (based on thermal subsidence of ~200 m).

PALAEOTEMPERATURE DATA

The following thermal regime for the Cooper Basin in South Australia is proposed, based on combined AFTA and measured vitrinite reflectance (R_o) analysis (Tingate and Duddy, 1996; Geotrack, 1997):

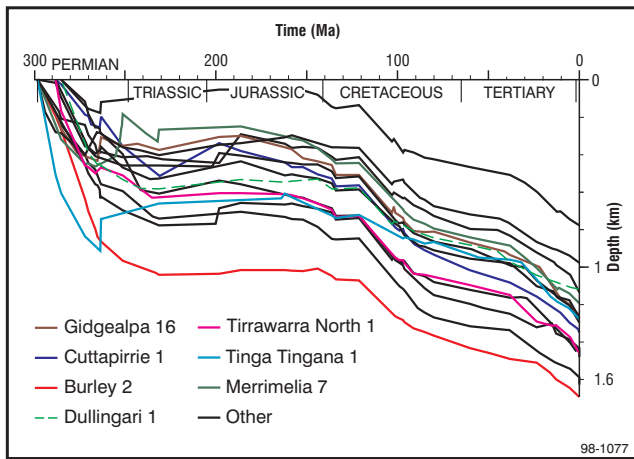


Fig. 9.5 Tectonic subsidence for selected Cooper Basin wells.

- Palaeotemperature profiles were highest at 90–100 Ma, with cooling prior to 70 Ma in the Cooper Basin. Cooling may have been caused by uplift and erosion, or heatflow decline.
- Palaeotemperature profiles were low prior to 2–5 Ma then increased to high at present. Argon dating (granite in Moomba 1; Gallagher, 1988), AFTA dating and reflectance modelling (not on all wells) indicate a recent rise in geothermal gradient of 10–20°C/km.

The results for four wells are shown in Figure 9.6, expressed in terms of geothermal gradient. The details for Burley 2 are shown in Figure 9.7.

This thermal scheme has been implemented in the current NGMA study, applying higher heatflows from 90 to 85 Ma, declining to below background till 2–5 Ma (see Figs 9.8, 9.9, 9.10). With the exception of ‘suppressed’ vitrinite, particularly just above the oil window (e.g. Figs 9.15, 9.21), this heatflow model successfully matches most vitrinite reflectance (VR) data.

PRESENT HEATFLOW

Areas of present heatflow maxima are generally coincident with distribution of granites and/or high conductivity basement. Heatflow ranges from 70 to 120 milliwatts per square metre (mW/m^2), with the higher values occurring over granite bodies and Warburton Basin ridges. The higher heatflows can be explained by 5 km thick, 50 km wide granite bodies which provide an additional 35–40 mW/m^2 above a background of 60–70 mW/m^2 (Gallagher, 1988, fig. 8.3.5). An additional 15 mW/m^2 can be produced by conductivity contrast in the basement (Gallagher, 1988, fig. 8.3.3). Minor heatflow maxima may be associated with aquifer discharge near basin depocentres.

PALAEOHEATFLOW MODEL

The palaeoheatflow curves shown in Figure 9.8, and which result in a valid palaeotemperature model, are commented on below.

Cooper event

Granite cooling may provide a method for overall declining heatflow in the Cooper Basin. Vitorello and

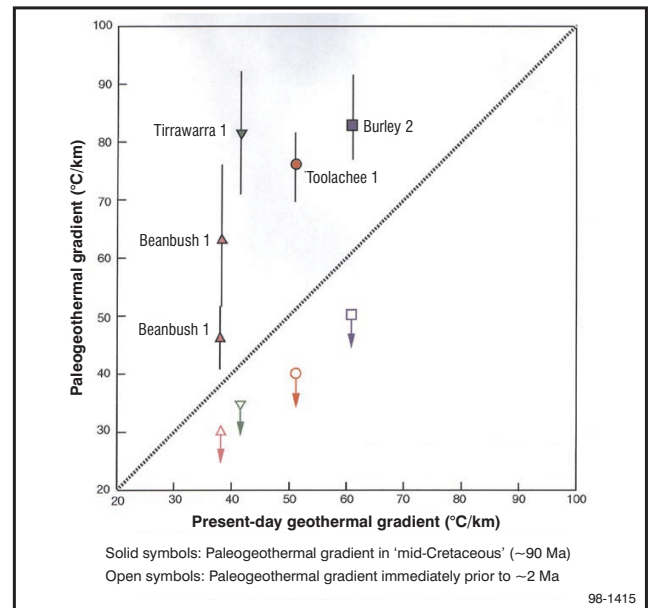


Fig. 9.6 Palaeogeothermal gradients determined from AFTA and VR palaeotemperature results versus present-day gradient for four Cooper–Eromanga wells (after Geotrack, 1997).

Pollack (1980) proposed a three-component model of decreasing heatflow with tectonic age as observed in continental granitic areas (Fig. 9.11). This model proposes that the main heatflow decline results from the decay of a sub-lithosphere transient thermal perturbation associated with tectogenesis of granite. In the case of the Cooper Basin, the age of the granite is ~300 Ma (i.e. only 5–10 million years prior to onset of Cooper Basin sedimentation). Thus, the majority of cooling proposed in the Vitorello and Pollack model took place during sedimentation of the Cooper and Eromanga Basins (Fig. 9.12). Most subsidence resulting from this cooling took place early, which explains the rapid subsidence of the Nappamerri Trough, over granite (represented by Burley 2) compared to the Patchawarra Trough (represented by Cuttapirrie 1 and Tirrawarra North 1). The deep-seated nature of the event means that lateral heat transfer will result in higher heatflow away from the granite basement areas and that similar (though lower) palaeoheatflow patterns should apply to areas without granite basement.

Eromanga event

A high heatflow peak has been modelled from 90 to 85 Ma to provide the high temperatures evidenced by AFTA and R_o data in the mid-Cretaceous, although the origin of this high temperature event is unknown. At least part of the rise may be due to thermal blanketing by very low conductivity smectitic Allaru Mudstone and Wallumbilla Formation sediments, combined with a smaller crustal heatflow increase. The decline in this temperature event may be as late as 60 to 70 Ma (Fig. 9.7).

Post-Eromanga event

The low temperature phase from 85 to ~5 Ma is also evidenced by AFTA and R_o analysis. Previous studies have proposed that the present heatflow is anomalous and the low temperature phase is ‘normal heatflow’. However, there is no easy mechanism to create a rise in heatflow over the last

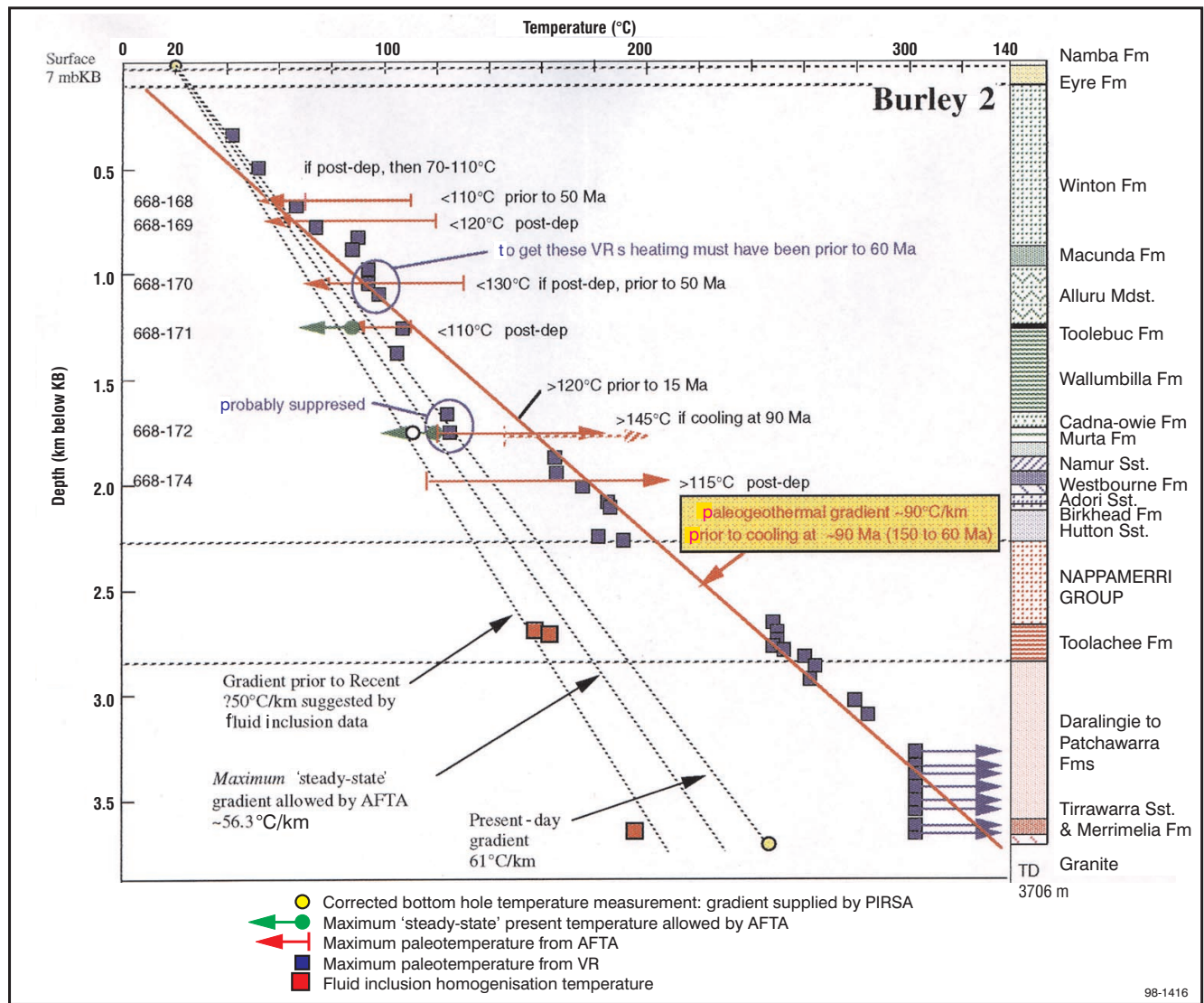


Fig. 9.7 Plot of palaeotemperatures derived from AFTA and VR data in Burley 2, against sample depth and the estimated present temperature profile for this well (after Geotrack, 1997).

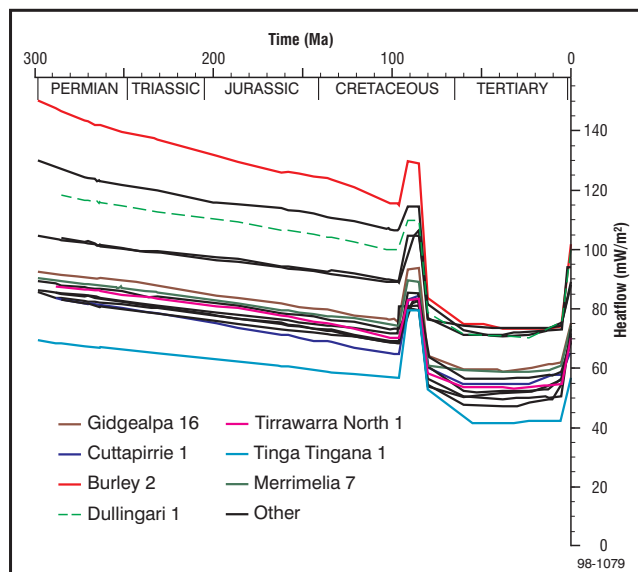


Fig. 9.8 Modelled heatflow versus time for selected Cooper Basin wells.

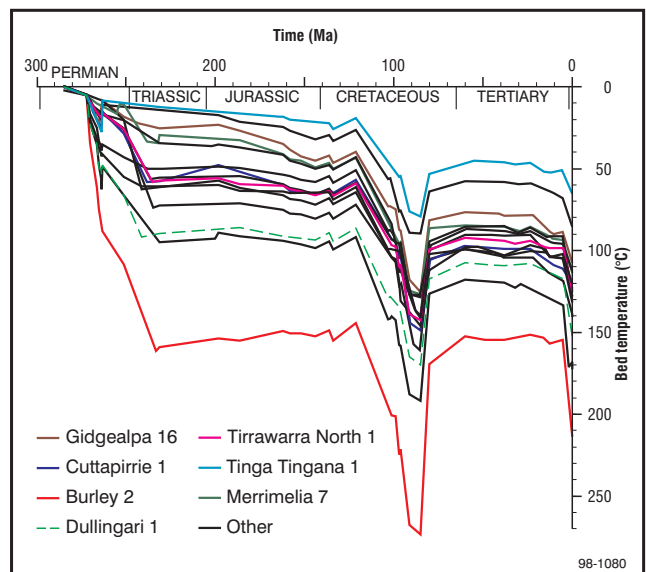


Fig. 9.9 Modelled temperature versus time, top Patchawarra Formation.

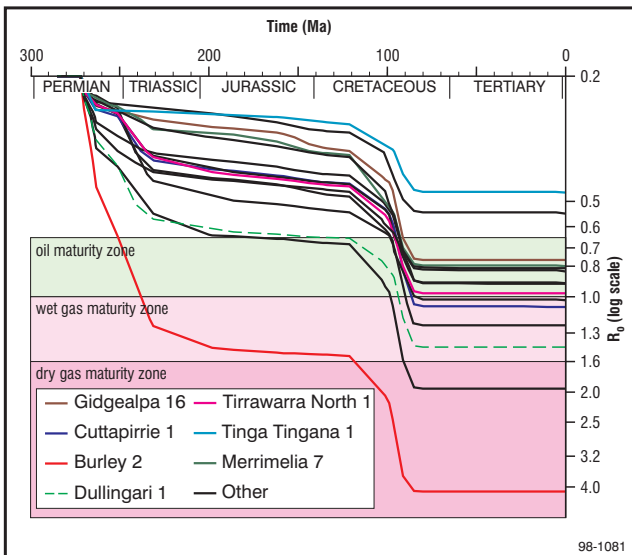


Fig. 9.10 Modelled maturity versus time, top Patchawarra Formation.

2–5 million years without some other geophysical evidence. For example, mantle hot spots or any other lower lithosphere heating event should cause some few hundred metres bulge, which is not observed.

Other studies have proposed that the present heatflow is ‘normal’ and that the low temperature phase is anomalous. This would suggest major changes in the aquifer flow regime of the Great Artesian Basin as the mechanism. These models propose that the low temperature phase results from increased artesian flow in the past, which removed large amounts of heat laterally, and that a slower rate in the last

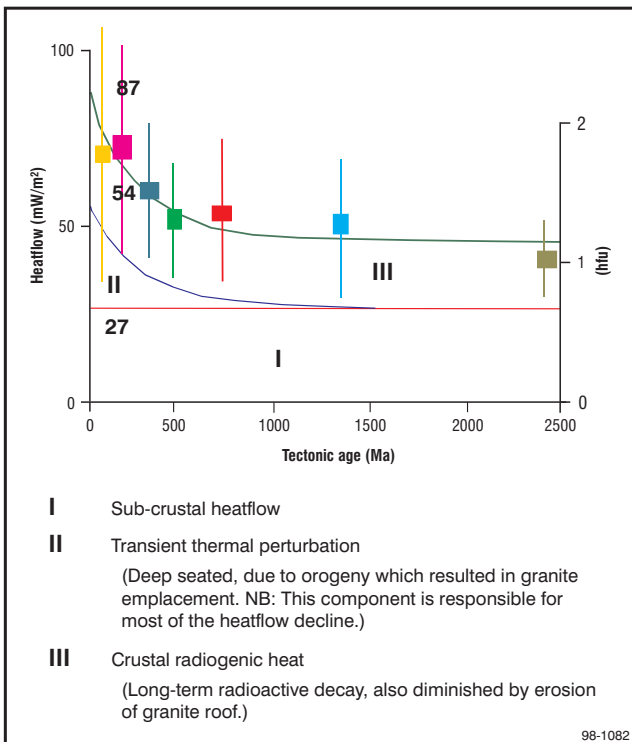


Fig. 9.11 Theoretical (and observed) heatflow decline in granite terranes (after Vitorello and Pollack, 1980). Total heatflow (green curve) is the sum of components I to III.

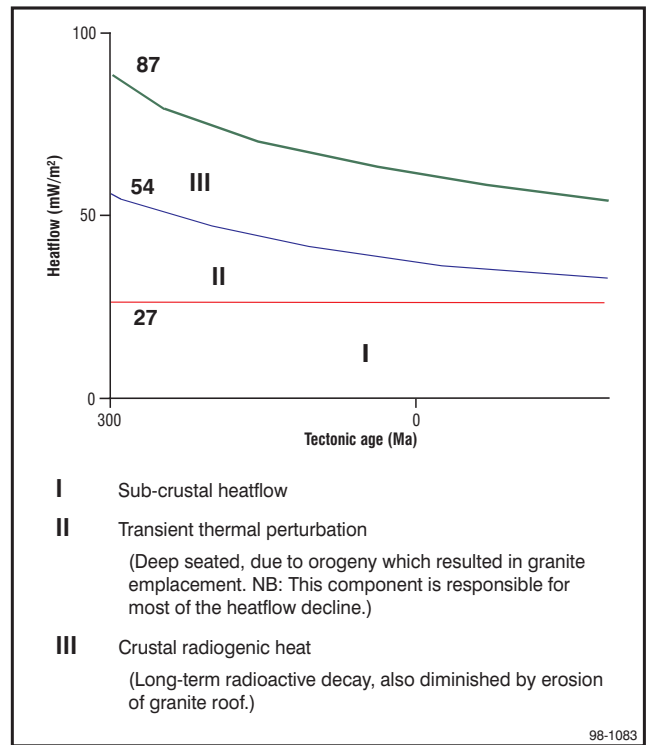


Fig. 9.12 Theoretical heatflow decline in young granite terranes (extracted from Fig. 9.11, with ages reversed. Cooper Basin granites are 290–300 million years old).

2–5 million years allowed the thermal regime to equilibrate to normal. Habermehl (1986), however, suggested that the hydrologic flow rate is at its peak now. Gallagher (1988) has shown that constant background heatflow is unlikely to be perturbed significantly by fluid flow except at the margins (or up faults) where vertical movement may be significant (Gallagher, 1988, p.94). Over the centre of the ‘granite’ the interval heatflow is lower above a 500 m thick aquifer (i.e. temperature gradient is lower). Gradients below are constant, but temperatures are lower for higher flow rates. For low flow rates, the gradient above the aquifer is the same as the gradient below. The main effects of high aquifer flow rates are to reduce temperatures over the granite and shift the temperature peak laterally downflow by about the half width of the granite. Toupin *et al.* (1997) proposed major uplift in the centre of the basin at the end of the Cretaceous as the origin of the cooling event, causing a depression of isotherms because of local influx of meteoric water. Although there was certainly uplift (though probably in the Late Cretaceous), it is difficult to see how this could provide the regional effect evidenced by AFTA and VR data. Not all areas were uplifted by the same amount (Moussavi-Harami, 1996b), with some experiencing no uplift at all.

RESULTS

Using the above heatflow model to produce the palaeotemperature paths evidenced by AFTA and R_0 data, kerogen generation and expulsion of the Cooper Basin sequence was modelled in version 2.4 of Winbury® using the standard industry model of Tissot and Welte (1984) and others. A summary of geohistories for major structural areas within the Cooper Basin using representative wells follows.

NAPPAMERRI TROUGH

Figure 9.13 shows the burial geohistory for Burley 2, indicating that Cooper Basin sediments passed through the oil and gas maturity windows very early, due to high heatflow in the Permian. The palaeotemperature paths for each layer are shown in Figure 9.14 whilst depths to maturity windows are summarised in Table 9.1.

Table 9.1 Hydrocarbon maturity, Burley 2.

Unit	R _o (%)	Maturity window	Depth (m subsea)
Allaru, upper Wallumbilla	0.65	oil	~1144
Lower Wallumbilla, Murta, Namur, Westbourne, Adori, upper Birkhead	1.0	~1513	
Lower Birkhead, Hutton, Poolowanna, Nappamerri, Toolachee, Epsilon, Murteree, upper Patchawarra, lower Patchawarra	1.6	dry gas	~2021

Figure 9.15 shows the cross-plot of observed and computed reflectance, which indicates a good fit except for some shallower data here presumed to be ‘suppressed’.

Figure 9.16 shows oil and gas generation through time for source rocks in Burley 2, calculated using standard techniques and compositional kerogen kinetics discussed in

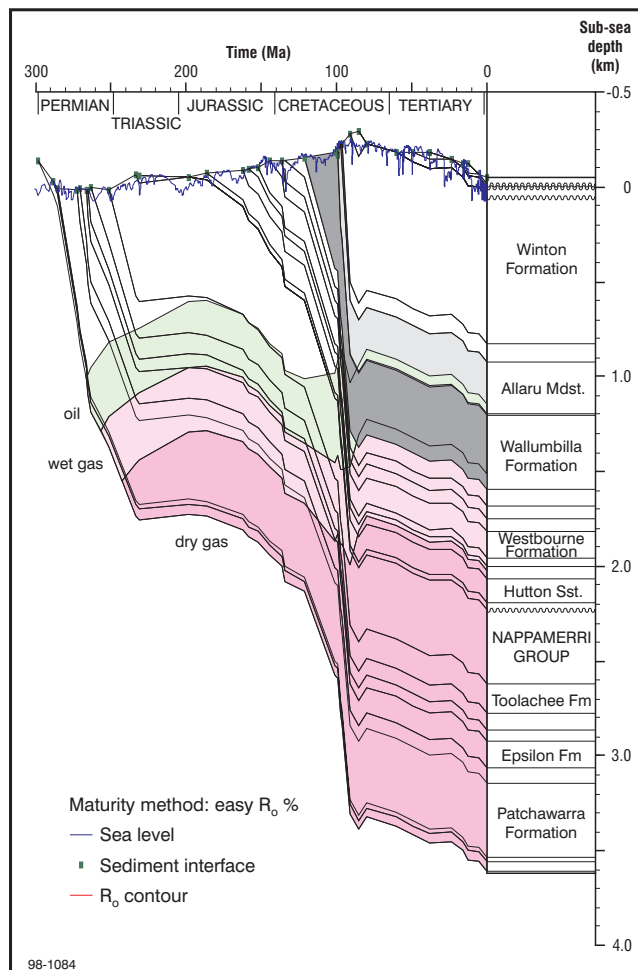


Fig. 9.13 Burial and maturity geohistory plot, Burley 2.

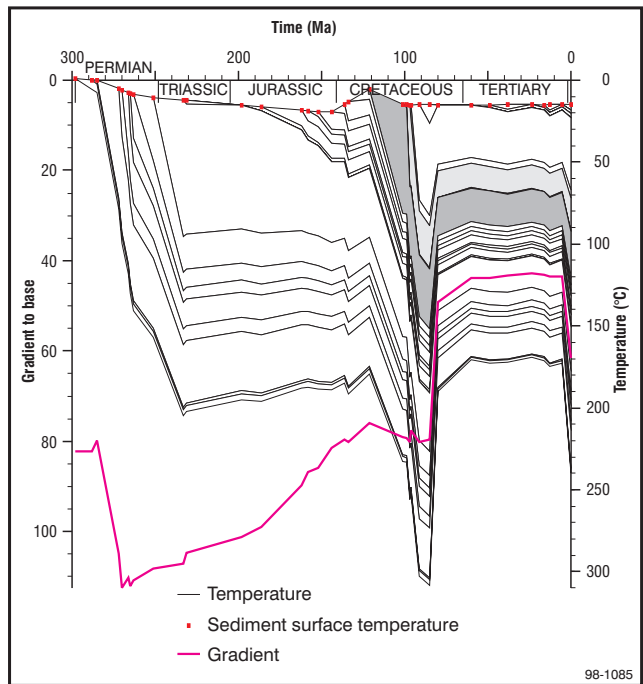


Fig. 9.14 Bed temperature versus time, Burley 2.

Chapter 8. These traces indicate that while some gas was generated in the Late Permian and Early Triassic from Patchawarra Formation coal and shale, most was generated from the Patchawarra and Toolachee Formations in the mid-Cretaceous. Patchawarra Formation shale expelled a total of 29 bbl equivalent/m² of gas compared to only 7 bbl

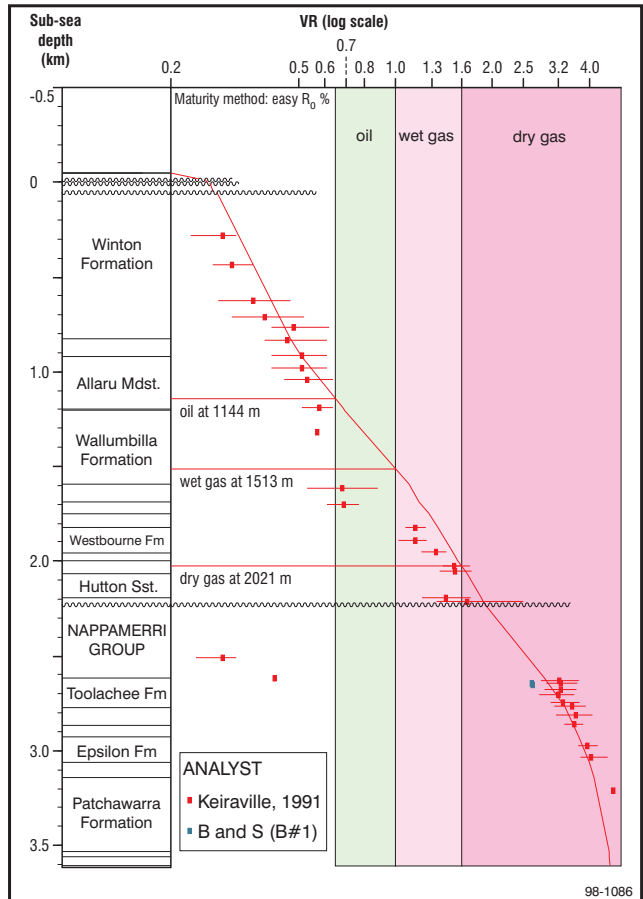


Fig. 9.15 Maturity versus depth plot, Burley 2.

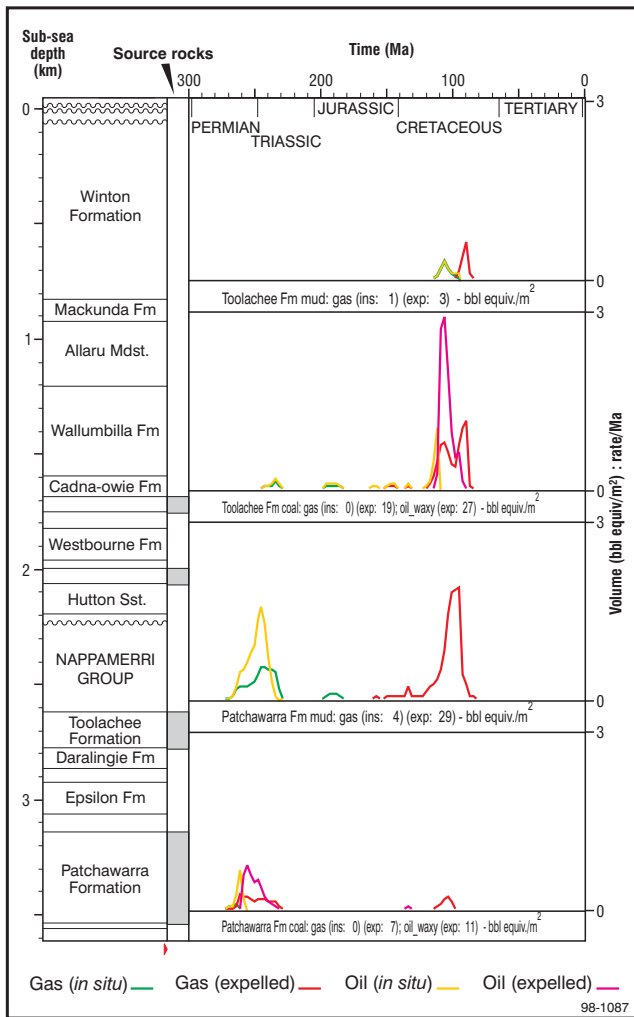


Fig. 9.16 Hydrocarbon generation and expulsion, Burley 2.

equivalent/m² of gas from coal*. Significantly, any oil expulsion from the Patchawarra Formation in Burley 2 took place in the Late Permian. Conversely, a total of 27 bbl equivalent/m² of waxy oil was expelled from Toolachee Formation coal in the mid-Cretaceous. There appears to be considerable scope for Toolachee Formation sourced oil to migrate up into Early Cretaceous reservoirs depending upon seal integrity of the intervening units.

PATCHAWARRA TROUGH

Burial and thermal histories of the western and central Patchawarra Trough are represented by Tirrawarra North 1 and Cuttapiirrie 1.

Cuttapiirrie 1

The geohistory plot of Cuttapiirrie 1 indicates that the Early Permian to Late Jurassic succession entered the oil window at ~95 Ma, with Early to Late Permian rocks entering the wet gas window at ~87 Ma until present day (Fig. 9.17; Table 9.2).

Figure 9.18 plots maturity with depth and clearly shows significant suppression of vitrinite up to 0.1% at the onset of oil generation over the Westbourne and Birkhead Formations.

* bbl equivalent/m² refers to yield/m² of kitchen area.

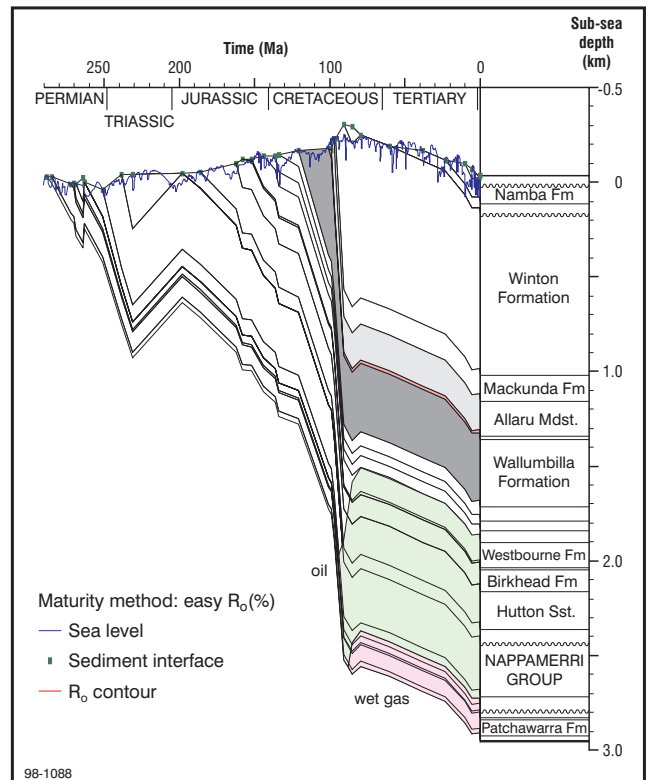


Fig. 9.17 Burial and maturity geohistory plot, Cuttapiirrie 1.

Table 9.2 Hydrocarbon maturity, Cuttapiirrie 1.

Unit	R ₀ (%)	Maturity window	Depth (m subsea)
Westbourne, Adori, Birkhead, Hutton, Poolowanna, Nappamerri, upper Toolachee	0.65	oil	~1896
Lower Toolachee, Epsilon, Patchawarra, Tirrawarra	1.0	wet gas	~2760

Figure 9.19 shows oil and gas generation through time for source rocks in Cuttapiirrie 1, calculated using standard techniques and compositional kerogen kinetics discussed in Chapter 8. These traces indicate that some oil and minor gas were expelled during the Late Cretaceous at ~90 Ma, principally from Patchawarra Formation (coal, 4 bbl equivalent/m² of oil; shale, 0 bbl equivalent/m² of oil) and Toolachee Formation (coal, 4 bbl equivalent/m² of oil) source horizons. Significantly, little or no oil appears to have been expelled from the Poolowanna Formation, which hosts commercial oil reserves. This is consistent with whole-oil gas chromatography data (Appendix 2) that support a Permian source.

Tirrawarra North 1

The geohistory plot of Tirrawarra North 1 indicates that the Early Permian to Late Jurassic succession entered the oil window at ~100 Ma. The Early Permian rocks entered the wet gas window at ~90 Ma and have remained there until the present day (Fig. 9.20; Table 9.3). It is worth noting that depths to the relative oil and wet gas windows for Tirrawarra North 1 are very close to those for Cuttapiirrie 1 (Tables 9.2, 9.3).

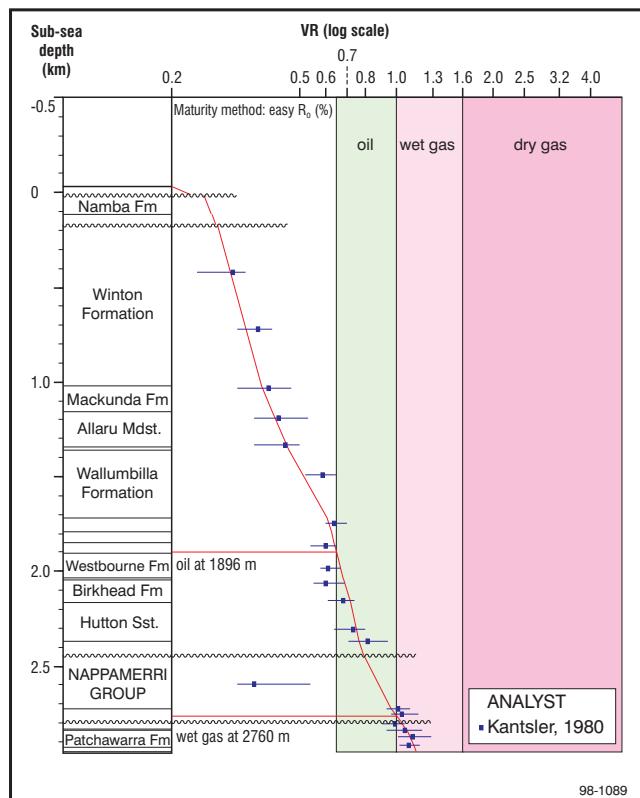


Fig. 9.18 Maturity versus depth, Cuttipirrie 1.

Figure 9.21 plots maturity with depth and also shows significant suppression of vitrinite up to 0.15% R_0 at the onset of oil generation over the Westbourne to Poolowanna Formations.

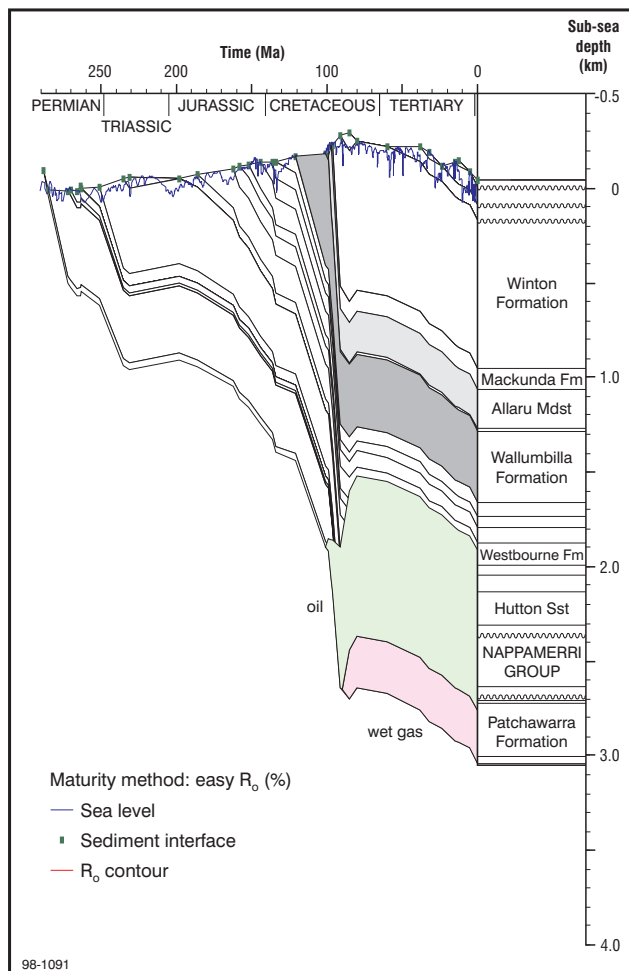


Fig. 9.20 Burial and maturity geohistory plot, Tirrawarra North 1.

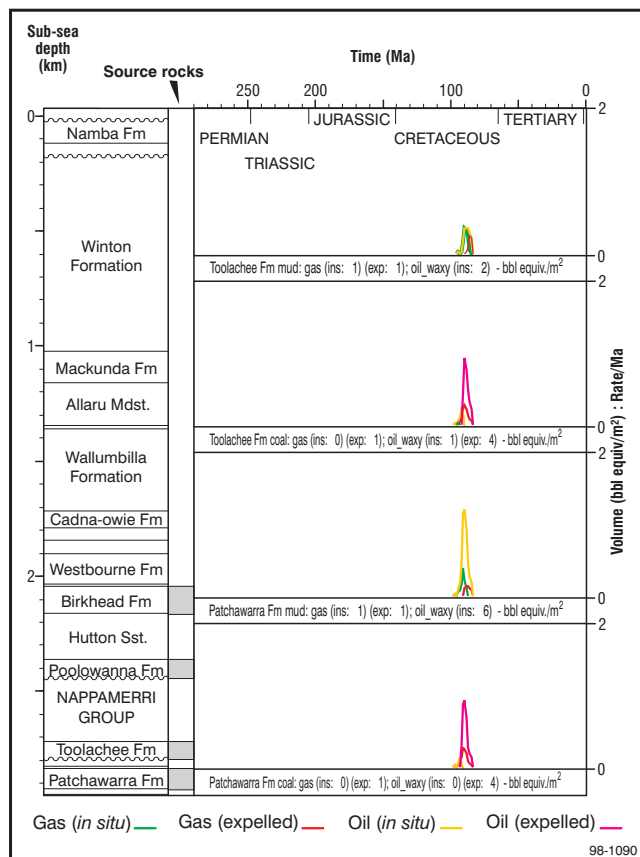


Fig. 9.19 Hydrocarbon generation and expulsion, Cuttipirrie 1.

Table 9.3 Hydrocarbon maturity, Tirrawarra North 1.

Unit	R_0 (%)	Maturity window	Depth (m subsea)
Westbourne, Adori, Birkhead, Hutton, Poolowanna, Nappamerri, Toolachee, Epsilon, Murteree, upper Patchawarra	0.65	oil	~1911
Lower Patchawarra, Tirrawarra	1.0	wet gas	~2761

A significant volume of oil was expelled during the Late Cretaceous at ~90 Ma principally from Patchawarra Formation coal (99 bbl equivalent/m²) with a further 7 bbl equivalent/m² of oil remaining *in situ*. Shale of the Patchawarra Formation contributes only minor amounts of expelled oil (1 bbl equivalent/m²).

It appears that Toolachee Formation source rocks have expelled wet gas in the order of 1 bbl equivalent/m² which is consistent with a minor gas accumulation in basal Toolachee Formation sand in crestal wells of the Tirrawarra Field (Fig. 9.22).

Tirrawarra Sandstone of the Tirrawarra Field hosts the largest Permian oil accumulation of the Cooper Basin; the oil is overlain by large gas reserves within Patchawarra Formation reservoirs. The kinetic model adopted in the NGMA study assumes that both oil and gas are generated simultaneously but with gas expulsion preceding oil

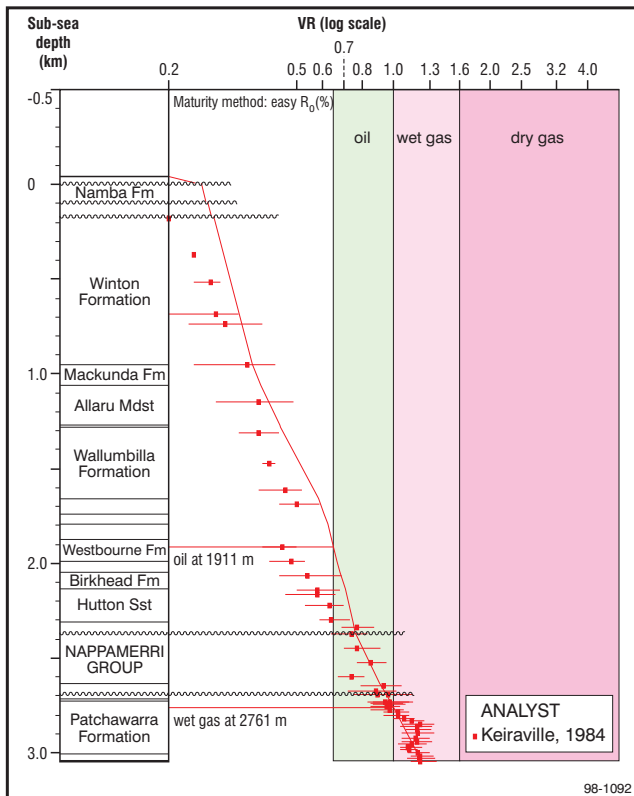


Fig. 9.21 Maturity versus depth plot, Tirrawarra North 1.

expulsion. This would account for gas occurring stratigraphically above the oil in the Tirrawarra Field.

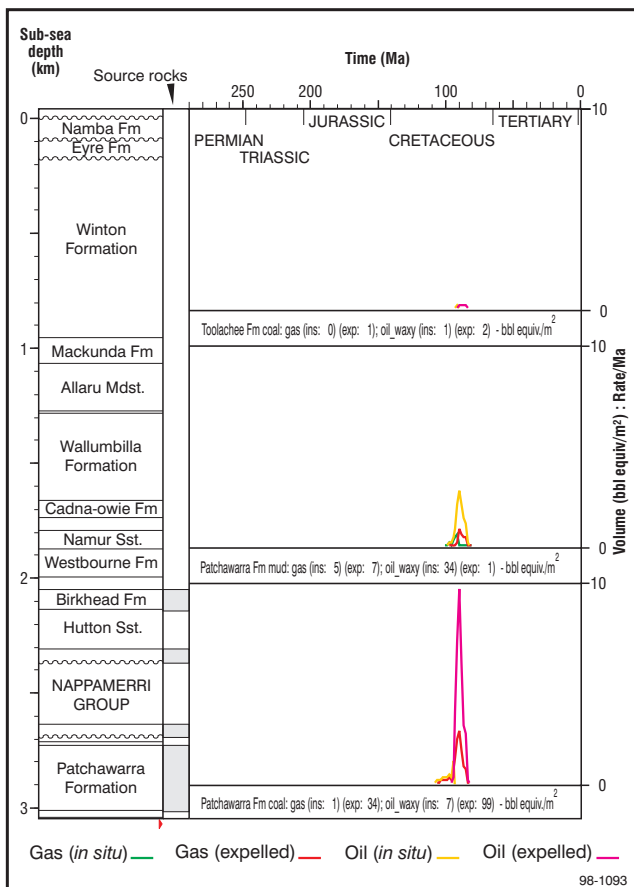


Fig. 9.22 Hydrocarbon generation and expulsion, Tirrawarra North 1.

METTIKA EMBAYMENT

Dullingari 1

Burial and thermal history of the Mettika Embayment of the Tenappera Trough is represented by Dullingari 1 (Fig. 9.23). Source rocks in Dullingari 1 entered the oil window close to the Late Permian – Early Triassic boundary, reflecting a higher geothermal gradient than the thermally cooler Patchawarra Trough wells discussed previously. With the exception of the lower Patchawarra Formation, which entered the dry gas window in the mid-Cretaceous (~90 Ma), the remainder of the Early and Late Permian succession has been in the wet gas window since ~108 Ma, whilst the Triassic to Early Cretaceous succession is currently within the oil window (Fig. 9.23). This is in agreement with hydrocarbon discoveries in the Dullingari Field with proven oil reserves in the Murta Formation, wet gas in the Toolachee and Daralingie Formations, and dry gas in Patchawarra Formation reservoirs. Depth to present day maturity windows are summarised in Figure 9.24 and Table 9.4.

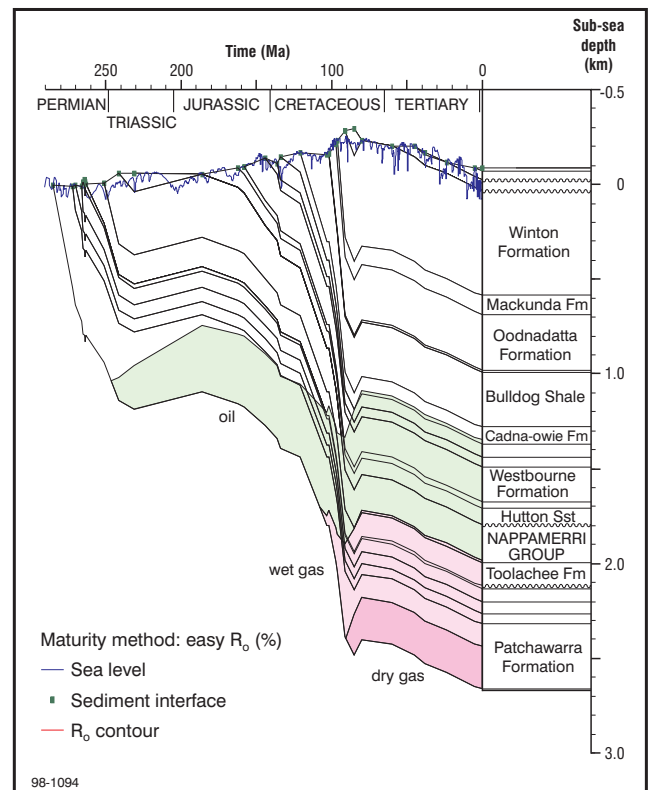


Fig. 9.23 Burial and maturity geohistory plot, Dullingari 1.

Table 9.4 Hydrocarbon maturity, Dullingari 1.

Unit	R ₀ (%)	Maturity window	Depth (m subsea)
Murta, Namur, Westbourne, Adori, Birkhead, Hutton, Poolowanna, Nappamerri	0.65	oil	~1345
Toolachee, Epsilon, Murteree, upper Patchawarra	1.0	wet gas	~1982
Lower Patchawarra	1.6	dry gas	~2439

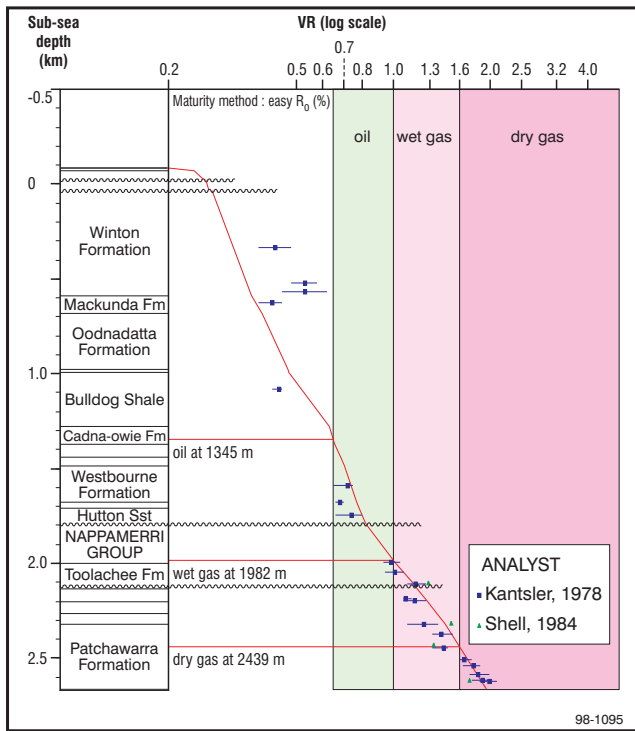


Fig. 9.24 Maturity versus depth, Dullingari 1.

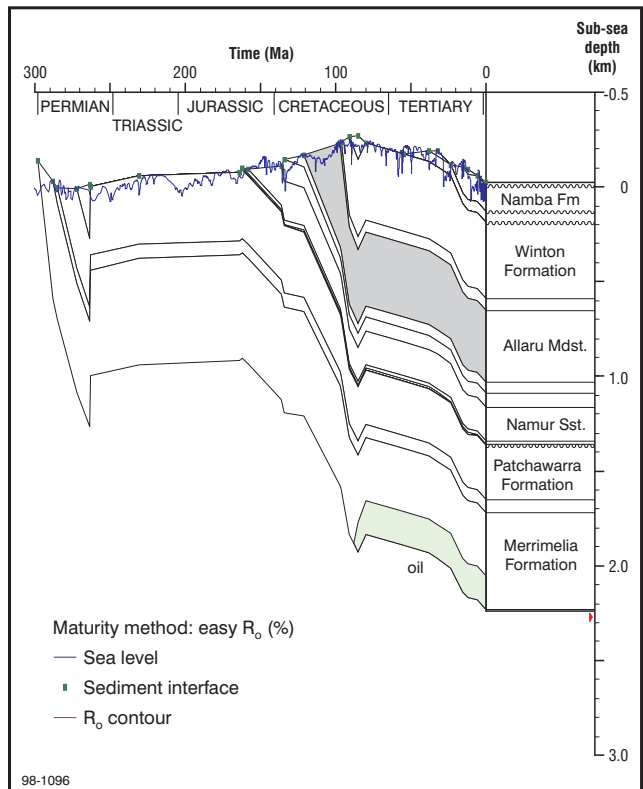


Fig. 9.25 Burial and maturity geohistory plot, Tinga Tingana 1.

TINGA TINGANA RIDGE

(adjacent to the Weena Trough)

Tinga Tingana 1

Tinga Tingana 1 is located on the Tinga Tingana Ridge (Fig. 5.5) and has been included in this review as a guide to the prospectivity of the Weena Trough which lies to the west. In the final report for the NGMA project, a synthetic well extrapolating thermal and burial history results from Tinga Tingana 1 to the central Weena Trough will provide a more accurate assessment of the region's prospectivity.

When considering the geohistory plot of Tinga Tingana 1 (Fig. 9.25) it is important to note that the well has limited maturity data (Fig. 9.26), resulting in a poorly constrained heatflow model. The majority of the sediments in the well are immature whilst the basal Merrimelia Formation has remained within the oil window since the mid-Cretaceous (Fig. 9.26; Table 9.5). Increased depth of burial and total coal thickness in the Patchawarra Formation, possibly in excess of 40 m (Fig. 6.6), suggests that the prospectivity of the Weena Trough has been underestimated.

GIDGEALPA AND MERRIMELIA RIDGES

The thermal and burial history of the Gidgealpa and Merrimelia Ridges is represented by Merrimelia 7 and Gidgealpa 16 (Fig. 9.1).

Merrimelia 7

Figure 9.27 shows that the Early Triassic to Late Jurassic succession in Merrimelia 7 entered the oil window between 80 and 90 Ma, and has remained there to the present day. This is consistent with oil production from the Nappamerri Group in Merrimelia 7. Depth to present day maturity windows are summarised in Figure 9.28 and Table 9.6.

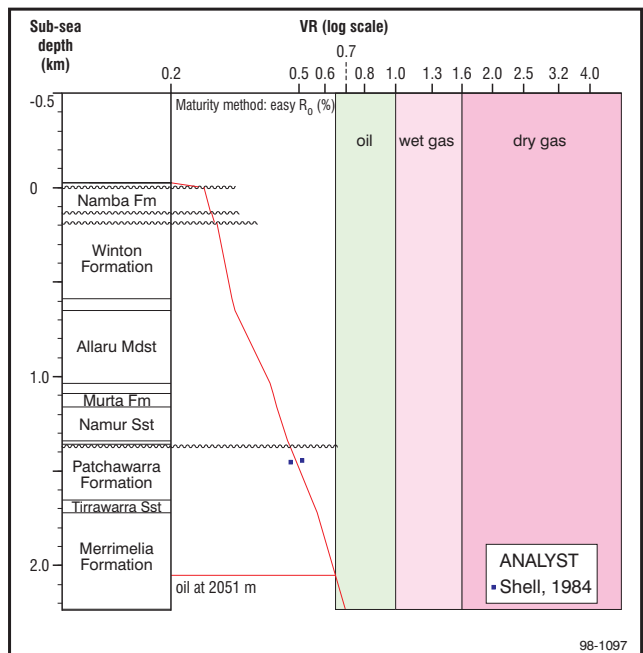


Fig. 9.26 Maturity versus depth, Tinga Tingana 1.

Table 9.5 Hydrocarbon maturity, Tinga Tingana 1.

Unit	R ₀ (%)	Maturity window	Depth (m subsea)
Murda, Namur, Birkhead, Hutton	<0.65	immature	-
Patchawarra, Tirrawarra, Merrimelia	0.65	oil	~2051

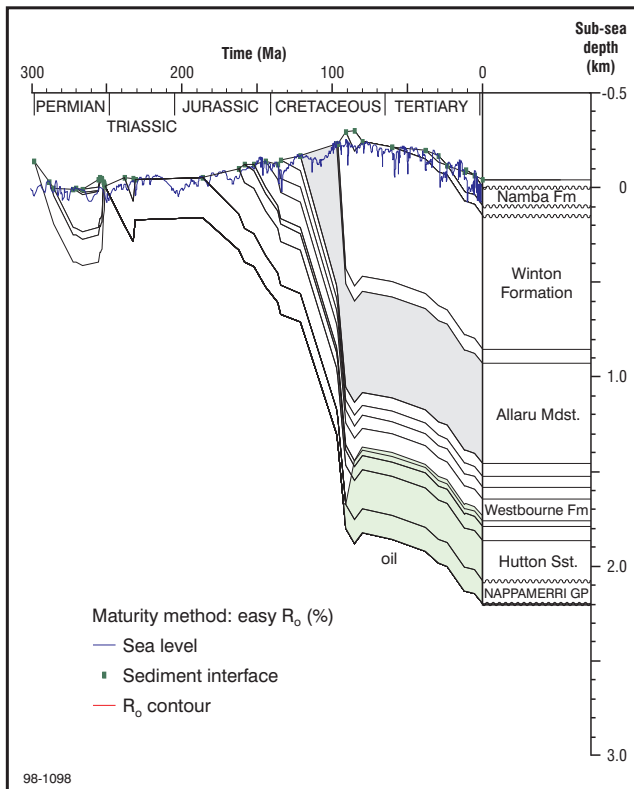


Fig. 9.27 Burial and maturity geohistory plot, Merrimelia 7.

Table 9.6 Hydrocarbon maturity, Merrimelia 7.

Unit	R ₀ (%)	Maturity window	Depth (m subsea)
Westbourne, Adori, Birkhead, Hutton, Nappamerri	0.65	oil	~1731

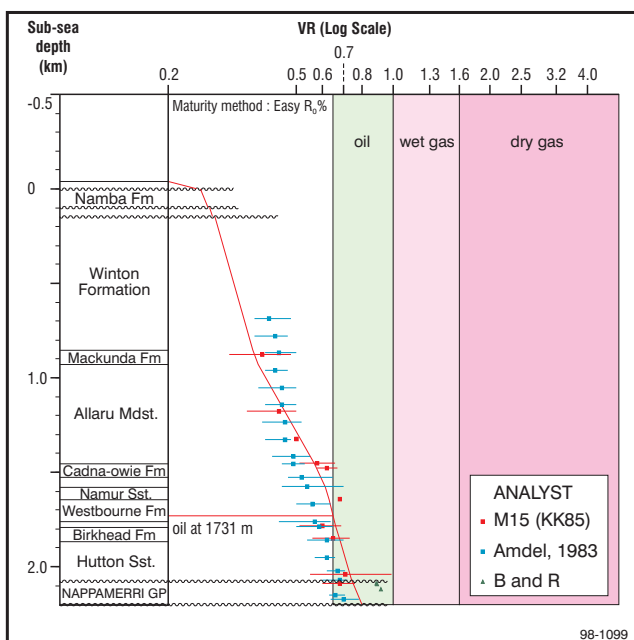


Fig. 9.28 Maturity versus depth, Merrimelia 7.

Gidgealpa 16

Figures 9.29 and 9.30 show that Early Permian to Middle Jurassic source rocks are capable of generating oil and entered the oil window in the mid-Cretaceous (~90 Ma) in Gidgealpa 16. Computed maturity values are less than observed values towards the base of the well (Fig. 9.30), although the latter still lie within the oil window, albeit close to the wet gas threshold. This may help to explain drillstem test (DST) results over the Toolachee and Patchawarra Formations and Tirrawarra Sandstone, where commercial rates of wet gas were tested. Significantly, DST 2 tested gas at a rate of $0.048 \times 10^6 \text{ m}^3$ (1.7 mmcf) per day and recovered 1.65 kL (10.4 bbl) of oil over the interval 2115.9–2123.5 m in the Toolachee Formation, whilst the deeper formations were only gas bearing. Gidgealpa 16 is structurally positioned to receive gas from gas-bearing source rocks on the flanks of the Gidgealpa Field. Depth to present day maturity windows is summarised in Table 9.7. The depth to the top of the oil window for Gidgealpa 16 closely matches that for Merrimelia 7.

Table 9.7 Hydrocarbon maturity, Gidgealpa 16.

Unit	R ₀ (%)	Maturity window	Depth (m subsea)
Adori, Birkhead, Hutton, Poolowanna, Nappamerri, Toolachee, Patchawarra, Tirrawarra, Merrimelia	0.65	oil	~1713

SUMMARY

Combining the results of the 15 wells studied provides a comparison across the Cooper Basin of the generation potential, and oil and gas expulsion with time. These are summarised below.

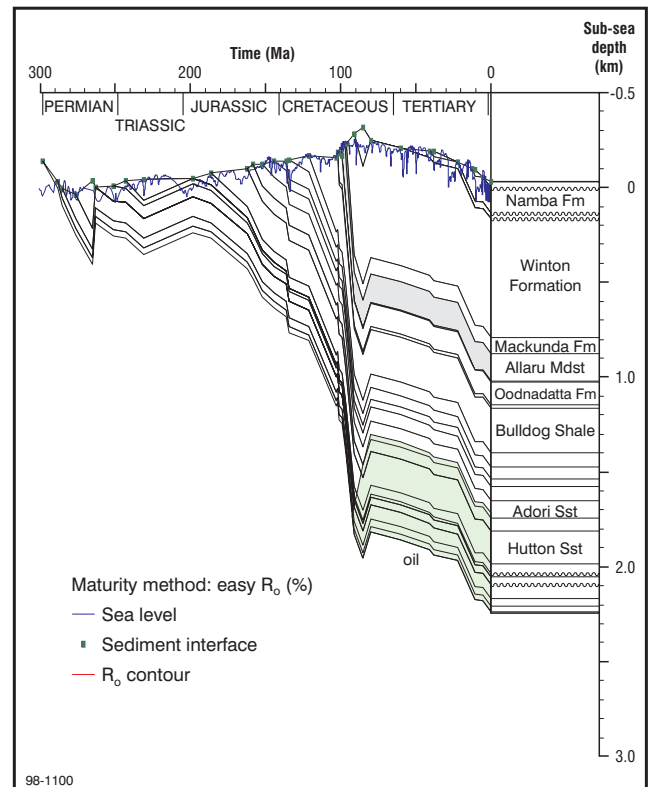


Fig. 9.29 Burial and maturity geohistory plot, Gidgealpa 16.

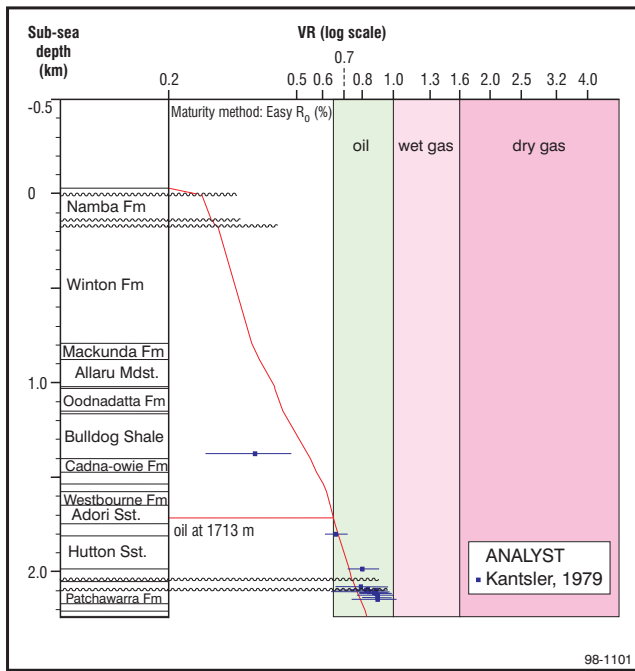


Fig. 9.30 Maturity versus depth, Gidgealpa 16.

Total (residual) generation potential through time for all wells in the study is shown in Figure 9.31, which indicates that most hydrocarbons were generated in the mid-Cretaceous. Minor amounts were generated during the Permian in the Nappamerri Trough.

Figure 9.32 shows total oil expulsion through time for all wells indicating major expulsion in the mid-Cretaceous, with minor amounts in the late Tertiary. Minor oil was expelled at Burley 2 in the Late Permian. The late Tertiary

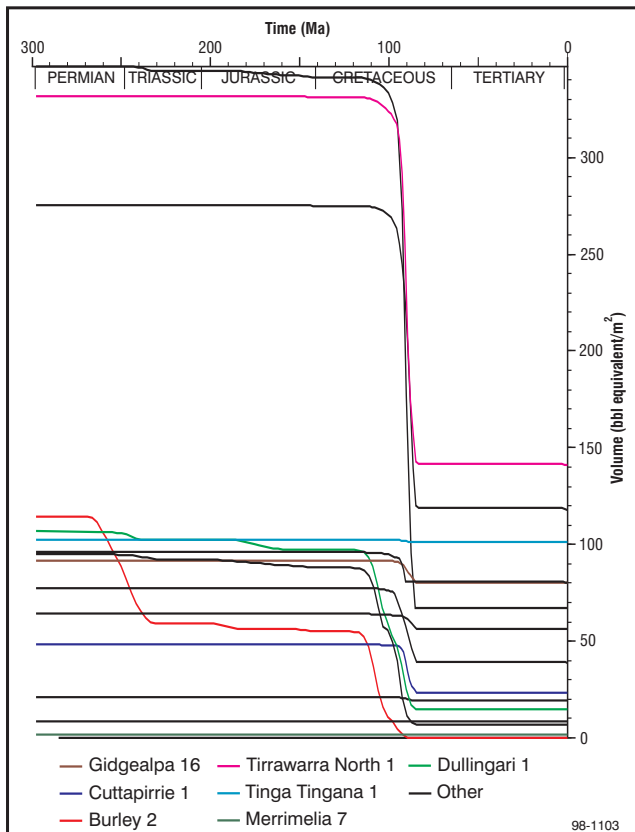


Fig. 9.31 Generation potential versus time, Cooper Basin.

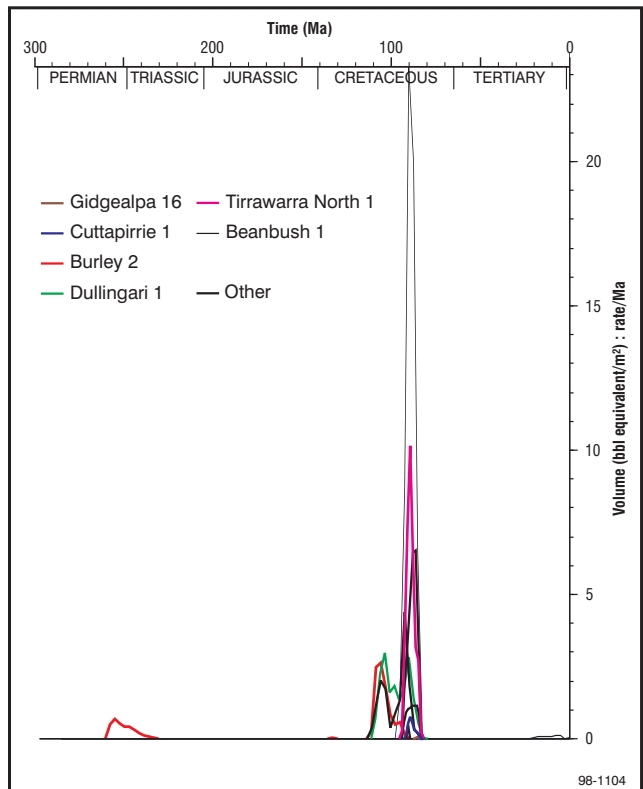


Fig. 9.32 Oil expulsion versus time, Cooper Basin.

event suggests that if sufficient residual kerogen remains, increased temperature as a result of the combined effect of Tertiary deposition and elevated temperatures in the late Tertiary may lead to late-stage oil expulsion in favourable parts of the basin.

Figure 9.33 demonstrates that gas expulsion is ubiquitous and mainly occurred in the mid-Cretaceous.

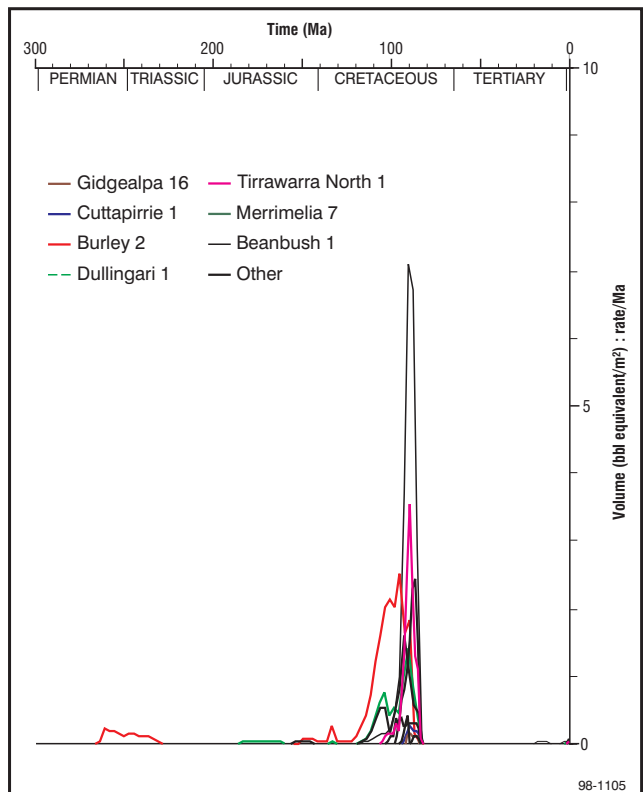


Fig. 9.33 Gas expulsion versus time, Cooper Basin.

The foregoing conclusions are based on the 15 wells used for this preliminary study. A more rigorous computed regional model (90 wells in South Australia and Queensland) will be used in the final NGMA report.

Previous studies based on consideration of the oil maturity window have implied significant hydrocarbon generation in the Late Cretaceous and early Tertiary (Kantsler *et al.*, 1986; Pitt, 1986). However, results of the present study indicate that the major generation occurred in the mid-Cretaceous, which provides explorers with a new perspective for understanding the timing of expulsion of hydrocarbons in the Cooper and Eromanga Basins. Accordingly, a reassessment of the changing migration pathways during Late Cretaceous or Tertiary structuring is warranted.

