Geology and mineral resources of the Northern Territory

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Chapter 38: Pedirka Basin


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Chapter 38: PEDIRKA BASIN
TJ Munson and M Ahmad

INTRODUCTION

The Cambrian–?Devonian Warburton Basin, Permian–Triassic Pedirka Basin and Late Triassic–Cretaceous Eromanga Basin are three stacked basins in the southeastern corner of the Northern Territory that also extend over areas of adjoining Queensland, South Australia and New South Wales (Figure 38.1). Triassic rocks were previously included within the ‘Simpson Basin’ (or ‘Simpson Desert Basin’, Smyth and Saxby 1981, Moore 1986), but following Ambrose et al (2012), these strata are here included within the Pedirka Basin succession and the name ‘Simpson Basin’ is abandoned. This arrangement is more consistent with the stratigraphic successions of the nearby Cooper and other significant Permian–Triassic Australian basins, which do not apportion their Permian and Triassic sections into different basins, and also reflects the lack of a substantial time break (Central Petroleum 2011a, Ambrose et al 2012) between the Permian and Triassic successions of these overlapping depositional areas.

The largely subsurface, intracratonic Pedirka Basin unconformably overlies the Amadeus and Warburton basins, above Proterozoic crystalline basement rocks, and is unconformably overlain by strata of the Eromanga basins. It contains an up to 1.5 km-thick diverse succession of fluvial-glacial, fluvial, lacustrine and coal swamp, and continental red bed deposits. It has an area of about 100 000 km²; approximately half of which is in the Northern Territory and the remainder in South Australia, with a small portion in southwestern Queensland (Figure 38.1). The basin is separated from the similarly aged subsurface Cooper Basin in South Australia and Queensland to the southeast by a basement high (Birdsville Track Ridge, Figure 38.2), which is a 150–200 km-wide zone of non-deposition and erosion (Ambrose et al 2007). To the southwest, it directly overlies, or is faulted against the Mesoproterozoic Musgrave Province and is separated from the subsurface Permian Arckaringa Basin (Hibburt 1995) by the Bitchera and Muloorina basement ridges (Gatehouse 1986, Hibburt and Gravestock 1995). It is possible that sedimentary deposits once extended across intervening basement ridges between the Pedirka and Arckaringa basins (Hibburt and Gravestock 1995) and that these have since been removed by erosion. The NT portion of the Pedirka Basin encompasses the following mapsheets: southeastern RODINGA1, southern HALE RIVER, southwestern SIMPSON DESERT NORTH, eastern FINKE, McDILLS and SIMPSON DESERT SOUTH.

The only outcropping strata of the Pedirka Basin is along the northwestern margin, where the Early Permian Crown Point Formation is exposed. Much of the remainder of the basin is at depths of greater than 400 m and the basin reaches maximum depths in excess of 3000 m at its deepest points in the east (Ambrose et al 2007). The major depocentres of the

1 Names of 1:250 000 mapsheets are in large capital letters, eg RODINGA.
Pedirka Basin

basin are the Eringa, Madigan and Poolowanna troughs, which are segmented and separated by a series of structural ridges and major faults (Figure 38.2, 38.3). The Eringa Trough (Eringa-Casuarina Trough of Questa 1990) is a significant, northeast-trending asymmetric depocentre in the west of the basin containing in excess of 1500 m of Permian and lesser Triassic sedimentary rocks. The trough is offset and probably segmented across a northwest–southeast-trending transverse fault (Camelot Fault of Ambrose and Heugh 2010), with older glacigenic deposits dominating the succession to the south of this structure and younger coal-bearing deposits more significant to the north. To the west, the Eringa Trough onlaps pre-Permian sedimentary rocks and a ridge of underlying basement rocks (Andado Ridge) that collectively form the Andado Shelf. Gently dipping Permian strata thin and pinch out to the west across the Andado Shelf as a result of onlap and erosion, so that only the Crown Point Formation occurs along the western flanks of the basin. The Eringa Trough is separated from the Madigan Trough to the east by a series of major faults flanking Palaeozoic basement structural ridges. These major structural features include, from south to north, the Dalhousie-McDills Ridge (Youngs 1976, Giuliano 1988), the referred to as the McDills Trend or McDills-Mayhew Trend. McDills Ridge. Dalhousie-structural features include, from south to north, the

Figure 38.2. Simplified geology of Pedirka Basin with covering strata removed (modified from Hibbert and Gravestock 1995, Ambrose et al 2002, Ambrose and Heugh 2010 and NTGS 1:2.5M geological regions GIS dataset), showing depocentres and major structural elements.
The Pedirka Basin, the Bonaparte Basin in the northwest (Figure 38.4). As the basin is mostly in the subsurface, details of the succession have mostly been derived from drillhole intersections and seismic profiles (Figure 38.5).


**Figure 38.3.** Schematic west–east structural cross-section across Pedirka and Eromanga basins, modified from Ambrose et al (2002) with additional data from Amerada Petroleum (1965), Beach Petroleum (1979) and Wiltshire (1983). Location shown in Figure 38.2.

<table>
<thead>
<tr>
<th>Unit, max thickness</th>
<th>Lithology</th>
<th>Depositional environment</th>
<th>Stratigraphic relationships</th>
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</thead>
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<tr>
<td><strong>Triassic</strong></td>
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<tr>
<td>Peera Peera Formation 190 m (Walkandi-1)</td>
<td>Shale, siltstone, minor sandstone and coal at base, overlain by cyclical upward-fining sandstone, capped by highly carbonaceous shale with occasional thin sandstone beds.</td>
<td>Meandering fluvial, lacustrine/paludal.</td>
<td>Unconformable beneath Poolowanna Formation (Eromanga Basin). Disconformable or unconformable (low-angle) on Walkandi Formation, or unconformable on Purni Formation or Warburton Basin strata.</td>
</tr>
<tr>
<td>Walkandi Formation 247 m (Blamore-1)</td>
<td>Interbedded shale, siltstone and minor very fine to fine sandstone.</td>
<td>Shallow ephemeral lacustrine (continental red-beds).</td>
<td>Unconformable on Purni Formation or Warburton Basin strata.</td>
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<td><strong>Permian</strong></td>
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<tr>
<td>Purni Formation 564.3 m (Blamore-1)</td>
<td>Sandstone, siltstone, shale, carbonaceous shale, coal, minor conglomerate. Four internal units (in ascending order A1, A, B, C).</td>
<td>Fluvial, paludal; glaciofluvial outwash towards base.</td>
<td>Conformable on Tirrawarra Sandstone equivalent or Crown Point Formation.</td>
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<tr>
<td>unit C 145 m (CBM107-001)</td>
<td>Sandstone, siltstone, shale, carbonaceous shale, coal.</td>
<td>Low-energy, meandering fluvial/paludal; finer sediments represent floodplain/overbank deposits.</td>
<td>Unconformable on unit B.</td>
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<td>unit B 257.3 m (Blamore-1)</td>
<td>Sandstone, siltstone, shale, carbonaceous shale, thin to thick coal seams.</td>
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<td>Disconformable on unit A.</td>
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<td>unit A 246 m (CBM107-001)</td>
<td>Fine sandstone, siltstone, carbonaceous shale, thin to thick coal seams.</td>
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<td>Conformable on unit A1.</td>
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<td>unit A1 118 m (Blamore-1)</td>
<td>Thินly interbedded pyritic sandstone and lesser siltstone, minor thin coal seams.</td>
<td>Glaciofluvial outwash with finer sediments representing floodplain/overbank deposits.</td>
<td>Conformable on Tirrawarra Sandstone equivalent or Crown Point Formation.</td>
</tr>
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<td>Tirrawarra Sandstone equivalent 200 m (Mount Hammersley-1)</td>
<td>Very fine to very coarse conglomeratic feldspathic sandstone, minor siltstone and claystone.</td>
<td>Glaciofluvial braided river/glacial outwash.</td>
<td>Interfingers with and conformable on Crown Point Formation.</td>
</tr>
<tr>
<td>Crown Point Formation 504 m (Mount Hammersley-1)</td>
<td>Conglomerate, diamiccite, cross-bedded pebbly and coarse sandstone, ripple-laminated fine sandstone and siltstone, thick claystone-dominated intervals with varvite bands.</td>
<td>Glaciofluvial, glaciolacustrine and periglacial.</td>
<td>Unconformable on Amadeus/Warburton basin strata, or on Proterozoic basement rocks.</td>
</tr>
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</table>

**Table 38.1.** Summary of Pedirka Basin stratigraphic succession. Drillholes are located in Figure 38.5a.
Pedirka Basin


PERMIAN

Crown Point Formation

The Crown Point Formation (Wells et al 1966) is widespread in the western Pedirka Basin and outcrops as mesas, buttes and low mounds in central northern FINKE, southeastern RODINGA and southwestern HALE RIVER (Shaw 1968, Wells 1969). The western limits of outcrops coincide with the Newland Ranges Ridge of Neoproterozoic–middle Palaeozoic rocks (Oakes et al 1991, Figure 38.2). The formation occurs across the Andado Shelf, and has been intersected in a number of drillholes within the Eringa and Madigan troughs and on the Colson Shelf, but is absent from

<table>
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<tr>
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<th>Period</th>
<th>Epoch</th>
<th>Stage</th>
<th>Bonaparte Basin (Petrel Sub-basin; NT, WA)</th>
<th>Arafura Basin</th>
<th>Pedirka Basin (NT, SA)</th>
<th>Cooper / basal Eromanga basins (SA, Qld)</th>
<th>Ackaringa Basin (SA)</th>
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the Poolowanna Trough further to the east. Exposures of the formation are up to 48 m thick in FINKE (Wells 1969), but are possibly much thicker (~365 m) in HALE RIVER (Shaw 1968). The formation is thickest in the southern Eringa Trough, where a thickness of 504 m was intersected in Mount Hammersley-1\(^2\) in South Australia (Ambrose 2006). In areas to the south of the Madigan Trough, to the

\(^2\) Middleton et al (2007) tentatively interpreted this interval as consisting of 347 m of Crown Point Formation overlain by 157 m of Stuart Range Formation of the Arckaringa Basin.

Figure 38.5. Location of (a) drillholes and (b) NT seismic lines within the Pedirka Basin. Seismic lines 85NT-03 and CB08-01 (labelled) are shown in Figures 38.7 and 38.8, respectively.
Pedirka Basin

east of the Dalhousie-McDills Ridge and Hallows Trend, intersections of up to ca 200 m have been recorded in several drillholes (Middleton et al. 2007). Thinner successions of less than 100 m have been intersected in Simpson-1 (Central Petroleum 2009c) and Colson-1 (Middleton et al. 2007) to the east on the Colson Shelf (Figure 38.5). The Crown Point Formation is unconformable on Amadeus/Warburton basin strata, or where these are absent, on Proterozoic basement rocks. It both interferes with and is conformably overlain by Tirrawarra Sandstone equivalent rocks or where this is absent, is overlain by the Purni Formation (Ambrose 2006, Central Petroleum 2011a).

The Crown Point Formation consists of conglomerate, diamicite, cross-bedded pebbly and coarse sandstone, ripple-laminated fine sandstone and siltstone, and thick claystone-dominated intervals with varvite bands (Crowell and Frakes 1971, Giuliano 1988). Striated and faceted erratics were reported by Wells (1969) from exposures in FINKE. These strata are interpreted as representing a range of glacioluvial, glaciallacustrine and periglacial environments. Conglomerate, coarse sandstone and diamicite are more common in the vicinity of depositional highs, whereas glaciallacustrine mudstone is present in basinal areas, such as the Eringa Trough (Hibburt and Gravestock 1995, Jones et al. 2011). Palynological evidence (Youngs 1975, 1976) indicates that the age of the Crown Point Formation is Early Permian (Zone 2 palynofloral Zone of Price 1983; Asselian, equivalent to the upper part of Zone APP121 of Price 1997), but the unit has also been interpreted as Late Carboniferous–Early Permian in various publications (eg Jones 1973, Kemp et al. 1977, Oaks et al. 1991, Ambrose 2006), depending on placement of the Carboniferous–Permian boundary. However, correlative late Palaeozoic glacial deposits in the Bonaparte Basin in northern Australia are relatively well dated as Early Permian (Gorter et al. 2008) and a Permian age is also supported by a lack of evidence for substantial glaciation in the Late Pennsylvannian in eastern Australia (Jones and Fielding 2011). The Crown Point Formation is correlated with the glacigene Merrimelia Formation of the Cooper Basin, Boorannah Formation of the Arckaringa Basin and upper Kuriyippi Formation of the Bonaparte basin (Figure 38.4).

Tirrawarra Sandstone equivalent
The Tirrawarra Sandstone (McKellar 2002) was defined in the Cooper Basin in South Australia and Queensland, where it comprises a succession of sandstone, conglomerate and lesser siltstone deposited in fluvi-al, lacustrine and outwash fan settings (Hill and Gravestock 1995). A similar sandstone-dominated unit is recognised in the Pedirka Basin, conformably between the Crown Point and Purni formations. The stratigraphic status of this equivalent unit is unclear; it has been regarded as a distinct formation (eg Ambrose 2006, Central Petroleum 2011a, Ambrose et al. 2012), but has also been included as the upper part of the Crown Point Formation (eg Jones et al. 2011). Tirrawarra Sandstone equivalent strata are recognised in the Eringa and Madigan troughs, and also occur across the Colson and Andado shelves. The unit is thickest in the southern Eringa Trough in South Australia, where it is about 200 m thick in Mount Hammersley-1 (Ambrose 2006). In Northern Territory drillholes, the Tirrawarra Sandstone equivalent is much thinner and is generally less than 50 m thick; in Simpson-1 it is 31 m thick (Central Petroleum 2009c) and it reaches a maximum-known thickness of 61.4 m in CBM93-002 (Central Petroleum 2011b). The unit thins and pinches out to the west across the Andado Shelf and is absent along the western margins of the basin. It is both conformable on and interferes with the Crown Point Formation, and is conformably overlain by the Purni Formation. The unit is possibly equivalent to the upper Boorannah or Stuart Range formations of the Arckaringa Basin (Figure 38.4).

The Tirrawarra Sandstone equivalent in the Pedirka Basin consists of very fine to very coarse to conglomeratic sandstone with minor siltstone and claystone. The sandstone is generally feldspar-rich, massive to cross-laminated or cross-bedded, kaolinitic, and has occasional carbonaceous interbeds (Central Petroleum 2011b). Both fining-upward and coarsening-upward beds are present. The age of the Tirrawarra Sandstone equivalent succession is interpreted to be Asselian (Zone 2 palynofloral Zone of Price 1983; equivalent to the upper part of Zone APP121 of Price 1997), as both the underlying Crown Point and overlying basal Purni formations are both also of this zone (Central Petroleum 2011a, Ambrose et al. 2012). The top of the unit is therefore older than the top of the Tirrawarra Sandstone in the Cooper Basin, which has been placed at the top of Zone 3a (APP122, see Draper 2002). A glacioluvial braided river/glacial outwash environment of deposition has been interpreted for the unit (Ambrose 2006, Central Petroleum 2011a).

Purni Formation
The Purni Formation (Youngs 1975) is widespread in the western Pedirka Basin and occurs in the Eringa and Madigan troughs, and across the Andado and Colson shelves. However, it is absent in the Poolowanna Trough and thins to the west across the Andado Shelf to be absent along the western flanks of the basin. In the Eringa and Madigan troughs, the Purni Formation ranges in thickness from about 300 m to greater than 550 m, with a maximum thickness of 564.3 m in drillhole Blamore-1 in the Madigan Trough (Central Petroleum 2008, Figure 38.5). On the Colson Shelf, the formation is much thinner and it is only 135 m thick in drillhole Simpson-1 (Ambrose et al. 2012). The Purni Formation is conformable on the Tirrawarra Sandstone equivalent, or where this is absent, the Crown Point Formation. It is unconformably overlain by the Early Triassic Walkandi Formation within and to the east of the Eringa Trough, or by Mesozoic strata of the Eromanga Basin elsewhere. The Purni Formation is considered to be the lateral equivalent of the Patchawarra and younger formations of the Gidgealpa Group of the Cooper Basin, and of the Stuart Range and Mount Toondina formations of the Arckaringa Basin (Alley 1995, Figure 38.4).

The Purni Formation is a thick succession of sandstone, siltstone, shale, coal and minor conglomerate. The succession in South Australia was informally subdivided into three

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Footnote:
1 Ambrose et al. (2007) tentatively assigned this interval to the Mount Toondina Formation of the Arckaringa Basin.
‘facies suites’ on the basis of relative proportions of sandstone, shale and coal by Youngs (1975). This subdivision consists of a basal suite of carbonaceous shale with lesser lenticular sandstone and coal stringers, deposited in a predominantly low energy, meandering stream environment; a medial suite of upward-fining sandstone with minor shale and coal, deposited in a braided to meandering fluvial environment; and an upper suite of carbonaceous shale with abundant coal seams, deposited in a paludal/flood plain environment. These ‘facies suites’ have not been identified in the NT, where four informal stratigraphic units (A1, A, B and C) are recognised, based on drillhole and seismic data (Central Petroleum 2011a, Ambrose et al. 2012, Figure 38.6). Units A1–B are equivalent to the ‘lower Purni Formation’ of Ambrose and Heugh (2010), whereas Unit C is equivalent to the ‘upper Purni Formation’.

The basal Unit A1 is a sandstone-rich interval conformably overlying Tirrawarra Sandstone equivalent rocks. It consists of thinly interbedded sandstone and lesser siltstone with minor thin coal seams, and reaches a maximum thickness of 118 m in drillhole Blamore-1. The unit lacks varved shale and has sandstone that is commonly pyritic rather than feldspathic, which along with the presence of more abundant carbonaceous material, serves to differentiate it from the underlying Tirrawarra Sandstone equivalent (Jones et al. 2011, Central Petroleum 2011a). This basal unit contains a palynological assemblage (Ambrose et al. 2012) assigned to the Zone 2–early Zone 3 (Asselian–Sakmarian) palynofloral Zone of Price (1983), which is equivalent to the upper Zone APP121 to APP122 zones of Price (1997). Like the Tirrawarra Sandstone equivalent, it has been interpreted as a glaciolfluvial outwash succession with the finer lithologies representing flood plain/overbank deposits (Central Petroleum 2011a).

The conformably overlying Unit A is a much thicker succession of mostly fine-grained sandstone, siltstone, shale, carbonaceous shale and coal that reaches a maximum thickness of 246 m in drillhole CBM107-001. It is characterised by the presence of numerous coal seams of varying thicknesses and lateral extent. The more substantial of these seams are laterally very extensive and the largest attains a maximum thickness of greater than 30 m and a strike length of 70 km. The Unit A succession was deposited in a predominantly low-energy, meandering fluvial/paludal depositional system (Jones et al. 2011) with the finer-grained clastic sediments representing flood plain/overbank deposits. Thicker and more extensive coal seams were probably deposited in long-lived, widespread peat mire systems formed by allocyclic processes such as changes in sea level and/or climate; the acidic peat that accumulated was dominated by moss/lichens and reed like plants. Thinner, less continuous coal seams are more likely to have had an autocyclic origin, such as river avulsion into peat swamps (Central Petroleum 2011a). Unit A contains

Figure 38.6. Schematic stratigraphic column showing relationships between units and distribution of coal seams in western Pedirka Basin (slightly modified from Central Petroleum 2011a).
palynological assemblages referred to the Sakmarian Zone 3a palynofloral Zone of Price (1983), which is equivalent to most of Zone APP122 of Price (1997). A probable disconformity of uncertain duration separates this interval from the overlying Unit B (Ambrose et al. 2012).

Unit B is a succession of sandstone, siltstone, shale and coal that reaches a maximum thickness of 257.3 m in drillhole Blamore-1. The basal 50 m of this unit consists of regionally extensive, coal-deficient siltstone and very coarse to fine sandstone arranged in finely to coarsely cyclic 1–2 m thick with erosive bases. This is overlain by a thin succession of sandstone, siltstone, shale, carbonaceous shale and coal seams of varying widths up to 25 m thick (Central Petroleum 2011a, Ambrose et al. 2012). Unit B contains palynological assemblages referred to the late Sakmarian–early Kungurian Zone 3b–early Zone 4 palynofloral zones of Price (1983), which is equivalent to the APP2–near-top APP32 zones of Price (1997). A similar environment of deposition to the underlying Unit A is probable (Ambrose et al. 2012).

Unit C contains a succession similar to that of the underlying units and was deposited in much the same setting. However, it is separated from Unit B and from the overlying Walkandi Formation by major unconformities. The unit varies in thickness from about 10 m in drillhole CBM93-003 to 145 m in CBM107-001, but its areal distribution is poorly understood and the unit may pinch out to the west before the zero edge of the Purni Formation succession. A palynological assemblage from Unit C has been referred (Ambrose et al. 2012) to the Late Permian Zone 5 palynofloral Zone of Price (1983), which corresponds to the APP4 and possibly APP5 zones of Price (1997).

As the Purni Formation contains major internal unconformities and its age has been extended to encompass much of the Permian, it may be appropriate to elevate the name to group status and to define the informal subdivisions of the unit as formations. This would be more consistent with the stratigraphic nomenclature in the adjacent Cooper Basin, where the corresponding Permian succession is subdivided into a number of formations and included within the Gidgealpa Group (Figure 38.4). However, more geological and geophysical data need to be acquired to better define the extent and age of these informal units before a stratigraphic revision of the formation can be confidently undertaken.

**TRIASSIC**

During the Triassic, deposition shifted towards the east of the Pedirka Basin and was accommodated in several depocentres, in particular the Poolowanna Trough, although Permian and Triassic strata overlap in central areas of the basin, including the Eringa and Madigan troughs (Figure 38.2). A major unconformity between the Permian and Triassic successions is indicated by erosion of Permian strata in structurally high positions, such as the Dalhousie-McDills Ridge (Moore 1986, Ambrose et al. 2002). This unconformity has been attributed to Late Permian–Early Triassic compressional reactivation of older fault systems, accompanied by southeasterly directed regional tilting (Questa 1990, Ambrose et al. 2007).

The Triassic succession is divided into two units, the basal Walkandi Formation and the unconformably overlying Peera Peera Formation, both of which occur only in the subsurface. The Walkandi Formation is correlated with the Arrabury Sandstone of the Cooper Basin (Ambrose 2006), whereas the Peera Peera Formation is correlated with the Cuddapan Formation of the basal Eromanga Basin* (Figure 38.4).

**Walkandi Formation**

The Walkandi Formation (Moore 1986) was deposited on a penepaned surface, resulting from erosion probably at the end of the Permian. The formation is a continental red-bed succession and consists of interbedded shale, siltstone and minor very fine-grained to fine-grained sandstone (Questa 1990, Ambrose and Heugh 2010). These rock types all have a distinctive colour ranging from grey-green/maroon to brick red. A maximum thickness for the formation of 247 m is attained in drillhole Blamore-1 (Ambrose and Heugh 2010), but significant thicknesses of over 100 m are also present in depocentres of the Poolowanna Trough (Ambrose et al. 2007). The Walkandi Formation unconformably overlies the Purni Formation in the central areas of the Pedirka Basin, but elsewhere unconformably overlies Warburton Basin strata. The unit is overlain unconformably or with a very low-angle unconformity by the Peera Peera Formation (Ambrose et al. 2007). A shallow, ephemeral lacustrine environment of deposition has been interpreted for the unit, with coarser rock types being suggestive of shoreline or near-shoreline deposition (Moore 1986, Questa 1990). Clay-filled cracks in mottled shale in drill core intersections of the formation are evidence of subaerial desiccation and pedogenesis (Moore 1986). Palynofloras indicate a broad Triassic age for the Walkandi Formation, but are not well enough preserved to enable greater precision (Gravestock 1995). The age of the top of the unit is constrained by its stratigraphic position beneath the ?Middle–Late Triassic Peera Peera Formation and a ?Late Permian–early Middle Triassic age is indicated by correlation of the unit with the red bed strata of the Arrabury Formation of the Cooper Basin (Figure 38.4).

**Peera Peera Formation**

The Peera Peera Formation is mainly developed within the Poolowanna Trough, where it attains a maximum thickness of ca 190 m in drillhole Walkandi-1 (Gravestock 1995, Figure 38.5). The formation thins westward onto the Colson Shelf, where it is ca 35 m thick in drillhole Colson-1 (Beach Petroleum 1979), and extends to the east of the Poolowanna Trough, where it overlaps the Birdsville Track Ridge in places, implying a possible direct connection with equivalent strata (Cuddapan Formation) of the basal Eromanga Basin. Ambrose and Heugh (2010) reported that the formation also extends north into the Colson Shelf–Madigan Trough area, but it is absent in drillholes Blamore-1 and Simpson-1 (Central Petroleum 2008, 2009c). The formation is disconformable or unconformable on the Walkandi Formation, or where this is absent in central areas of the basin, is unconformable on the Purni Formation, or where both formations are absent in areas to the east, is presumed to be unconformable on Warburton Basin strata.

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* Originally considered to be the uppermost unit of the Cooper Basin, but reassigned to the basal Eromanga Basin by Draper (2002).
A three-fold subdivision of the Peera Peera Formation was recognised by Moore (1986) from studies of drillholes in the deepest section of the Poolowanna Trough; a basal unit of grey shale, siltstone, and minor sandstone and coal is overlain by a medial unit consisting of several upward-fining sandstone cycles, which is in turn overlain by an upper unit of black, silty, highly carbonaceous shale with occasional thin sandstone interbeds. Sandstone tends to be coarser grained at the base of the formation, but is very fine to fine grained towards the top (Questa 1990). These features collectively indicate a meandering fluvial/flood plain environment of deposition for the formation, with dark shale in the lower and upper units being indicative of lacustrine or paludal environments (Moore 1986, Questa 1990). The basal contact with the Walkandi Formation is marked by a regional sheet sandstone up to 20 m thick, interpreted to have been deposited in response to a sharp drop in the base level of erosion, followed by a more gradual rise in base level, responding to rising sea levels (Ambrose 2006). The Peera Peera Formation is correlated with the Late Triassic Cuddapan Formation of the basal Eromanga Basin (Gravestock 1995) and may also be equivalent to the uppermost part of the Tinchoo Formation (Figure 38.4), if the base is as old as Middle Triassic, as suggested by Ambrose (2006).

**STRUCTURE AND TECTONIC HISTORY**


**Basement structures**

There are a number of northeast- to north-trending anticlinal structural ridges (trends) across the basin (Figures 38.2, 38.3), separating or segmenting the major depocentres; some of the more significant of these include, from west to east, the collinear Dalhousie-McDills Ridge, Hallows Trend and Hector Trend, and the Border, Colson, Macumba-Bejah, East Border and Poolowanna-Thomas trends. These structural ridges are reflected by gravity anomalies and are interpreted to be composed of folded and faulted pre-Permian sedimentary rocks (Questa 1990, Hibburt and Gravestock 1995). They are flanked by reverse faults that, with the exception of the ridges immediately to the east of the Eringa Trough, are mostly downthrown to the east (Questa 1990). Many of these marginal faults experienced Mesozoic and Cenozoic reverse movements, but they have a long history and there is evidence that they have been repeatedly reactivated during the Phanerozoic.

Several tectonic events are recognised in adjacent regions that may have been involved in the structuring of pre-Permian basement rocks underlying the Pedirka Basin (see Geological framework). These include the 580–530 Ma Petermann Orogeny, which was mainly focused on the Musgrave Province and Amadeus Basin to the west, the late Early and Middle Ordovician (480–460 Ma) Larapinta Event, which was mostly confined to the Irindina Province to the north, the long-lived 450–300 Ma Alice Springs Orogeny (ASO) of central Australia, and the 360–320 Ma Kanimbil Orogeny of eastern Australia.

In the eastern Warburton Basin, Cambrian and Ordovician rocks have been affected by folding and northwest-directed thrusting, poorly constrained between the Late Ordovician and Late Carboniferous (Haines et al 2001). Gravestock et al (1995) and Apak et al (1995) both favoured a Carboniferous age for the deformation, but attributed it to the Alice Springs and Kanimbil orogenies, respectively. A Carboniferous age for the deformation is consistent with the age of granites that intrude the Warburton Basin succession in the east (Gatehouse et al 1995) and with ca 330 Ma thermal overprinting of Cambrian volcanic rocks low in the succession (Wopfner 1972). Haines et al (2001) suggested that the northwest-directed thrusting might indicate that the Warburton Basin occupied a transitional domain between the east–west compression in eastern Australia and the predominantly north–south compression characteristic of the ASO in central Australia.

**Permian and Triassic structures**

Early Permian deposition in the Pedirka Basin was probably initiated at about the same time, or shortly after the final northwest–southeast compressional phase of the 450–300 Ma Alice Springs Orogeny of central Australia (Alexander and Carne 1997) and the Permian sedimentary fill within the basin appears to have been largely derived from orogenic highlands associated with this orogeny (Ambrose et al 2002, Ambrose 2006). It was probably deposited on a moderately undulating eroded topography (Ambrose et al 2007). The overall architecture of the Permian basin is difficult to reconstruct, due to the limited structural information available from this largely subsurface basin and because of the effects of later tectonic activity during the Mesozoic and Cenozoic, which has resulted in folding and the reactivation of major structures. The major Permian depocentres (Eringa and Madigan troughs) have complex geometries and are associated with significant faults that are likely to have controlled subsidence and depositional patterns. The Eringa Trough is strongly asymmetric and is deepest along its eastern margin (Figure 38.3). It is flanked intermittently to the east by a series of major faults associated with Dalhousie-McDills Ridge, and Hallows and Hector trends (Ambrose and Heugh 2010), suggesting that its original structure may have been that of a half-graben or a series of half-grabens, developed in an overall strike-slip setting. These faults preserve Mesozoic and Cenozoic reverse movements, but they have a long history of reactivation and probably experienced oblique and/or normal movements during the Permian in order to accommodate the considerable (up to 1000 m) subsidence indicated by the thick successions in adjacent depocentres.

The Madigan Trough is bounded to the north by the northwest-trending Pellinor Fault Zone (Figure 38.2), which comprises a series of northwest-trending, originally down-to-basin normal faults on the southern margin of the Hale River High that were reactivated as reverse faults in the Miocene (Ambrose et al 2012). Adjacent to the hangingwall of this fault system is a thick Permian conglomeratic facies apparently shed off the fault scarps bounding this high (Ambrose and
Heugh 2010), indicating that the fault zone was an active structure controlling sedimentation in the trough at this time. The Madigan Trough is bounded to west by the Hallows and Hector trends, and to the east by the Madigan Fault, but the effects of these structures on sedimentation within the trough are unclear. The Permian succession to the east of the Madigan Fault on the Colson Shelf is condensed and sand prone (Central Petroleum 2011a, Ambrose et al. 2012), suggesting that this fault had at least some influence on deposition within the trough. The normal movements on the Pellinor Fault Zone at that time are indicative of northeast–southwest-directed extension, suggesting that these near-orthogonal north- and northeast-trending structures were most likely to have experienced strike-slip or oblique-slip movements.

In the Late Permian, an episode of mild structural deformation and uplift, accompanied by regional southeasterly tilting and subsidence is indicated by the erosion of Permian strata from structural highs and the migration of Triassic depositional areas southeastward into the developing Poolowanna Trough (Ambrose et al. 2002, 2007, Central Petroleum 2011a). The resulting basin framework was largely inherited by the overlying Eromanga Basin, as the Poolowanna Trough was also the main depocentre for this basin in this area. The western part of the Pedirka Basin at this time was being subjected to continued uplift and erosion, and this provided an important sediment source for the slowly subsiding Poolowanna Trough (Questa 1990). The Poolowanna Trough comprises several elongate synclinal depocentres, segmented by several Palaeozoic ridges extending into its northern areas (Questa 1990, Ambrose and Heugh 2010). These include the Colson, Macumba, Bejah, East Border, Thomas and Poolowanna trends (Figure 38.2), which are commonly associated with north-trending reverse faults, most of which are downthrown to the east. Vertical displacement on these structures was less than that on faults flanking the Eringa Trough to the west (Ambrose and Heugh 2010). At the end of the Triassic, the basin succession experienced minor uplift and erosion (peneplanation) resulting from mild rejuvenation of pre-existing faults prior to the onset of Eromanga Basin deposition (Ambrose et al. 2007). Ambrose and Heugh (2010) noted that there was also major rejuvenation along the same structural trends during the Late Cretaceous and Cenozoic.

Although the intracratonic Pedirka Basin developed in an area that was relatively distant from active plate boundaries, the initiation and subsequent development of the basin may have been related to long-lived plate convergence between eastern Gondwana and the Panthalassan Ocean that formed the Devonian to Cretaceous New England Orogen, as well as a number of Early Permian to Middle Triassic sedimentary basins inboard of this orogen in eastern Australia. Wopfner (1981, 1985) suggested that far-field stresses related to plate convergence may have been expressed in the Pedirka Basin area as strike-slip movements along northeast- and northwest-trending shear zones. Wopfner speculated that Early Permian half-graben and trough structures could have developed as strike-slip displacements at depth were transmitted through overlying sedimentary cover. Direct evidence of dextral shearing was subsequently noted by Ambrose (2006) from the presence of deep-seated flower structures in seismic profiles across the Dalhousie-McDills Ridge (Figure 38.7). A series of compressional tectonic events at about the Permian–Triassic boundary (Hunter-Bowen event; see Holcombe et al. 1997) might be reflected by regional unconformities in the Pedirka Basin succession (see Table 38.1), by southeasterly platform tilting within the basin at about this time (Ambrose et al. 2002, 2007), and by northeasterly tilting in the Cooper Basin area (Gravestock and Jensen-Schmidt 1998). In the Middle Triassic, the thrust front in the New England Orogen propagated westward into Permian–Triassic basins inboard of the orogen (e.g. Bowen and Gunnedah basins) effectively ending sedimentation in these areas (Korsch and Totterdell 2009). The Late Triassic hiatus that followed this event is also evident in basins further to the west, where it is expressed as unconformities at the top of the Cooper and Pedirka basin successions.

**MINERAL RESOURCES**

The Pedirka Basin contains substantial resources of coal, which could potentially be exploited by mining, or for unconventional petroleum. The basin is also very prospective for conventional petroleum. The basin is incompletely covered by several vintages of 2D seismic data and contains a number of petroleum and mineral exploration drillholes (Figure 38.5).

**Coal**

Significant coal-bearing intervals occur within the Permian Purni Formation and minor coal occurs within the Triassic Peera Peera Formation. These coal resources may have economic potential via mining and/or Underground Coal Gasification (UCG) and ultimately Coal to Liquids (CTL) techniques (see Petroleum).

Thick extensive coal seams, generally sub-bituminous in rank and interbedded with clastic rocks, occur within Purni Formation units A, B and C (Figure 38.6) on the Andado Shelf, and in the Eringa and Madigan troughs. Coal seams reach a maximum thickness in excess of 30 m and can be laterally very extensive (Figure 38.8), attaining a strike length of over 70 km for the A3 ‘super seam’, which is one of the largest within the basin (Ambrose and Heugh 2010). Thick coal-rich intervals have been intersected in a number of exploration drillholes, including: CBM93-004, which has a net 153 m of coal in seams >1 m; Blamore-1, which has a net 160 m of coal in seams >0.2 m or a net 111.3 m of coal in seams >1 m, and CBM93-001, which has net 139.4 m of coal in seams >1 m thick, with the thickest seam being 34.6 m (Jones et al. 2011, Central Petroleum 2011c). Drilling has intersected thick Permian coal successions on the central portion of the Andado Shelf (drillholes CBM93-001, 93-004) and a thinner coal section on the northern margin, as defined in drillholes SHEL27109-1, 27109-2 and 28095-1. Coal-bearing successions thicken downdip towards the axis of the Eringa Trough (Central Petroleum 2011a, Ambrose et al. 2012, Figure 38.3), but are buried at depths of up to 2000 m. Within the Eringa Trough, coal-bearing successions are more prominent to the north of the northwest–southeast-trending transverse Camelot Fault (Figure 38.2), with older glaciogene deposits tending to dominate the succession to the south of this structure (Ambrose and Heugh 2010). Towards the western basin margin across the Andado Shelf, coal seams...
Figure 38.7. West–east seismic line 85NT-03 (Adelaide Petroleum NL) across Dalhousie-McDills Ridge, showing interpreted flower structure indicative of strike-slip tectonics (after Ambrose et al 2002). Location shown in Figure 38.5.

Figure 38.8. Northwest–southeast seismic line CB08-01 (Central Petroleum Ltd) across Eringa Trough showing thickness and extent of Purni Formation coal succession (after Central Petroleum 2009a). Drillhole control provided by CBM93-01 and Blamore-1. Note characteristic high-amplitude reflection expression of coal seams. Length of seismic line is about 65 km. Location shown in Figure 38.5.
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are at shallower and possibly mineable depths, but are yet to be studied in detail. Thick coal seams have been intersected at relatively shallow depths of 300–400 m in drillhole CBM107-002 and coal could occur at lesser depths in other areas in this part of the basin (Central Petroleum 2011a, Ambrose et al. 2012). In the Madigan Trough, coal-bearing successions up to 750 m thick occur to the west of the north–south-trending Madigan Fault at depths of up to 2000 m; to the east of this fault on the Colson Shelf, the Purni Formation is more condensed and sand prone, and only one 7 m coal interval was intersected in drillhole Simpson-1 where the Permian succession is just 135 m thick (Central Petroleum 2009c). Jones et al. (2011) provided a JORC Exploration Target5 tonnage estimate for coal within Central Petroleum’s NT petroleum permits alone of between 470 and 570 Gt at depths <1000 m below the surface, plus a further 1570 to 1920 Gt of coal at depths >1000 m.

In Purni Formation unit A, coal seam thicknesses and abundance both increase upsection to the topmost A3 ‘super seam’ (Ambrose and Heugh 2010). This laterally very extensive seam has been identified in both the Eringa and Madigan troughs and across the Andado Shelf. A3 coal contains various amounts of vitrinite and inertinite with the latter being slightly more abundant; liptinite contents, dominated by sporinite, average 5–10%. Unit B coals are best developed along the south-central Andado Shelf, but are also laterally extensive along the strike of the Andado Shelf and may extend to mineable depths in the west of the basin (Ambrose and Heugh 2010). The coals are truncated by erosion along the western basin margin of the Andado Shelf in the vicinity of CBM107-002 (Figure 38.5), but they could be at mineable depths in other areas, such as the western–northwestern basin margin. Unit B coals have variable amounts of vitrinite and inertinite (Ambrose and Heugh 2010: table 4), with vitrinite dominant in some drillhole samples (e.g. CBM93-001, 93-004) and inertinite in others (e.g. CBM107-001); liptinite content averages 5–10% with a maximum of 11.37% in samples from CBM93-004. Unit C coals are stratigraphically the highest in the succession, so are therefore an attractive exploration target, but their distribution is poorly known. The relatively thin unit C may be absent in the shallower western part of the basin, due to erosion or to pinching out of the unit in that direction. A net thickness of 35 m of coal was intersected in drillhole CBM107-001, where unit C is 145 m thick. The coal comprises 50–60% inertinite, 25–35% vitrinite and is rich in liptinite averaging 10–15% (Ambrose and Heugh 2010).

Pedirka Basin coal is generally sub-bituminous in rank and has good thermal/steaming qualities. However, economically viable open-cut mining of the coal would require the presence of significant coal seams at depths of less than 2–300 m and this has yet to be demonstrated. Underexplored areas of the basin that might be targeted for shallow coal deposits by exploratory drilling include the western margin of the Andado Shelf along a strike length >100 km, where thick coal seams could occur on broad uplifted fault blocks, and where both Purni Formation and pre-Purni Formation strata have been eroded to some extent, and a number of other areas within the basin, including uplifted fault blocks along the margins of the Hale River Block (Ambrose and Heugh 2010).

Petroleum

Stacked basins in the southeastern corner of the NT and adjacent areas are prospective for both conventional and unconventional petroleum at a number of stratigraphic levels. Possible plays in this region are associated with fractured basement rocks (Central Petroleum 2011e), early and mid Palaeozoic rocks of the Warburton Basin, Permian and Triassic rocks of the Pedirka Basin, and Mesozoic rocks of the Eromanga Basin. These basins have structures and depocentres in common and petroleum systems are not necessarily confined to any one basin succession. The Pedirka Basin contains elements of the Permian–Triassic Gondwanan petroleum supersystem of Bradshaw (1993) and Draper (2000).


Conventional petroleum

The NT portion of the Pedirka Basin has only been sparsely explored for conventional petroleum, although there is good potential for commercial accumulations. The succession has been penetrated by 18 drillholes (Figure 38.5) and there is about 3500 line km of modern seismic data over a relatively large prospective area of 70 000 km² (Ambrose et al. 2002). So far, only non-commercial conventional hydrocarbon accumulations have been found in this area, in basal Jurassic sandstones of the overlying Eromanga Basin.

Source rocks

Coal measures and carbonaceous shale within the Permian Purni and Triassic Peera Peera formations constitute the best source rocks within the basin. Thick coal measures from the Purni Formation have a high content of type II/III or oil-prone kerogen (Smyth and Saxby 1981) and have fair to good source potential. The Peera Peera Formation also has fair to good source potential, mostly due to the formation’s coals, and Ambrose et al. (2007) reported that it is a mixed oil–gas source rock in the Madigan and northern Poolowanna troughs. The formation has a total organic content of up to 18%, with most of the organic material occurring towards the top of the unit (Questa 1990, Ambrose et al. 2007). Samples from NT and South Australian drillholes record a high content of type III kerogen, but type II kerogen is present in shaly coal facies in Poeppeps Corner-1 (Ambrose and Heugh 2010).

Reservoirs

In the Pedirka Basin, potential sandstone reservoirs possessing fair to good reservoir quality occur at the levels of the Crown Point Formation, Tirrawarra Sandstone equivalent and Peera Peera Formation. Good sandstone reservoirs also occur in the Poolowanna Formation and Algebuckina Sandstone of the overlying Eromanga Basin (Questa 1990). There is also some potential for sandstone reservoirs within the Purni Formation (Ambrose et al. 2007, Ambrose and Heugh 2010). Porosities are in the range <9–13% for the Crown Point Formation, 9–14% for

5 Note that this is not a JORC-compliant Resource.
the Tirrawarra Sandstone equivalent and 10–18% for the Peera Peera Formation (Kingsley 1987). Secondary fracture porosity could also be significant in some of the more deeply buried units and in the tighter rocks of the Crown Point Formation and Tirrawarra Sandstone equivalent (Ambrose et al. 2002).

**Thermal maturity**

Existing quantitative data on maturity from the NT portion of the Pedirka Basin indicate that the source rocks are mature for oil generation over much of the basin at depth. Ambrose (2006) noted that the thick Permian successions in the Madigan and northern Poolowanna troughs are oil-prone and -mature. Questa (1990) reported that Permian–Triassic successions have reached the main oil-generative window [Vitrinite Reflectance values (Ro) = 0.7–0.9%] over large portions of the basin and Mulready Consulting Services (2009) reported samples of Purni Formation coal from drillhole Blamore-1 that yielded Ro values in the range 0.52–0.58%, which places them in the early oil generating window. However, they noted that values from drillholes within the Madigan Trough from further south, where the coals are more deeply buried, will be higher and well within the oil generative window. Ambrose and Heugh (2010) reported that the Purni succession has probably not reached the gas window in the axis of the Madigan Trough and hence, oil may not have been displaced on a regional scale to the distal basin margins by gas displacement, as it has in the Cooper Basin area. Rock Evaluation (Rockeval) Pyrolysis data, Hydrogen Indices and Vitrinite Reflectance data from Blamore-1 show that the organic matter at the top of the Purni coal succession is immature for oil generation, but is in the early oil generating window near the base of the unit. The data indicate that the oil generative window in the Pedirka Basin will be at a probable maximum depth of about 1250 m, with the hot dry gas window more deeply buried (Mulready Consulting Services 2009).

Maturity modelling for the Triassic Peera Peera Formation in the Poolowanna Trough indicates that it is in the mid–late mature oil window (Ambrose et al. 2007). Late Permian and Late Triassic episodes of regional tilting to the southeast indicate that the most deeply buried Permian and Triassic source rocks will also occur in the southeast, where they are probably in the late stages of oil generation (Ambrose 2006).

**Prospectivity**

The Warburton, Pedirka and Eromanga basins have an abundance of organically rich source rocks, porous and permeable reservoirs with effective vertical seals, and closed anticlinal structures. Reservoir objectives and their associated source rocks range in age from earliest Cambrian to Early Cretaceous. Upper Palaeozoic and Mesozoic rocks remain the primary exploration targets but underlying Palaeozoic (Cambrian to Devonian) clastic and carbonate rocks provide significant secondary objectives.

At least three unnamed petroleum systems are present in the Simpson Desert area (Questa 1990, Ambrose et al. 2002); these incorporate source rocks of the Permian Purni and Triassic Peera formations (Pedirka Basin), and the Early Jurassic Poolowanna Formation (Eromanga Basin), plus a number of possible reservoir configurations. Hydrocarbons were generated prior to Oligocene–Miocene tectonism, but there is some uncertainty as to the exact timing. Questa (1990) indicated that Permian and post-Permian source rocks would have been incapable of generating liquid hydrocarbons until after the deposition of thick Winton Formation covering sediments (Eromanga Basin) in the Late Cretaceous and suggested it would be unlikely that significant oil generation would have taken place much before Eocene time. However, Ambrose and Heugh (2010) preferred a Late Cretaceous time for maximum hydrocarbon generation, with initial generation/ expulsion possibly occurring as early as the Early Cretaceous. In both cases, hydrocarbon generation is interpreted to have been in response to increasing temperatures related to loading associated with deposition of the Winton Formation, so that pre-Cenozoic structural and stratigraphic traps in the basin could have been effective trapping mechanisms prior to any significant oil migration. There is also some possibility that traps could have been filled at an earlier time if significant hydrocarbons have been generated and migrated from older Warburton Basin source rocks. Questa (1990) indicated that modelling of early Palaeozoic rocks in the Eringa Trough suggests that these more deeply buried rocks could have generated hydrocarbons in the Permian or possibly during the later stages of the Alice Springs Orogeny in the Late Carboniferous.

Significant reservoir/seal couplets within the Pedirka Basin (Ambrose and Heugh 2010, Figure 38.9) include: Tirrawarra Sandstone equivalent sandstone blanket on basalt shale of the Purni Formation shale, equivalent to the Tirrawarra Sandstone/lower Patchawarra Formation reservoir/seal couplet of the Cooper Basin (Ambrose et al. 2002); intra-Purni Formation sandstone/shale; and intra-Peera Peera Formation basal sandstone/top shale (Ambrose et al. 2007). The basal Triassic Walkandi Formation is also an important regional seal (Ambrose 2006) and significant sheet-like regional reservoir/seal couplets that could have trapped petroleum sourced from Permian–Triassic rocks also occur in the overlying Mesoozoic Eromanga Basin succession, including intra-Poolowanna Formation sandstone/shale, Algebuckina Sandstone/Cadnaowie Formation basal shale and Cadnaowie Formation sandstone/Wallumbilla Formation shale.

Figure 38.10 shows the known distribution of Permian prospects and leads and Permian Purni Formation source kitchens in the Pedirka Basin. Significant Permian and Triassic source kitchens that would be expected to be mature for oil generation (Ro >1.0) are located in the Madigan, northern Poolowanna and northern Eringa troughs. The absence of gas displacement of early-reservoired oil would be conducive to relatively short migration pathways for oil generated in these troughs, and traps formed prior to loading by the Winton Formation that are within 5–20 km of source kitchens are therefore good exploration targets (Ambrose and Heugh 2010). Favourable structural settings would be enhanced by a prolonged history of structural growth that would maximise the possibility of migration postdating structuring (Ambrose et al. 2002). Possible traps (Figures 38.9, 38.10) include numerous four-way dip closures, combination structural-stratigraphic plays on the flanks of reactivated basement highs involving onlap

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6 Equivalent to uppermost ‘Murta Formation’ shale of previous usage (eg Ambrose and Heugh 2010), but referred to basal Cadnaowie Formation by Gray et al. (2002, see Eromanga Basin). Murta Formation and underlying Namur Sandstone in Cooper Basin are equivalent to upper Algebuckina Sandstone in Poolowanna Trough (Krieg et al. 1995).
Pedirka Basin

of sandstone reservoirs, hangingwall fault plays, eg on the southern, fault-bounded margin of the Hale River High, and pinchout plays towards the basin margins (Ambrose et al 2002, Ambrose and Heugh 2010). Effective traps might occur within these structures at a number of stratigraphic levels ranging from the early Palaeozoic to the Mesozoic within the stacked Warburton, Pedirka and Eromanga basins. The major risk for the preservation of early-formed oil pools is the breaching of traps by the reactivation of faults in the Cenozoic (Ambrose and Heugh 2010).

There are a number of petroleum leads and prospects (Figure 38.10) in the vicinity of the Pedirka Basin that have attracted recent exploration interest, including the Madigan, Simpson East, Avalon and Blamore prospects. The Madigan Prospect is a multi-level robust 4-way dip closure at Permian–Jurassic and probably earlier Palaeozoic levels to the northeast of the adjacent Madigan Trough. It has a best estimate Undiscovered Oil Initially In Place (UOIIP) potential of 4 Bbbl (billion barrels) in post-Permain sediments alone (Central Petroleum 2011). The Simpson East Prospect is a robust 4-way dip closure at Palaeozoic and Mesozoic levels, located between the Madigan and northern Poolowanna troughs. This prospect is interpreted to have formed largely as a result of drape and compaction over a massive ?Devonian carbonate platform developed on a regional high. It could have a best estimate UOIIP of up to 350 MMbbl (million barrels)

Figure 38.9. Schematic petroleum migration model for Pedirka and western Eromanga basins, showing significant reservoir/seal couplets (slightly modified after Ambrose et al 2002).

Figure 38.10. Distribution of Permian prospects and leads, and thermal maturity (isorelectance contours) of Purni Formation (modified from Ambrose et al 2002, Ambrose and Heugh 2010).
in post-Permian strata and an additional 1.5 Bbbl UOIP at pre-Permian levels (Central Petroleum 2011d). Drillhole Simpson-1 tested a small sub-closure to the west of the main structure, but only encountered minor oil shows at Jurassic levels (Central Petroleum 2009c). The Avalon and Blamore prospects are the northernmost of a series of prospects, located along the northern end of the anticlinal Hallows Trend between the Eringa and Madigan troughs. These structures together could have a best estimate UOIP of up to 120 MMbbl (Central Petroleum Ltd internet site: http://www.centralpetroleum.com.au/exploration.php, accessed January 2012). Drillhole Blamore-1 tested the Blamore structure, and intersected a 15+ m residual oil column at Mesozoic levels (Central Petroleum 2008), but no live oil. Ambrose and Heugh (2010) speculated that this residual oil column may represent a migration pathway that raises the possibility of spill-migration updip along the Hallows Trend to a greater fault-dependent closure associated with the Camelot Fault (Figure 38.2).

**Unconventional petroleum**

The extensive Permian and lesser Triassic coal measures and carbonaceous shale of the Pedirka Basin have considerable potential for coal bed methane drainage and/or underground coal gasification, which could be exploited via Gas-To-Liquids (GTL) processes, so as to produce ‘ultra-clean’ distillate fuels. Because potential source rocks are rich in oil-prone macerals, the gas adsorbed to the coal will contain higher homologues than methane and should produce more synthetic crude and syngas during synthesis than methane alone would (Mulready Consulting Services 2009). Mulready Consulting Services (2009) estimated the total unrisked and as yet undiscovered, prospective recoverable synthetic gas (syngas) resource contained within the coals of the Purni Formation, above an arbitrary 1000 m cutoff, to be in the range 11 100–13 900 TCF (trillion cubic feet) for Central Petroleum’s Pedirka Basin acreage alone. This is sufficient to produce between 1.11 and 1.39 trillion barrels of liquids in a typical GTL plant. However, commercial exploitation of these resources would need to take into account the potential for environmental problems due to the presence of a major aquifer of the Great Artesian Basin in the overlying Algebuckina Sandstone of the Eromanga Basin (Krieg 1985).

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