Department of
Minerals and Petroleum Resources

RECORD
2003/4

LEADS AND PROSPECTS WITHIN TENEMENTS OF THE NORTHERN PERTH BASIN WESTERN AUSTRALIA, 2002

compiled by C. D'Ercole, A. Pitchford
and A. J. Mory

Geological Survey of Western Australia

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

Record 2003/4

LEADS AND PROSPECTS WITHIN TENEMENTS OF THE NORTHERN PERTH BASIN WESTERN AUSTRALIA, 2002

compiled by

C. D'Ercole, A. Pitchford[1], and A. J. Mory

[1] present address Roxar Pty Ltd, Mount Pleasant, Perth

Perth 2003

REFERENCE
The recommended reference for this publication is:
D'ERCOLE, C., PITCHFORD, A., and MORY, A. J., 2003, Leads and prospects within tenements of the northern Perth Basin, Western Australia, 2002: Western Australia Geological Survey, Record 2003/4, 126p.

National Library of Australia Card Number and ISBN 0 7307 8908 X

Grid references in this publication refer to the Geocentric Datum of Australia 1994 (GDA94). Locations mentioned in the text are referenced using Map Grid Australia (MGA) coordinates, Zone 50. All locations are quoted to at least the nearest 100 m.

Published 2003 by Geological Survey of Western Australia

Copies available from:
Information Centre
Department of Mineral and Petroleum Resources
100 Plain Street
EAST PERTH, WESTERN AUSTRALIA 6004
Telephone: (08) 9222 3459 Facsimile: (08) 9222 3444
This and other publications of the Geological Survey of Western Australia are available online through the Department's bookshop at www.mpr.wa.gov.au

Contents

Abstract 1
Introduction 1
  Commercial considerations 3
  Structural divisions 3
    Beagle–Dongara Ridge 3
    Beermullah Trough 3
    Dandaragan and Coomallo Troughs 3
    Fault terraces 4
    Greenough and Bookara Shelves 4
  Stratigraphy 4
    Lower Permian 6
    Upper Permian 6
    Triassic 6
    Jurassic–Cretaceous 11
  Exploration history 11
Summary of existing fields and accumulations 15
  Beharra Springs gasfield 15
  Dongara oil- and gasfield 15
  Gingin accumulation 15
  Mondarra gasfield 20
  Mount Horner oilfield 21
  North Yardanogo accumulation 22
  Walyering accumulation 23
  Woodada gasfield 24
  Yardarino oil- and gasfield 25
Recent discoveries 33
  Beharra Springs North 33
  Cliff Head 33
  Hovea 34
  Jingemia 34
Petroleum prospectivity 38
  Source rocks and maturity 39
  Reservoirs 42
  Seals 42
  Traps 42
Prospects and leads inventory 43
  Beagle–Dongara Ridge 43
    EP 413 43
      Freshwater Point prospect 43
      Stockyard prospect 45
    Cliff Head trend 47
    L1 and L2 47
      Beharra West lead 48
      High Cliff lead 49
      Hovea South lead 49
  Beermullah Trough 50
    EP 389 — Gingin–Bullsbrook trend 50
      Eclipse prospect 50
      Eclipse West prospect 54
      Gingin Brook prospect 56
      Gingin South lead 58
      Gingin West prospect 59
  Dandaragan and Coomallo Troughs 61
    EP 23 61
      Sundalara prospect 61
    EP 321 65
      Dandaragan Deep prospect 65
    EP 414 66
      Carnamah prospect 66
  Fault terraces 69
    L1 69
      Nutsyia prospect 69
  Greenough and Bookara Shelfs 71
    EP 111 71

W-1 prospect ... 71
W-2 prospect ... 74
W-3 prospect ... 76
Tabletop lead ... 77
EP 394 ... 80
Wye prospect ... 80
Re-appraisal of known accumulations ... 82
Tight gas accumulations ... 82
Ocean Hill prospect ... 82
Warro prospect ... 83
Post-mortems of recent exploration wells ... 84
Arradale 1 ... 84
Beharra Springs South 1 ... 86
Walyering 4 ... 88
Acknowledgements ... 92
References ... 93

Appendices

1. Abbreviations ... 96
2. List of northern Perth Basin permits, operators, and contact details as of December 2002 ... 97
3. Surveys conducted for petroleum exploration in the northern Perth Basin to January 2002 ... 98
4. Wells drilled for petroleum exploration in the northern Perth Basin ... 111
5. Summaries of wells relevant to prospects and leads ... 116

Figures

1. Location of the northern Perth Basin ... 2
2. Northern Perth Basin tectonic units and basin framework ... 2
3. Fields and existing facilities and infrastructure of the southwestern part of Western Australia ... 4
4. Perspective view of top Holmwood Shale, northern Perth Basin ... 5
5. Stratigraphy and petroleum elements of the northern Perth Basin ... 7
6. Stratigraphic summary using selected wells across the northern Perth Basin ... 8
7. Pre-Cainozoic geology, onshore northern Perth Basin ... 9
8. Geological cross section showing interfingering of the Beekeeper Formation and Dongara Sandstone ... 10
9. Seismic coverage on the northern Perth Basin ... 12
10. Gas and oil production showing significant dates, northern Perth Basin ... 16
11. Prospects and leads and distribution of petroleum wells of the northern Perth Basin ... 17
12. Depth contours to the top Beekeeper Formation, Beharra Springs gasfield ... 18
13. Depth contours to the base Kockatea Shale, Dongara oil- and gasfield ... 19
14. Depth contours to the top Cattamarra Coal Measures, Gingin accumulation ... 20
15. Two-way time contours to the top Dongara Sandstone, Mondarra gasfield ... 21
16. Cross section of the Mondarra 1, Mondarra 2, and Nutsyia structures ... 22
17. Depth contours to the top ‘F sand’ body within the Cattamarra Coal Measures, Mount Horner oilfield ... 23
18. Geological cross section of the Mount Horner oilfield ... 24
19. Two-way time contours to the top Kockatea Shale, near the top of the Arranoo Member, Mount Horner oilfield ... 25
20. Depth contours to the intra-Cattamarra Coal Measures, North Yardanogo accumulation ... 26
21. Seismic section B90-476 showing the structure of the North Yardanogo accumulation ... 27
22. Schematic cross section from the Walyering accumulation to Cataby 1 ... 27
23. Depth contours to the top Beekeeper Formation, Woodada gasfield ... 28
24. Geological cross section through the Woodada gasfield ... 29
25. Cross section of the Yardarino oil- and gasfield showing the reservoirs and general structure in the area ... 30
26. Two-way time contours to the base Kockatea Shale, near top Dongara Sandstone, Yardarino oil- and gasfield ... 31
27. Two-way time contours to the top Irwin River Coal Measures, Yardarino oil- and gasfield ... 32
28. Depth contours to the top Dongara Sandstone, Beharra Springs North 1 ... 33
29. Prospects and leads of the Cliff Head trend ... 35
30. Reservoir contours of the Cliff Head oilfield and Mentelle ... 36
31. Seismic section PM99-42 showing the structure of the Cliff Head oilfield ... 37
32. Outline of the top Dongara Sandstone for Hovea and Hovea South ... 38
33. Seismic section A98-EW1-R showing the structure of Hovea 1 ... 39
34. Porosity data from the northern Perth Basin ... 41
35. Prospects and leads of EP 413 ... 44
36. Two-way time contours of the basal Triassic horizon, Freshwater Point prospect ... 46

37. Seismic section SB93-02 showing the structure of the Freshwater Point prospect 47
38. Prospects and leads of L1 and L2 48
39. Prospects and leads along the Gingin–Bullsbrook trend, EP 389 51
40. Depth contours to the top Cattamarra Coal Measures, Eclipse and Eclipse West prospects 52
41. Cross section over the Eclipse and Eclipse West prospects 53
42. Seismic section 99BBN-02 showing the structure of the Eclipse and Eclipse West prospects 54
43. Seismic section 99BBN-04 showing the structure of the Eclipse prospect 55
44. Depth contours to the top Cattamarra Coal Measures, Gingin Brook prospect 56
45. Seismic section 99GG-01 showing the structure of the Gingin Brook prospect 57
46. Two-way time contours to the top Cattamarra Coal Measures, Gingin South lead 58
47. Depth contours to the top Cattamarra Coal Measures, Gingin West prospect 60
48. Seismic section E97-17 showing the structure of the Gingin West prospect 60
49. Seismic section E97-19 showing the structure over the Gingin West prospect 61
50. Prospects and leads of EP 23 62
51. Two-way time contours to the basal Triassic horizon, Sundalara prospect 63
52. Seismic section B88-305 showing the structure of the Sundalara prospect 64
53. Allan diagram of the Eneabba Fault, Sundalara prospect 64
54. Two-way time contours to the intra-Yarragadee horizon, Dandaragan Deep prospect 66
55. Seismic section A89-711-R showing the structure of the Dandaragan Deep prospect 67
56. Depth contours to the top Yarragadee Formation, Carnamah prospect 68
57. Seismic section DR97-19-R showing the structure of the Carnamah prospect 68
58. Predicted present day hydrodynamic flow below the Otorowiri Formation 69
59. Two-way time contours of the top Dongara Sandstone, Nutsyia prospect 70
60. Seismic section P89-12L showing the structure of the Nutsyia prospect 71
61. Two-way time contours for the W-1 prospect 72
62. Seismic section JM99-05 showing the structure at the W-1 prospect 73
63. Two-way time contours for the W-2 prospect 75
64. Seismic section S86-04 showing the structure at the W-2 prospect 76
65. Two-way time contours for the W-3 prospect 78
66. Seismic section S86-02 showing the structure at the W-3 prospect 79
67. Two-way time contours of the top Bookara Sandstone, Tabletop lead 79
68. Two-way time contours of the base Kockatea Shale, Wye prospect 80
69. Seismic section DN95-106 showing the structure for the Wye prospect interpreted by AusAm Resources 81
70. Seismic section DN95-106 showing the structure for the Wye prospect interpreted by GSWA 81
71. Seismic section B89-450 showing the structure of the Ocean Hill prospect 83
72. Two-way time contours of the lower Yarragadee Formation, Warro prospect 85
73. Seismic section P76-3L showing the structure of the Warro prospect 86
74. Two-way time contours of the basal Triassic horizon, Arradale 1 87
75. Seismic section BS82-05 showing the structure of Arradale 1 88
76. Two-way time contours of the Newmarracarra Limestone, Arradale 1 89
77. Two-way time contours of the Dongara Sandstone, Beharra Springs South 1 90
78. Seismic section DR97-21 showing the structure of the Walyering accumulation 90
79. Two-way time contours of the Cattamarra Coal Measures for the Walyering accumulation and its possible extension 91

Tables

1. Northern Perth Basin fields and significant shows 13
2. Summary of the petroleum potential of the northern Perth Basin 40

Leads and prospects within tenements of the northern Perth Basin Western Australia, 2002

compiled by

C. D'Ercole, A. Pitchford[1], and A. J. Mory

Abstract

Recent Perth Basin discoveries, as well as improvements in the gas market, technological advancements, and open access to existing pipeline infrastructure, have considerably improved the exploration prospectivity in the northern Perth Basin, an area, which to date has produced 19.8 Gm^3 (0.7 Tcf) of gas, 0.67 GL (4.2 MMbbl) of oil, and 0.22 GL (1.4 MMbbl) of condensate.

The majority of petroleum discoveries in the northern Perth Basin indicate two main play types are the most prospective: Permian and Triassic sandstones in faulted anticlinal traps along the margin of the Dandaragan Trough, and similar Jurassic plays targeting the Yarragadee Formation and Cattamarra Coal Measures in deeper parts of the Dandaragan Trough.

Individual leads and prospects are grouped according to the major basin subdivisions and assessed using a combination of trap, source, migration and timing, and reservoir criteria as well as comparisons with existing fields and nearby wells. The most prospective area is in the vicinity of the Dongara oil- and gasfield where relative geological risk is estimated to be as low as 1:3, compared to almost 1:20 for the most unfavourable lead on the Greenough Shelf.

KEYWORDS: petroleum potential, reservoir rock, prospect evaluation, source rock, north Perth Basin, Western Australia

Introduction

The northerly trending Perth Basin extends for over 650 km along the southwestern margin of Western Australia, between Augusta at 34°18'S and Geraldton at 28°45'S. It contains a predominantly siliciclastic sedimentary succession deposited in a Permian to Cretaceous rift system that culminated with the breakup of Gondwana in the Early Neocomian (Harris, 1994; Mory and Iasky, 1996; Song and Cawood, 2000a). The basin is bounded by the Darling Fault to the east and extends west to the edge of the continental shelf. The Dandaragan Trough is the main onshore depocentre and contains up to 12 km of Permian and Mesozoic sedimentary rocks (Mory and Iasky, 1996). Pre-Permian sedimentary rocks are restricted to the northernmost part of the basin (Mory and Iasky, 1996; Mory et al., 1998) where they lie outside the area covered by modern exploration data. The thickest post-Cretaceous section is in the central part of the basin near Perth or offshore; elsewhere this succession is typically thin and volumetrically insignificant.

This Record deals primarily with the onshore northern part of the Perth Basin, between 29°S and 31°30'S (Fig. 1), an area from which 19.8 Gm^3 (0.7 Tcf)* of gas, 0.67 GL (4.2 MMbbl) of oil, and 0.22 GL (1.4 MMbbl) of condensate has been produced to December 2001. Geoscience Australia (GA) estimates of the undiscovered reserves are 22.26 GL (140 MMbbl) oil and 11.33 Gm^3 (0.4 Tcf) gas (both P_{50}; Longley et al., 2001). More than half of the oil and gas produced from the basin has come from the Dongara oil- and gasfield, and about 85% of the condensate has come from the Beharra Springs gasfield.

The development of the Perth Basin has been strongly influenced by two main tectonic events (Harris, 1994; Harris et al., 1994; Mory and Iasky, 1996; Song and Cawood, 2000b): northeasterly extension during the

[1] present address Roxar Pty Ltd, Mount Pleasant, Perth

* See Appendix 1 for list of selected petroleum industry abbreviations used in this Record

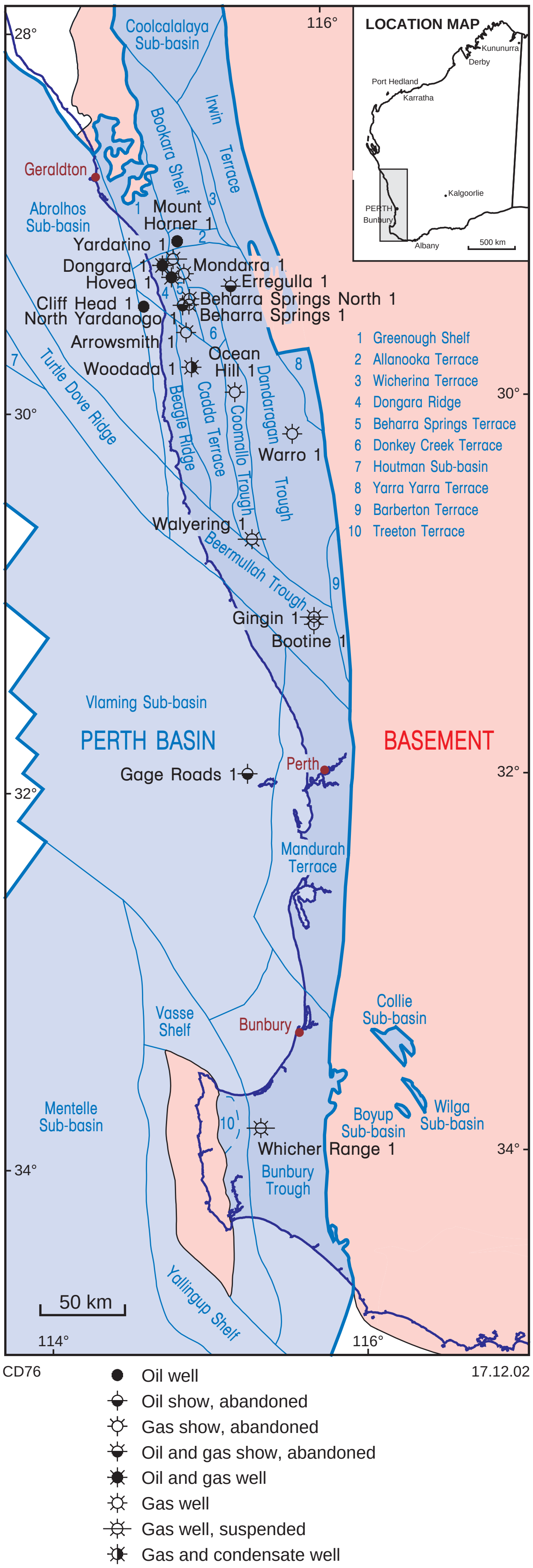


Figure 1. Location of the northern Perth Basin

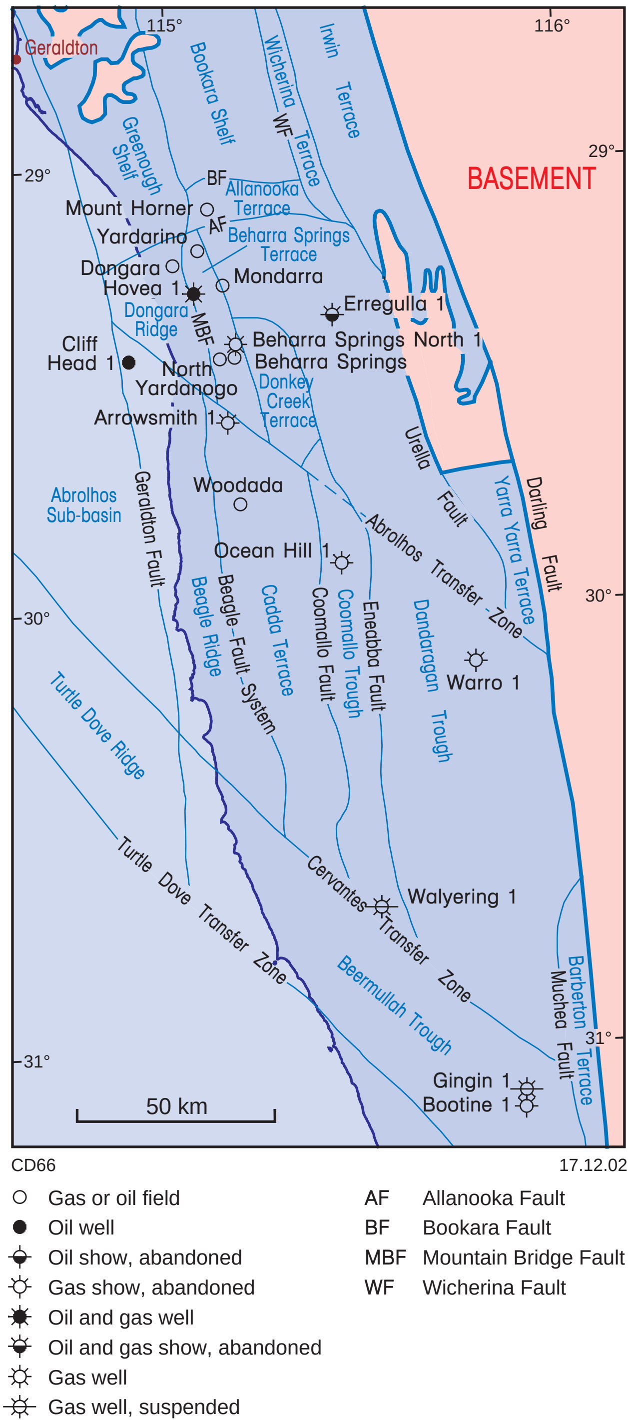


Figure 2. Northern Perth Basin tectonic units and basin framework (after Mory and Iasky, 1996; Tyler and Hocking, 2002)

Permian, and northwesterly, Early Cretaceous transtension during the breakup of Greater India from Australia. Sinistral and dextral movements respectively are inferred along the Darling Fault during these phases. The major faults within the Perth Basin were rejuvenated by breakup tectonism, which created wrench-induced anticlines as well as additional faults.

The search for hydrocarbons in the northern Perth Basin has yielded six commercial onshore oil- and gasfields: the Beharra Springs gasfield, Dongara oil- and gasfield, Mondarra gasfield, Mount Horner oilfield, Woodada gasfield, and the Yardarino oil- and gasfield (Fig. 2). Minor production was also recorded at Gingin, North Yardanogo, and Walyering. Recent discoveries such as Hovea, Beharra Springs North, and Cliff Head await further appraisal. Whereas much of the area is covered by exploration and production permits, there is scope for further exploration and an innovative approach to production from tight gas accumulations. A discussion of the hydrocarbon potential of the northern Perth Basin is given by Crostella (1995).

This Record presents the geology and hydrocarbon potential of leads and prospects within the northern Perth Basin. Prospects and leads have been assessed according to play elements of trap, source, migration and timing, and reservoir. Although the respective operating companies have reviewed the manuscript, the estimated probability of recovering hydrocarbons has been determined entirely by the Geological Survey of Western Australia (GSWA). No attempt has been made to assign an economic value to any of the leads and prospects. Information contained herein is believed to be reliable, but the accuracy cannot be guaranteed. The Department of Mineral and Petroleum Resources (MPR) expressly disclaim any and all responsibility for errors and omissions, and any person or company acting on the information contained in this publication assumes all risks.

Commercial considerations

The northern Perth Basin is a commercially attractive exploration area with straightforward logistics for untested hydrocarbon prospects. In addition, joint venture partners in the area actively farm-out exploration opportunities, and generally welcome genuine farm-in proposals (Appendix 2).

Production facilities and gas-pipeline capacity are currently and underutilized and thus, new discoveries can be easily developed. In addition, the deregulation of the Western Australian gas market in 1998 has provided a growing and dynamic local market. Significantly, the Perth Metropolitan Area and associated oil and gas markets, including the southwest of the State, are close to the northern Perth Basin. Lower pipeline tariffs to these markets give northern Perth Basin gas an approximate $1.00/GJ price advantage over gas from the North West Shelf. Another commercially attractive factor is the proximity of petroleum industry facilities, including trucking facilities to the Kwinana oil refinery 30 km south of Perth (Fig. 3). These factors have allowed the rapid development of small onshore fields in the northern part of the basin (Fig. 3).

Structural divisions

Western Australian basins have been subdivided based primarily on present structural configurations rather than focusing on depocentres (Hocking et al., 1994; Tyler and Hocking, 2002). Although the Perth Basin has a complex history throughout the Permian – Early Cretaceous with some structural inversion, the sub-basins identified as ridges, fault terraces, and shelves were structurally elevated regions in which relatively thin sections accumulated compared to the troughs, which were depocentres. For simplicity, and to aid the discussion of the prospectivity, the common small sub-basins differentiated by Crostella (1995) and Mory and Iasky (1996) are considered here as five larger sets: Beagle–Dongara Ridge, Beermullah Trough, Dandaragan and Coomallo Troughs, the fault terraces, and Greenough and Bookara Shelves (Fig. 4)

Beagle–Dongara Ridge

The Beagle–Dongara Ridge is a north-northwesterly trending, mid-basin ridge along the coast between the Beermullah Trough in the south and the Greenough Shelf (Fig. 2). The ridge forms a continous basement high, which was active at least throughout the Triassic and Jurassic with movement along the Beagle Fault system. The northernmost of those faults displays a prominent kink where the Abrolhos Transfer Zone crosses it. The Permian and at least part of the Mesozoic section thins onto the ridge with basement ranging from 1800 to 3000 m depth (Mory and Iasky, 1996). The Dongara Ridge (previously the Dongara Saddle) is the northern extension of the Beagle Ridge to the Greenough Shelf, west of the Beharra Springs Terrace (Fig. 2). It gradually deepens towards the south, is characterized by several elongated faults with subordinate folds, and has proven potential for oil and gas accumulations.

Beermullah Trough

The Beermullah Trough lies south of the Dandaragan Trough between the Cervantes and Turtle Dove Transfer Zones. The trough is differentiated from the Dandaragan Trough as its axis lies further to the west and anticlines are more common because the bounding transfer zones converge to the northwest (Fig. 2; Crostella and Backhouse, 2000). The Beermullah Trough is characterized by several compressional anticlines along the eastern flank, of which only the Gingin–Bullsbrook trend has been tested. In this area the Upper Jurassic – Lower Cretaceous Yarragadee Formation and Parmelia Group thicken towards the Muchea Fault to the east, whereas the Lower Jurassic Cattamarra Coal Measures thicken towards the western flank of the Beermullah Trough.

Dandaragan and Coomallo Troughs

The Dandaragan Trough, adjacent to the Darling Fault on the eastern margin of the onshore northern Perth Basin, is the major depocentre (Fig. 2). The trough is about 500 km long and contains up to 12 km of Permian and Mesozoic sedimentary rocks. Shallowing of the trough to the north corresponds to thinning of Triassic and Jurassic units and post-Jurassic erosion (Mory and Iasky, 1996).

The Coomallo Trough lies immediately west of the Dandaragan Trough and has features intermediate between

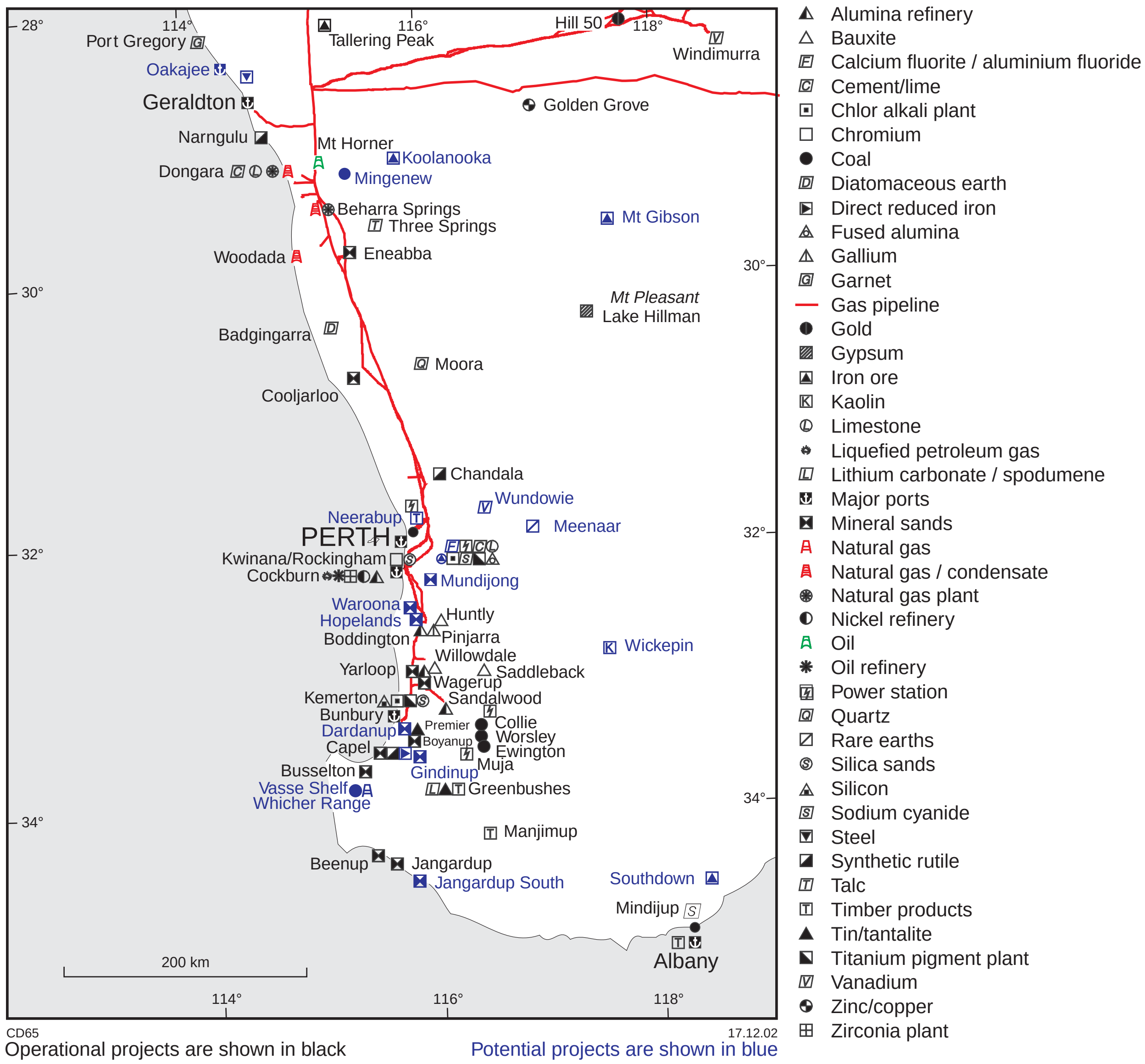


Figure 3. Fields and existing facilities and infrastructure of the southwestern part of Western Australia

a trough and a faulted terrace. For example, anticlines similar to those on the Cadda Terrace are present, but the thickness of sedimentary rocks and low geothermal gradient are similar to the Dandaragan Trough (Mory and Iasky, 1996).

Fault terraces

The fault terraces lie along all but the southern margin of the Dandaragan and Coomallo Troughs and include the Cadda, Donkey Creek, Beharra Springs, Allanooka, Wicherina, Irwin, Yarra Yarra, and Barberton Terraces (in clockwise order from the southwestern side of the troughs; Fig. 2). They all contain faults that dip down towards the Dandaragan and Coomallo Troughs. The Permian to Jurassic succession in all but the Irwin Terrace is intermediate in thickness between the troughs and the shelves/ Dongara–Beagle Ridge. The Irwin Terrace contains only pre-Mesozoic strata (probably entirely Permian in age) where the Mesozoic section, although entirely removed by erosion, did not exceed 1500 m in thickness.

Greenough and Bookara Shelves

The Greenough Shelf is an area of shallow granitic basement containing up to 1500 m of Mesozoic and Permian sedimentary rocks north of the Dongara Ridge (Fig. 2). The Bookara Shelf, to the east of the Greenough Shelf and north of the Allanooka Terrace (Fig. 2), is another area of relatively shallow basement east of the Mountain Bridge Fault, but contains up to 3600 m of Permian to Jurassic strata.

Stratigraphy

This summary of the Permian to Early Cretaceous stratigraphy of the northern Perth Basin is based on

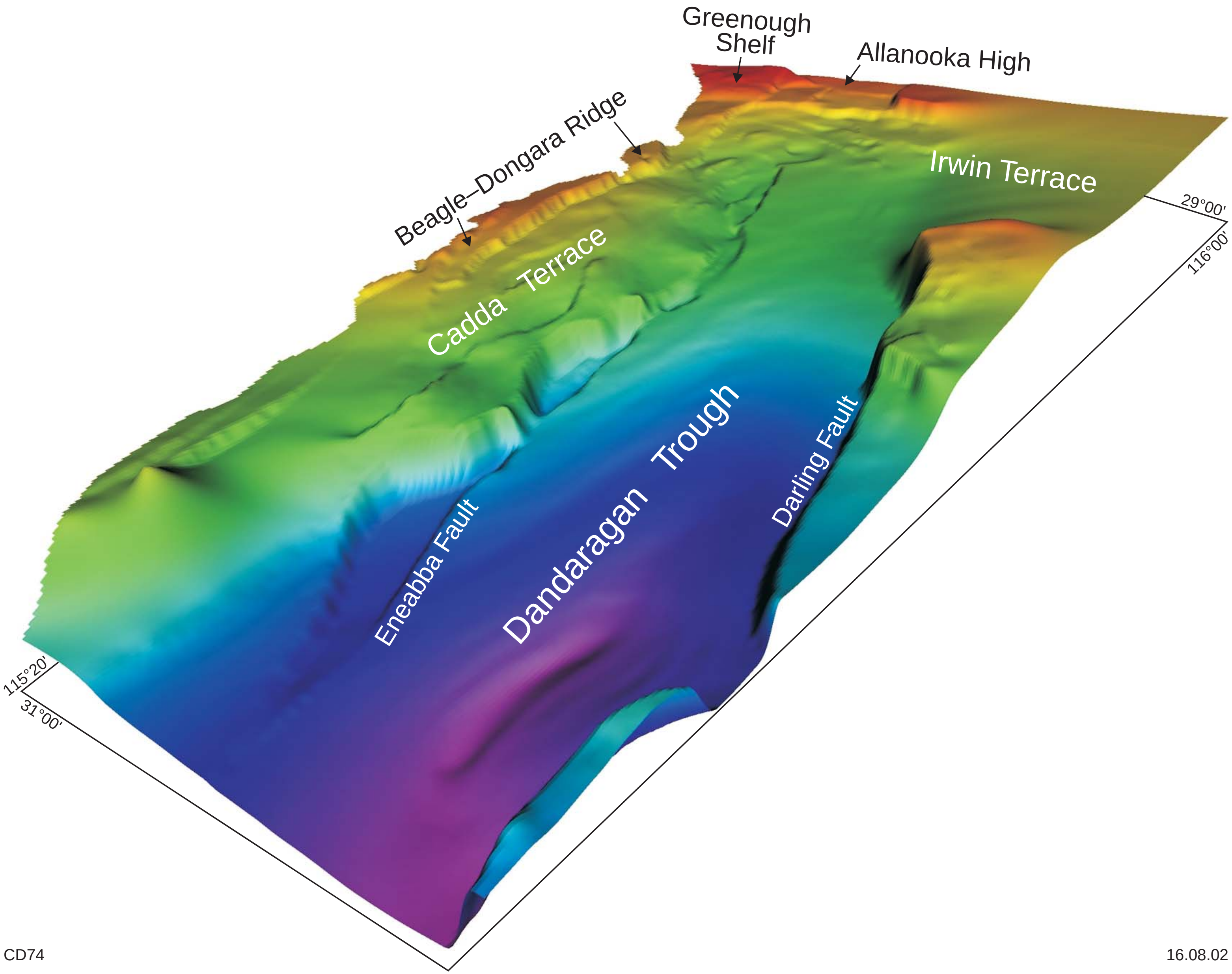


Figure 4. Perspective view of top Holmwood Shale, northern Perth Basin

seismic and well data, hydrogeological drilling, and outcrop mapping (Mory and Iasky, 1996; Crostella, 2001; Figs 5 and 6).

The economically most significant reservoir in the northern Perth Basin is the Upper Permian Dongara Sandstone sealed by the Lower Triassic Kockatea Shale. Other productive reservoirs are the Lower Permian Carynginia Formation and the Irwin River Coal Measures. Hydrocarbon accumulations also have been recorded from sandstone in the Arranoo Member of the Lower Triassic Kockatea Shale, the Lower Jurassic Cattamarra Coal Measures, and the Upper Jurassic Yarragadee Formation below sealing facies of the Otorowiri Formation (Fig. 5). The pre-Cainozoic distribution of stratigraphic units is shown in Figure 7.

Lower Permian

The oldest units within the prospective part of the basin are Lower Permian, continental and marine sedimentary rocks of the Nangetty Formation, Holmwood Shale, High Cliff Sandstone, Irwin River Coal Measures, and Carynginia Formation (in ascending order). This succession unconformably overlies a variety of Precambrian crystalline rocks, and, further north, Ordovician sandstone.

The Nangetty Formation is a siltstone and sandstone unit with minor dropstones and conglomerate intervals. Along with the overlying Holmwood Shale, it represents a glacial to proglacial transition on a marine shelf. Both units have low organic content and thin dramatically to the west from 1000 and 600 m respectively, near the Urella Fault, pinching out near the coast on the Beagle–Dongara Ridge (Mory and Iasky, 1996). Nevertheless, the basal sandstone in the Nangetty Formation has some reservoir potential. The High Cliff Sandstone represents a shallow marine to deltaic transition below the Irwin River Coal Measures, which contain alternating sandstone, siltstone, shale, and coal beds, deposited as a series of coarse-grained deltas at high latitudes (Le Blanc Smith and Mory, 1995). The thickest part of the Irwin River Coal Measures is near Arrowsmith 1 (between the Beharra Springs and Woodada gasfields) in which the unit reaches 307 m. This unit is gas bearing in the Dongara gasfield, but its contribution to production is modest due to low permeability. It is also the reservoir in the recent Cliff Head discovery. Coal beds in the unit are a likely source for gas in the basin (Crostella, 1995; Boreham et al., 2001a).

The Carynginia Formation is a marine unit of Early Permian age that conformably overlies the Irwin River Coal Measures and is unconformably overlain, locally with a distinct angular discordance, by the Upper Permian Wagina Sandstone, Dongara Sandstone, or Beekeeper Formation. In the southern half of the Dongara gasfield, gas has been produced from sandstone beds with fair porosity and permeability (5–9%, 1 mD) in the Carynginia Formation. In this part of the gasfield the total gas column is about 50 m thick and spans the Carynginia Formation and Dongara Sandstone. The Carynginia Formation probably contains about 5% of the field's gas reserves.

Upper Permian

The Wagina Sandstone, Dongara Sandstone, and Beekeeper Formation are approximately coeval, interfingering Upper Permian units restricted to the northern part of the basin (Fig. 8). They are interpreted as fluvial facies (Wagina Sandstone) along the eastern part of the Irwin Terrace and northern part of the Allanooka Terrace, shallow-marine sandstone facies (Dongara Sandstone) to the west and north, and shallow-marine carbonate facies to the southwest (Beekeeper Formation; Mory and Iasky, 1996). Coeval marine shale facies in Leander Reef 1 have been referred to as equivalent to the Beekeeper Formation (Crostella, 2001). Company nomenclature varies from the facies approach applied by previous GSWA studies in that all of the Upper Permian is commonly referred to as the Wagina Formation, with the carbonate facies and uppermost sandstone intervals assigned as members ('Beekeeper and Dongara Members' respectively).

The Dongara Sandstone increases in thickness to the east, reaching a known maximum of 336 m in Depot Hill 1 compared to 5 m in Dongara 2, and 57 m in Dongara 19. The unit is absent in Dongara 26 and interfingers with the Beekeeper Formation to the south in the Beharra Springs gasfield. At Dongara, the unit is an excellent gas reservoir, with porosity of 23% and permeability of 200 mD being typical. The unit was deposited in a lower shore-face environment that concentrated heavy minerals. Much of the heavy mineral component of the unit is radioactive and is in sufficient quantities to complicate interpretation of the wireline logs. Present data suggest that the Dongara Sandstone does not extend west of the Dongara Ridge as it is absent in all offshore wells, the Greenough Shelf, and Dongara 26. Therefore, the possibility of an equivalent offshore reservoir immediately west of the Dongara–Beagle Ridge is low. South of the Dongara gasfield, the major risk to reservoir quality in the Dongara Sandstone is the rapid decline in porosity with depth, a risk for which a conclusive predictive model has yet to be determined.

To the south, the Beekeeper Formation (a carbonate–shale unit approximately coeval to the Dongara Sandstone) is the reservoir in the Beharra Springs and Woodada gasfields (Mory and Iasky, 1996). In the Beharra Springs gasfield, the main production is from thick sandstone beds within the Beekeeper Formation. In the Woodada gasfield, the main reservoir is either fractured limestone or thin sandstone interbeds, with an average porosity of 7.5% and permeability of 5 mD.

Triassic

The Lower Triassic Kockatea Shale probably disconformably overlies Upper Permian units or, where those units are absent, Lower Permian or basement rocks commonly with an angular relationship. The Kockatea Shale provides the major oil source-rock and seal in the northern Perth Basin (Thomas, 1979; Boreham et al., 2001a), and small gas shows are typically encountered in this unit during drilling. It was deposited under shallow marine conditions and contains some sandstone facies

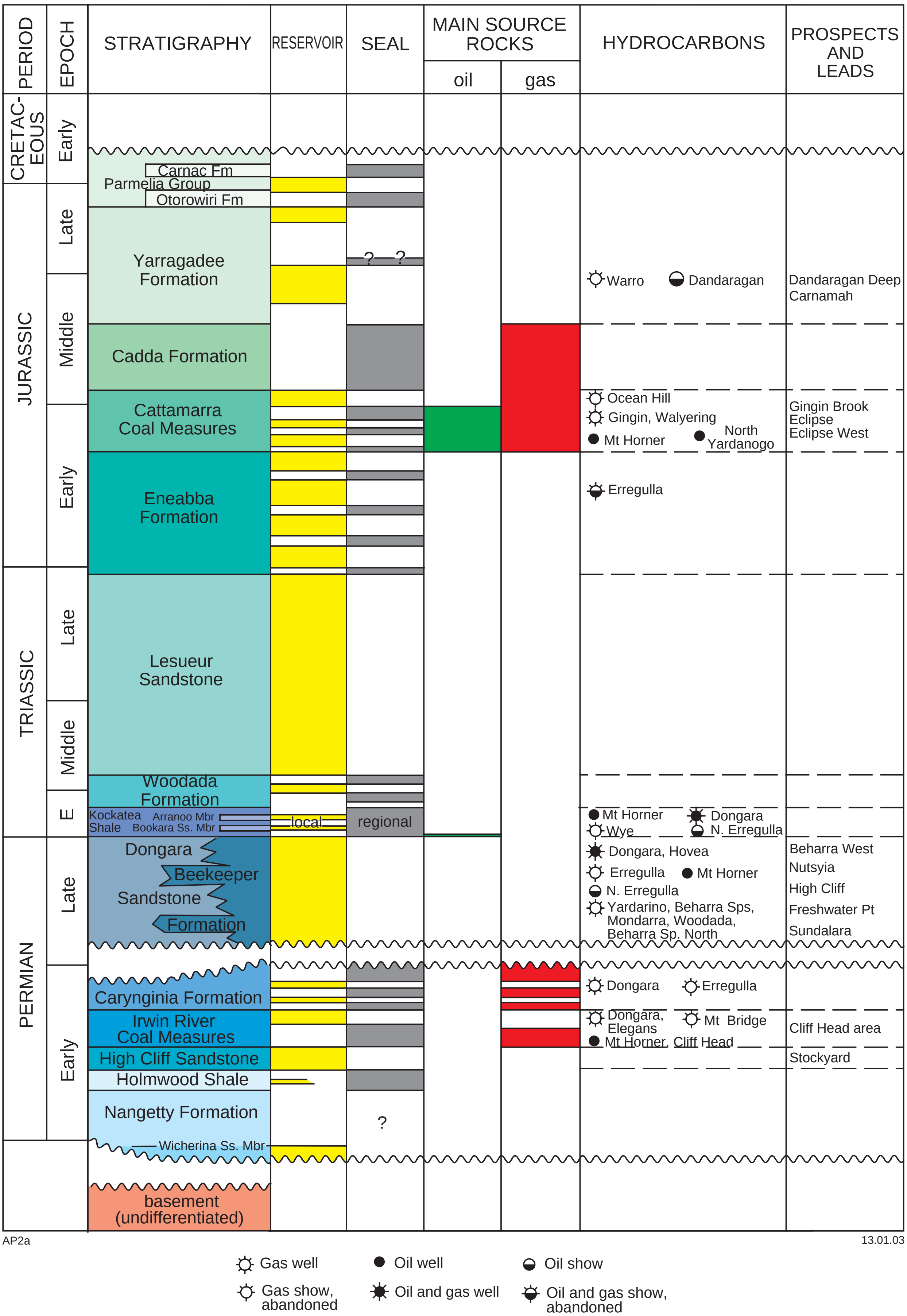


Figure 5. Stratigraphy and petroleum elements of the northern Perth Basin

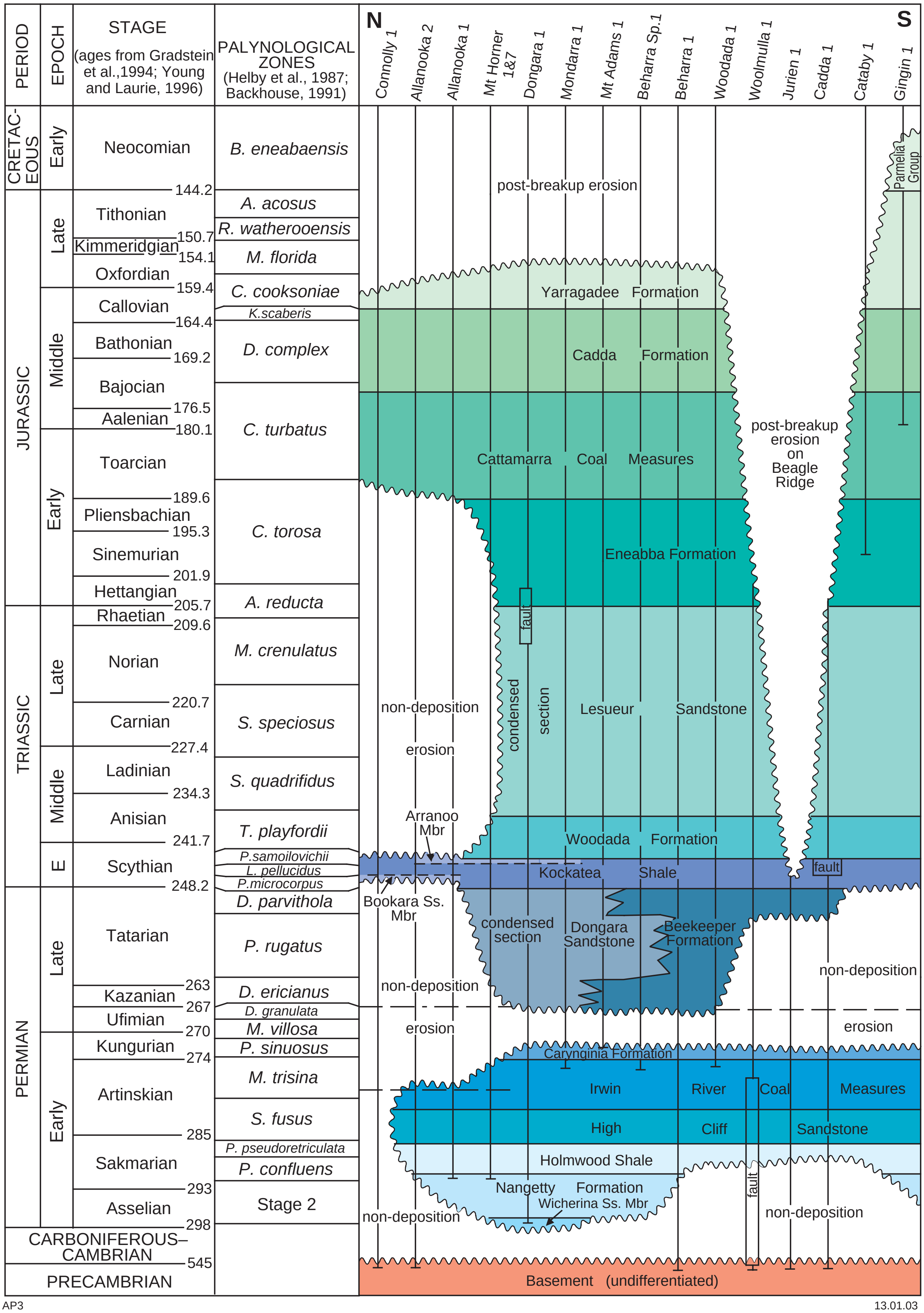


Figure 6. Stratigraphic summary using selected wells across the northern Perth Basin

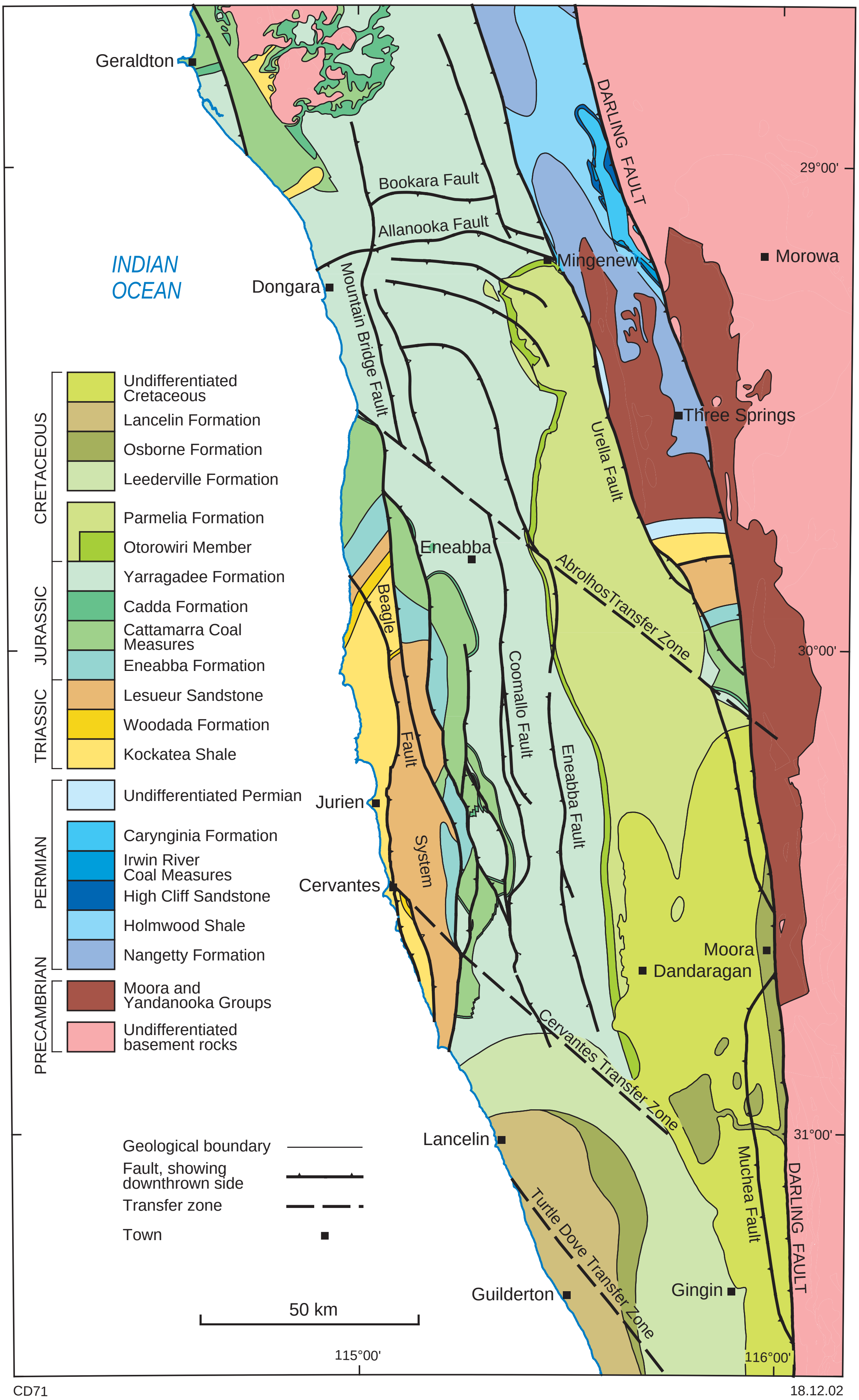


Figure 7. Pre-Cainozoic geology, onshore northern Perth Basin (after Mory and Iasky, 1996)

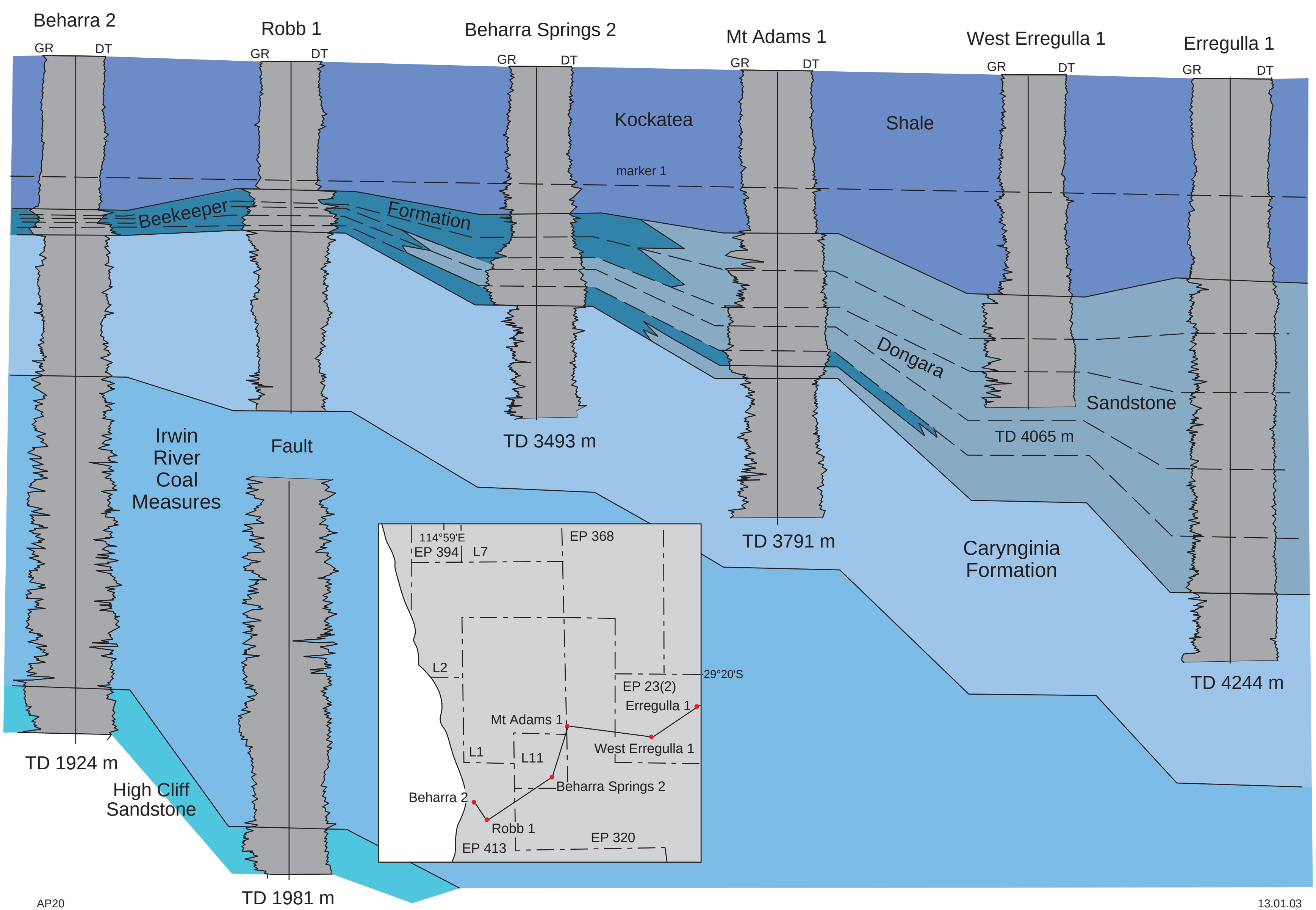


Figure 8. Geological cross section showing interfingering of the Beekeeper Formation and Dongara Sandstone

deposited as strandlines or offshore bars. The thickness of the unit increases to the south, reaching 1060 m in Woolmulla 1, and represents the only regional seal across the entire northern part of the basin. The Arranoo Member forms an economic sandstone reservoir, but in the Dongara gasfield, for example, it has yielded minor oil and less than 1% of the field's gas production. This member also produced the first oil from the Mount Horner oilfield. By comparison, the basal Bookara Sandstone Member has yielded only a small flow of gas during testing of Wye 1.

Above the Kockatea Shale, the Woodada Formation consists of interbedded sandstone and carbonaceous siltstone. It thickens to the south and reaches 230 m in the Woodada gasfield. Offshore in the Abrolhos Sub-basin, the finer grained parts of the unit have fair to very good petroleum generating potential (Crostella, 2001). The conformably overlying Lesueur Sandstone is Middle to Late Triassic in age and thickens to the southeast, where it reaches over 3000 m next to the Darling Fault in Barberton 1. This unit contains little shale.

Jurassic–Cretaceous

The Eneabba Formation is a lowermost Jurassic terrigenous red bed unit. The unit contains both sealing and reservoir quality intervals and thickens to the south and east, where it reaches 854 m in Donkey Creek 1 (Mory and Iasky, 1996).

The Lower Jurassic Cattamarra Coal Measures are a deltaic unit consisting of fine- to coarse-grained sandstone interbedded with carbonaceous siltstone, claystone, and coal. The Cattamarra Coal Measures thicken to the south and east, from about 200 m in the Mount Horner area to 1500 m in Cataby 1. Porosity varies from 29% in Mount Horner to 8% in Gingin 1. In the Gingin area, porosity degradation with depth is the major reservoir risk. However, porosity preservation due to the presence of hydrocarbons has been reported in the Gingin area (Owad-Jones and Ellis, 2000). The unit has reasonable hydrocarbon generating potential in the deeper parts of the basin.

The Cadda Formation is composed of clastic rocks and fossiliferous limestone, such as the Newmarracarra Limestone in the north of the area. The unit has potential as a seal and possibly also a source rock in the central part of the northern Perth Basin where it forms a depocentre.

The Middle to Upper Jurassic Yarragadee Formation thickens dramatically to the east and south, reaching a maximum known thickness of almost 3000 m in the Gingin wells. The formation contains predominantly fine- to coarse-grained feldspathic sandstone interbedded with siltstone, claystone, minor conglomerate, and coal. The beds are discontinuous and correlations are difficult, but local reservoir–seal pairs are present.

In the northern Perth Basin, the latest Jurassic to earliest Cretaceous Parmelia Group consists of feldspathic sandstone with minor siltstone and claystone, and is lithologically similar to the underlying Yarragadee Formation (Mory and Iasky, 1996). The Otorowiri Formation of the Parmelia Group forms a regional seal for the Yarragadee Formation, but is restricted to the eastern margin of the basin (Fig. 7). The base of the Otorowiri Formation contains sandstone that forms part of the reservoir in Dandaragan 1.

Exploration history

Petroleum exploration commenced in the Perth Basin in the 1950s, when the Bureau of Mineral Resources (BMR; now Geoscience Australia) conducted the first gravity surveys in the northern onshore area in 1951. West Australian Petroleum Pty Ltd (WAPET) was the first company to explore the acreage with various geophysical surveys and drilling. A significant amount of exploration was carried out in the northern part of the basin in the 1960s and 1980s.

BMR and WAPET drilled the first stratigraphic wells in the onshore northern part of the Perth Basin in the late 1950s, leading WAPET to drill the first wildcat hole, Eneabba 1, in 1961. Drilling activity has concentrated on the onshore part of the basin with over 200 wells drilled to date, compared with 24 wells offshore. Three-quarters of these wells, and the majority of the known hydrocarbon accumulations, are in the northern part of the basin.

Regional seismic surveys have not been conducted across the entire northern Perth Basin. To date, surveys have been conducted only over small exploration permits, making it difficult to evaluate the regional petroleum potential of the area. Figure 9 shows the acquisition of seismic data by decade and highlights the area of recent activity around Dongara.

Exploration of the Perth Basin has led to the discovery of six commercial hydrocarbon fields and numerous additional accumulations. WAPET was responsible for the discovery of the majority of the fields (Dongara, Gingin, Mondarra, Mount Horner, Walyering, and Yardarino). Other notable discoveries are the Woodada gasfield, a new pool discovery at Mount Horner (oil), Beharra Springs, Hovea, Cliff Head, and Beharra Springs North. The last three of these have not been fully evaluated.

Fields producing in 2002 were Dongara, Woodada, Mount Horner, Beharra Springs, and Hoevea (Table 1). Cliff Head and Beharra Springs North have yet to come into production. The remaining fields are either sub-economic or depleted. The gas in the north of the basin is mainly dry with minimal condensate production, and the oil is a highly paraffinic crude, commonly solid at the surface.

More detailed accounts on the history of petroleum exploration on the Perth Basin are given by Hall (1989), Hall and Kneale (1992), Mory and Iasky (1996), and Crostella and Backhouse (2000). Appendices 3 and 4 provide information on the seismic surveys carried out and the wells drilled in the northern Perth Basin.

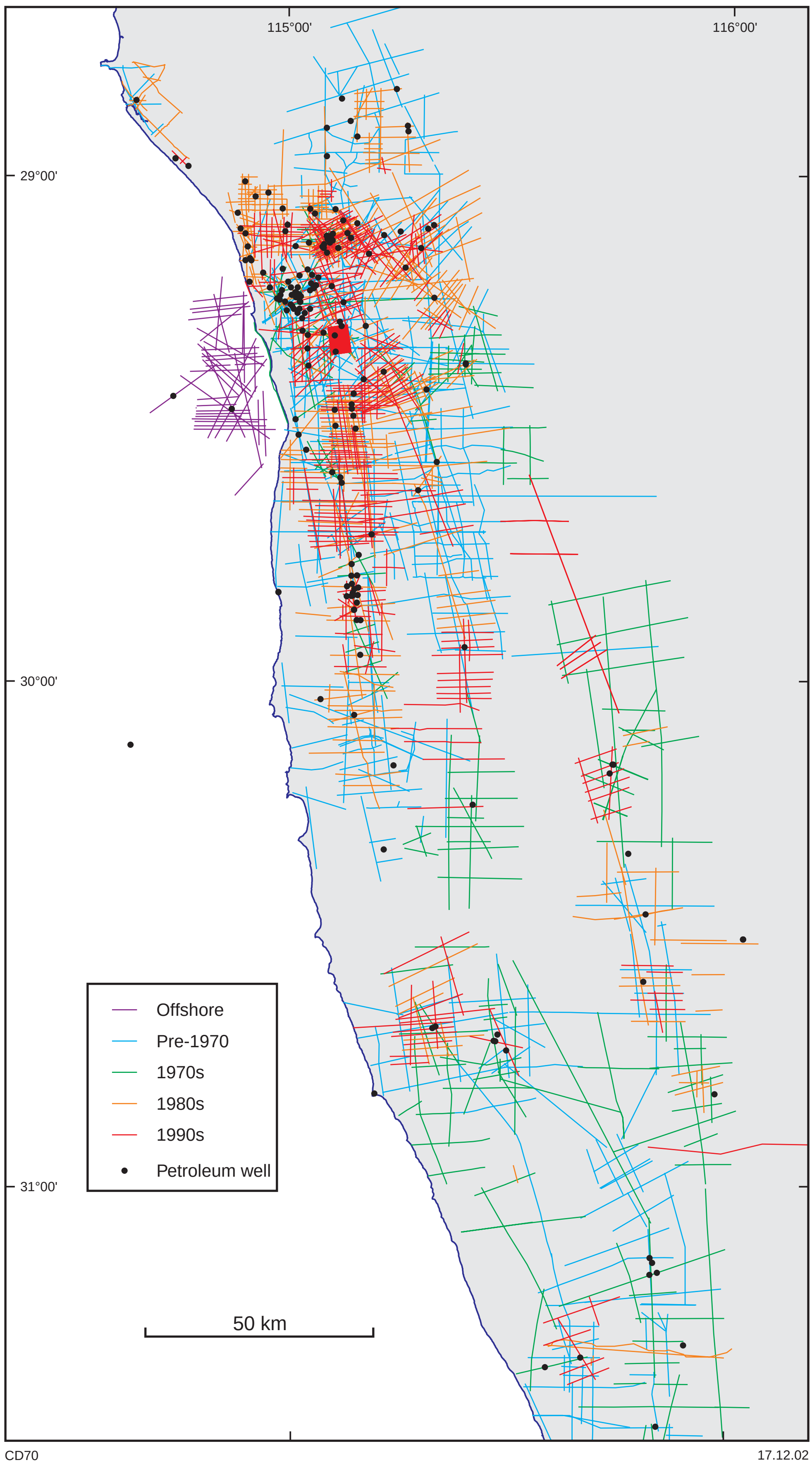


Figure 9. Seismic coverage of the northern Perth Basin

Table 1. Northern Perth Basin fields and significant shows

Field/well	*Year*	*Reservoir*	*Depth (-mSS)*	*Average porosity (%)*	*Maximum permeability (mD)*	*Seal*	*Trap*	*Hydrocarbon type*	*API gravity (°API)*	*Cumulative production*	*Remaining reserves (P_{50})*	*Filled to spill point?*
Field/accumulation												
Beharra Springs	1990	Beekeeper/Dongara	3200–3390	13	696	Kockatea	Tilted fault block	Gas	0.63	1.90 Gm^3	0.31 Gm^3	?
								Condensate	49	0.02 GL	0.003 GL	
Beharra Springs North	2001	Dongara	3310–3335	–	–	Kockatea	Faulted anticline	Gas	–	–	0.3 – 0.7 Gm^3	?
Cliff Head	2002	IRCM	–	18–23	–	Kockatea	Faulted anticline	Oil	31.6	–	–	?
Dongara	1966	Arranoo	1439–1504	11	94	Kockatea	Structural/stratigraphic	Gas	0.77	12.40 Gm^3	0.36 Gm^3	yes
		Carynginia	1567–1653	15	5	Kockatea	Structural/stratigraphic	Oil and condensate	35 (oil)	0.23 GL	0.19 GL	
		Dongara	1621–1654	21	230	Kockatea	Faulted anticline					
		IRCM	1641–1645	20	44.5	Kockatea	Faulted anticline					
Elegans	1999	Carynginia	–	–	–	Carynginia	Structural/stratigraphic	Gas	–	–	–	?
(Yardarino ext.)		IRCM	–	–	–	IRCM	Structural/stratigraphic					
Gingin	1965	Cattamarra	3661–4449	8	70	Cattamarra	Faulted anticline	Gas	0.61	0.05 Gm^3	nd	?
								Condensate	46	3169 kL	nd	
Hovea	2001	Dongara	1927–1946	–	–	Kockatea	Tilted fault block	Oil	41.6	–	–	?
								Gas	–	–	~0.6 Gm^3	
Mondarra	1968	Dongara	2602–2617	15	127	Kockatea	Tilted fault block	Gas	0.63	0.67 Gm^3	No. 1 pool: depleted	no
								Condensate	–	9184 kL	No. 2 pool: nd	
								Oil show	36			
Mount Horner	1965	Cattamarra 'B'	943–947	25	–	Cattamarra	Structural/stratigraphic	Oil	35.5 – 37.4	0.27 GL	0.007 GL	yes
		Cattamarra 'F'	1004–1024	26	380	Cattamarra	Anticline					
		Arranoo	1273–1282	15	10	Kockatea	Tilted fault block					
North Yardanogo	1990	Cattamarra	1597–1598	22.5	518	Cattamarra	Anticline	Oil	34	295 kL	prob. depleted	?
Walyering	1971	Cattamarra	3190–3291	10	–	Cattamarra	Faulted anticline	Gas	0.611	0.007 Gm^3	nd	?
								Condensate	44.9	237 kL	nd	
Woodada	1980	Beekeeper	2240	7.5	5	Kockatea	Structural/stratigraphic	Gas	0.64	1.28 Gm^3	2.09 Gm^3	yes
								Condensate	53.6	0.009 GL	0.01 GL	
Yardarino	1964	Dongara	2237–2260	13	200	Kockatea	Faulted anticline	Gas	–	0.16 Gm^3	0.005 Gm^3	?
								Oil and condensate	36 – 36.5 (oil)	0.14 GL	0.005 GL	
Significant shows												
Arranoo 1	1994	Dongara	1390–1393	20	–	Kockatea	Anticline	Oil show	–			
		Carynginia	1458–1462	14	–	Carynginia	Anticline					
Arrowsmith 1	1965	Carynginia	2761	24	–	Kockatea	Fault trap	Gas show	–			
Beharra Springs South 1	2001	Kockatea	3249–3302	–	–	Kockatea	Fault anticline	Oil show	25.5, 53.5			

Table 1. (continued)

Field/well	*Year*	*Reservoir*	*Depth (-mSS)*	*Average porosity (%)*	*Maximum perm. (mD)*	*Seal*	*Trap*	*Hydrocarbon type*	*API gravity (°API)*	*Cumulative production*	*Remaining reserves (P_{50})*	*Filled to spill point?*
Cataby 1	1994	Cattamarra	1625–1628	15	–	Cattamarra	Faulted anticline	Oil show	38			
Dandaragan 1	1995	Yarragadee	828–832	22	500	Otorowiri	Anticline	Oil show	10.3, 100			
Erregulla 1	1966	Eneabba	2937–2944	8–34	109	Eneabba	Tilted fault block	Oil show	47			
								Gas show	–			
Mountain Bridge 1	1993	High Cliff	3139–3189	1–8	0.01	IRCM	Fault block	Gas show	–			
North Erregulla 1	1967	Dongara	3044–3068	–	–	Kockatea	Tilted fault block	Oil show	38			
		Kockatea	2751–2763	–	–	Kockatea	Tilted fault block					
Ocean Hill 1	1991	Cadda/Cattamarra	2850–2910	10–15	0.18	Cadda	Faulted anticline	Gas show	–			
Warro	1977	Yarragadee	3451–4086	9	3	Yarragadee	Anticline	Gas show	–		?160 Gm^3	
West Erregulla 1	1990	Dongara	3588–3793	5	–	Kockatea	Anticline	Gas show	–			
Wye 1	1996	Arranoo	573–595	13–18	–	Kockatea	Anticline	Gas show	–		0.0078 Gm^3	
		Bookara	615–618	13–18	–	Kockatea	Anticline	Oil show	–		1.43 GL	
		Cattamarra	306–315	11–15	–	Cattamarra	Anticline					

NOTES:
G: 10^9
IRCM: Irwin River Coal Measures
nd: not determined
-mSS: metres below sub sea-level datum
mD: millidarcies
° API: standard method of measuring density of liquid hydrocarbons by the American Petroleum Institute
P_{50}: median probability reserves

Production and reserves at 30 June 2001

Summary of existing fields and accumulations

The following summaries of existing fields and accumulations are based largely on Cadman et al. (1994), Crostella (1995), West Australian Petroleum Pty Ltd (1996), and Owad-Jones and Ellis (2000). Subcommercial, small, or undeveloped hydrocarbon pools are here referred to as accumulations. Oil and gas production from these fields are shown in Figure 10 and Table 1.

Beharra Springs gasfield

Operator	Origin Energy Developments Pty Ltd
Trap type	Fault trap
Reservoir	Beekeeper Formation/Dongara Sandstone
Source	Irwin River Coal Measures, Carynginia Formation, ?Kockatea Shale
Seal	Kockatea Shale (lateral), intraformational (vertical)
Production	1.62 Gm^3 (57.1 Bcf) gas, 0.02 GL (122.7 Mbbl) condensate
Original in place	2.41 Gm^3 (85 Bcf) gas
Hydrocarbon type	0.63 gravity gas (>91% CH_4, 5.3 – 5.4% CO_2), 49° API condensate
Average porosity	Main reservoir sandstone: 13% (range = 10.4 – 15.2%, log); 11% (core) Tight sandstone: 4.6% (range = 3.4 – 5.9%)
Average permeability	Main reservoir sandstone: range = 514–696 mD

The Beharra Springs gasfield lies about 30 km southeast of Dongara within production licence L11 (Fig. 11). The discovery well, Beharra Springs 1, was drilled in 1990 and intersected a 20 m gross hydrocarbon column with 12.5 m of net gas pay in a section in which the Dongara Sandstone and Beekeeper Formation facies interfinger. A drillstem test (DST) between 3298 and 3303 m* yielded 241 km^3/day (8.5 MMcf/day) through a 12.7 mm (½") choke. Two appraisal wells were subsequently drilled: Beharra Springs 2, in 1991, confirmed the southern extent of the gasfield, and Beharra Springs 3, in 1992, confirmed the northern extent of the gasfield. Production commenced in January 1991.

The Beharra Springs gasfield lies within the Beharra Springs Terrace (Fig. 2) on a northerly trending, tilted fault block bound to the east by the Beharra Springs Fault and to the west by the Mountain Bridge Fault. At the top of the Beekeeper Formation, the faulted anticline has three-way dip closure and is faulted to the east (Fig. 12).

* Unless other stated, the depths used in this Record refer to metres below Kelly bushing (KB)

Dongara oil- and gasfield

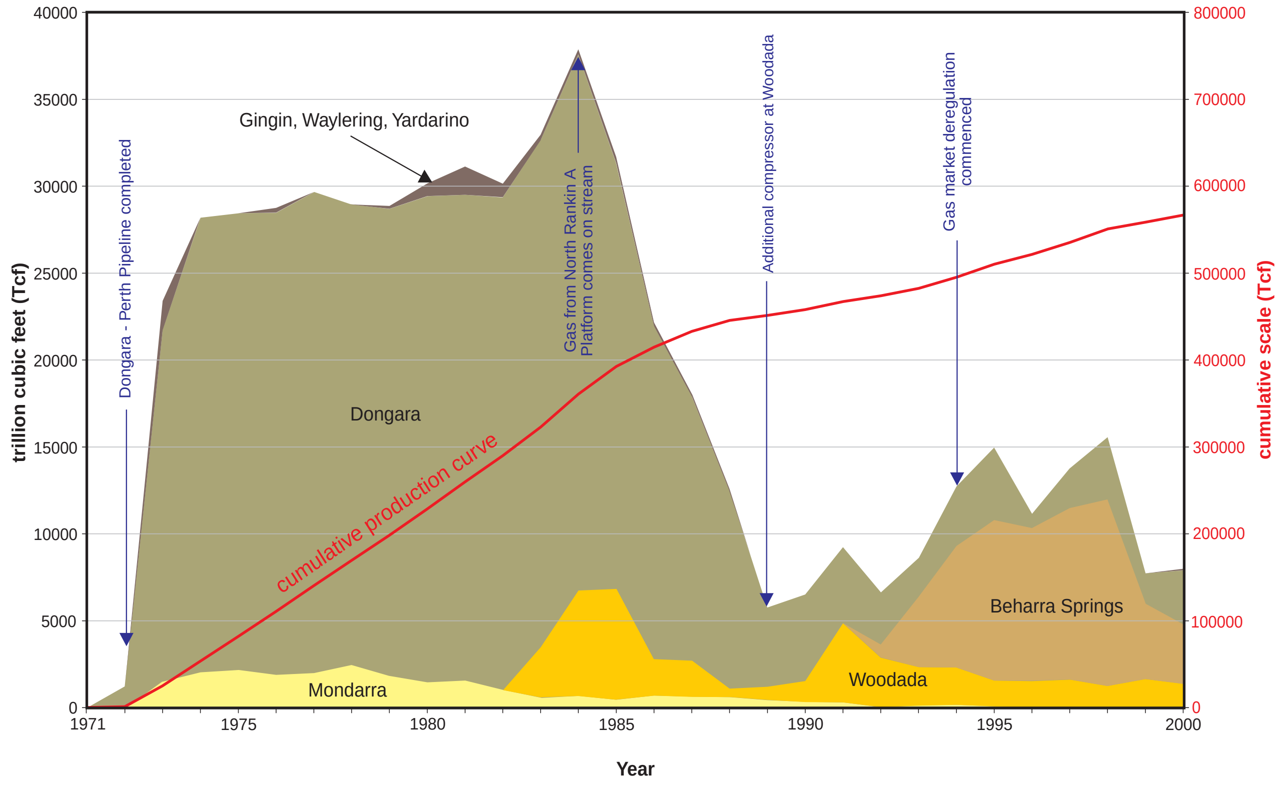
Operator	Arc Energy NL
Trap type	Faulted anticline
Reservoir	Dongara Sandstone, Carynginia Formation, Arranoo Member Irwin River Coal Measures
Source	Kockatea Shale (oil and gas), Carynginia Formation and Irwin River Coal Measures (gas)
Seal	Kockatea Shale
Production	0.229 GL (1.44 MMbbl) oil and condensate, 12.24 Gm^3 (432 Bcf) gas
Original in place	13.8 GL (86.8 MMbbl) oil, 15.19 Gm^3 (539.7 Bcf) gas
Hydrocarbon type	0.7707 gravity gas (lean gas 96% CH_4, <2% CO_2), 35° API oil
Average porosity	Dongara Sandstone: 21% Carynginia Formation: 15% Irwin River Coal Measures: 20% Arranoo Member: 11% (log), 17.7% (core)
Average permeability	Dongara Sandstone: 230 mD (range = 26–2744 mD) Irwin River Coal Measures: 8 and 44.5 mD (based on 2 samples) Arranoo Member: 13.6 mD

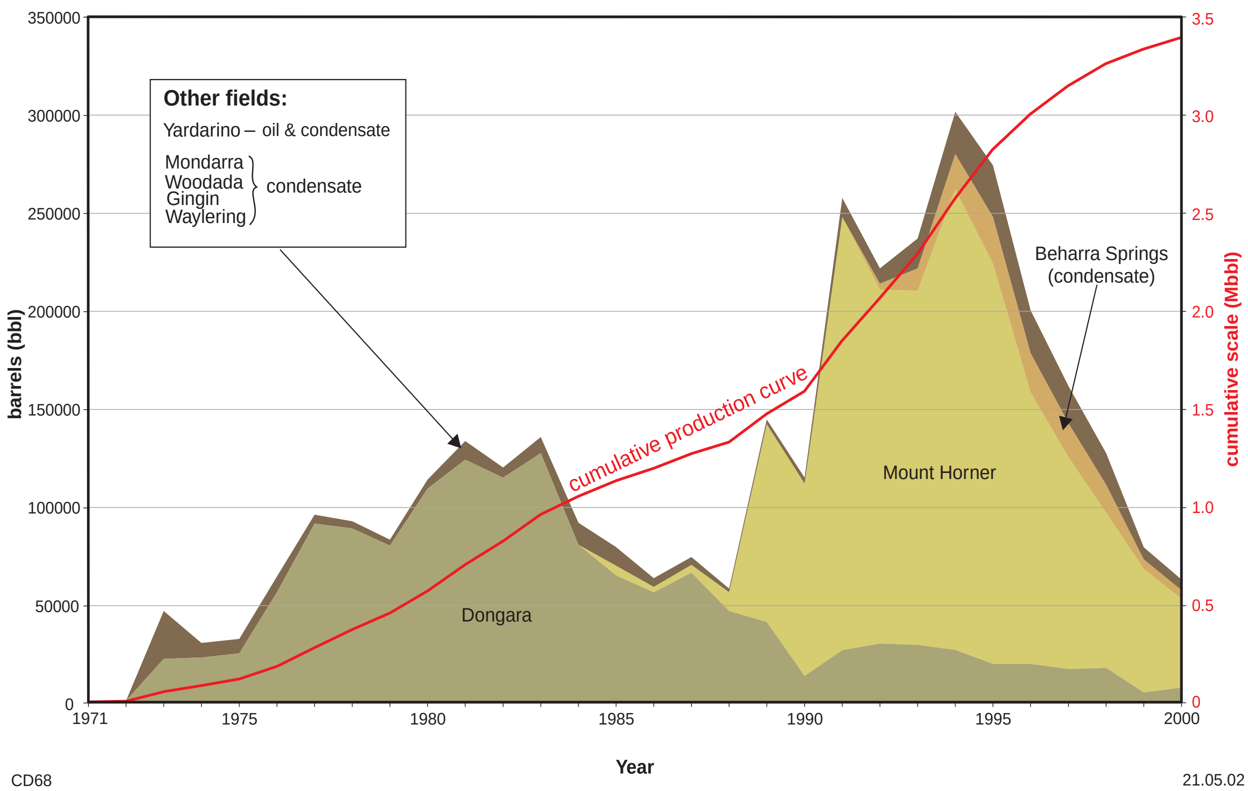
The Dongara oil- and gasfield (Ellis and Bruce, 1998) lies about 5 km east of Dongara within production licences L1 and L2 (Fig. 11). The field was discovered in 1966 when Dongara 1 intersected an 11 m gross and net gas column in the Dongara Sandstone. A DST over the interval 1670.9 – 1674.9 m yielded 290 km^3/day (10.33 MMcf/day) through a 12.7 mm (½") choke. Gas in the Irwin River Coal Measures was first found in Dongara 3 with a DST that flowed 54.8 km^3/day (1.95 MMcf/day) through a 6.4 mm (¼") choke. Dongara 8 discovered 35° API oil in the Dongara Sandstone with a DST yielding 95–127 kL/day (600–800 bbl/day) through a 12.7 mm (½") choke. The Carynginia Formation first flowed gas from Dongara 15, and oil and gas was first found in the Arranoo Member of the Kockatea Shale by Dongara 24. Gas production commenced in October 1971 and oil production in 1975. To date, 30 wells have been drilled in, or adjacent to, the Dongara oil- and gasfield.

The field lies on the Dongara Ridge (Fig. 2) within a strongly faulted, northwesterly trending anticline bounded to the east by the northerly trending Mountain Bridge Fault (Fig. 13). The oil leg is confined to the northeastern flank of the field, and gas to the southwestern flank.

Gingin accumulation

Operator	Empire Oil and Gas NL
Trap type	Faulted anticline
Reservoir	Cattamarra Coal Measures





CD68 21.05.02

Figure 10. Gas and oil production from the northern Perth Basin showing significant dates

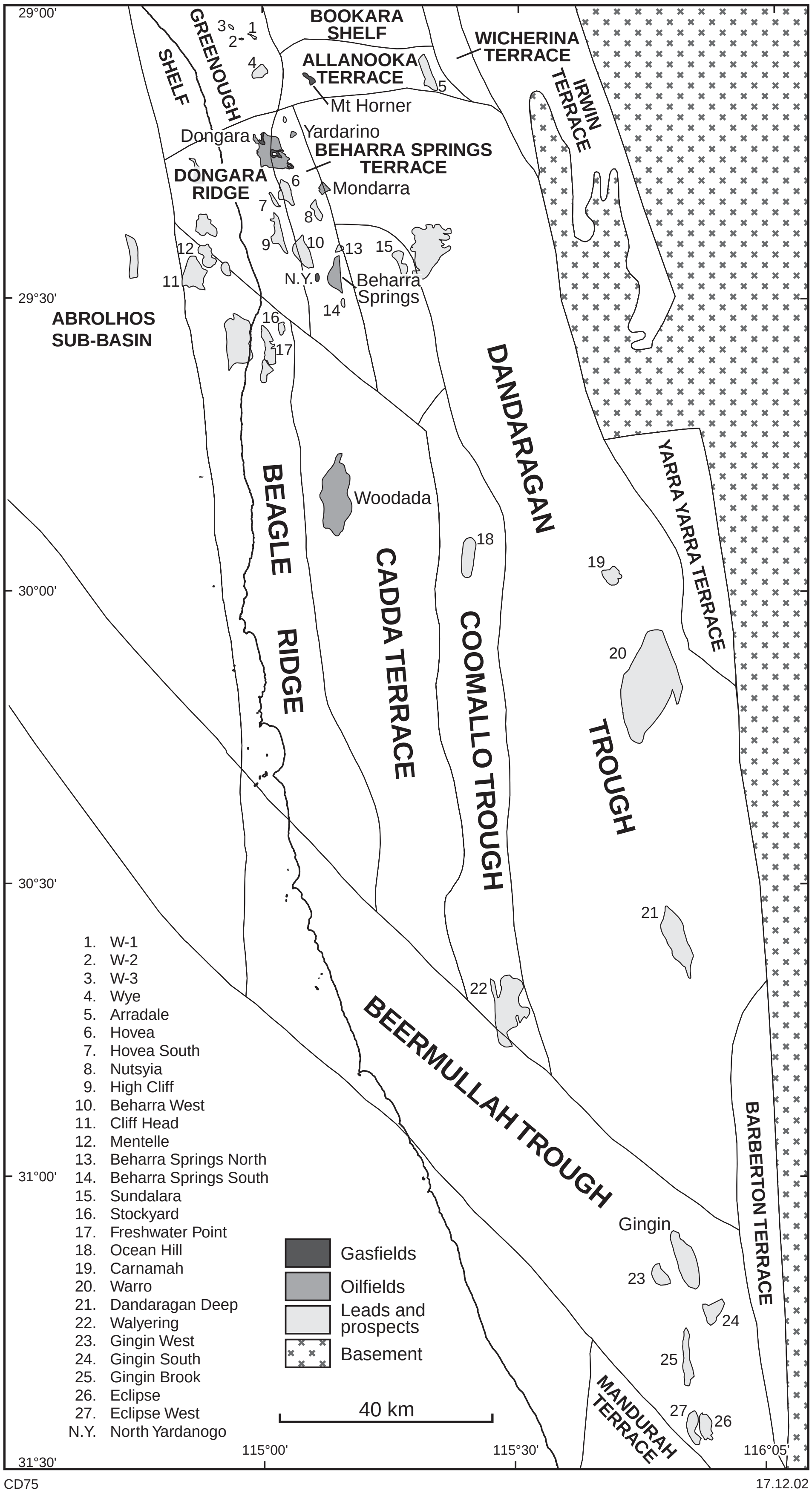


Figure 11. Prospects and leads and distribution of petroleum wells of the northern Perth Basin

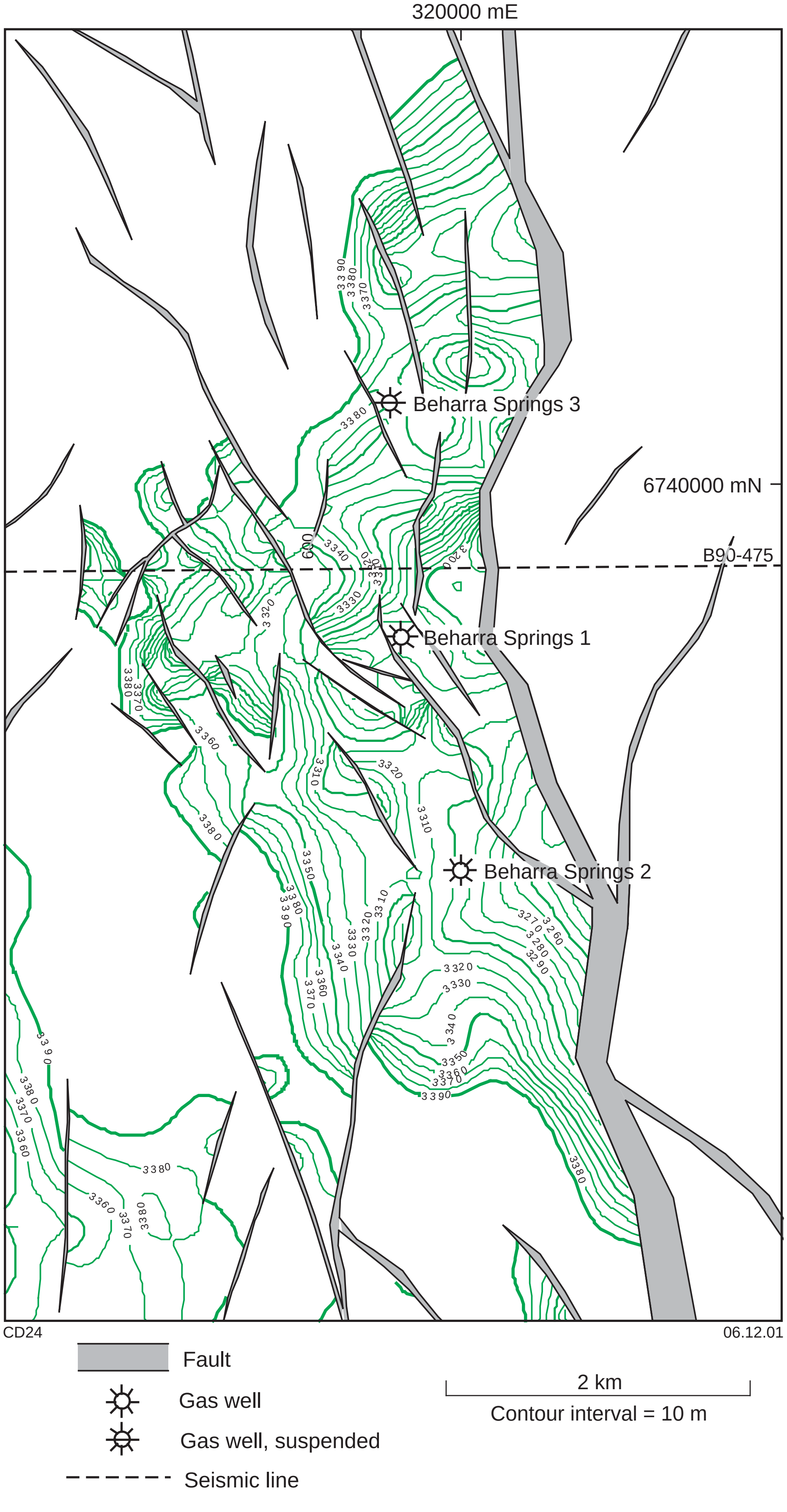


Figure 12. Depth contours to the top Beekeeper Formation, Beharra Springs gasfield (after Owad-Jones and Ellis, 2000)

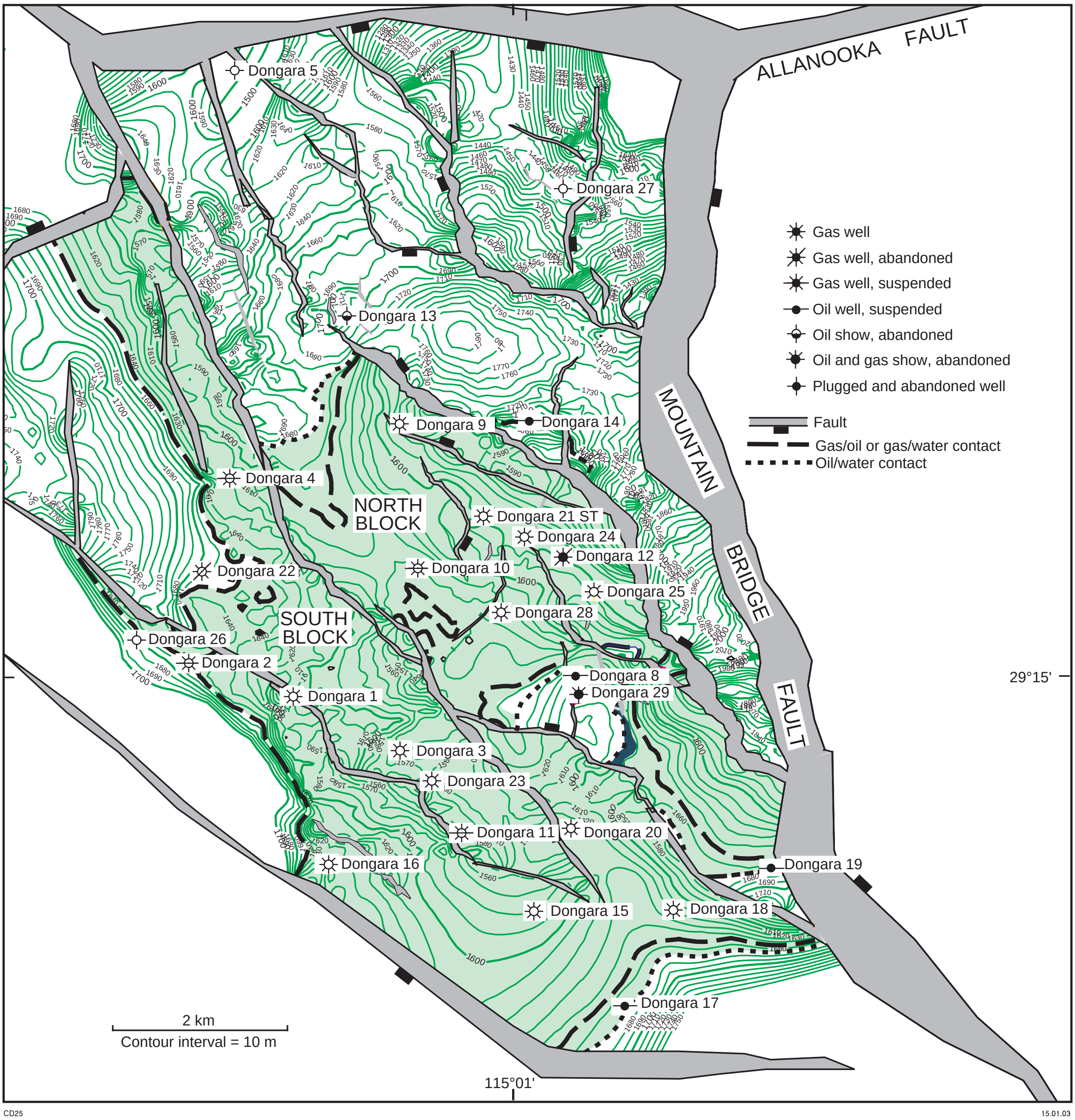


Figure 13. Depth contours to the base Kockatea Shale, Dongara oil- and gasfield (after Owad-Jones and Ellis, 2000)

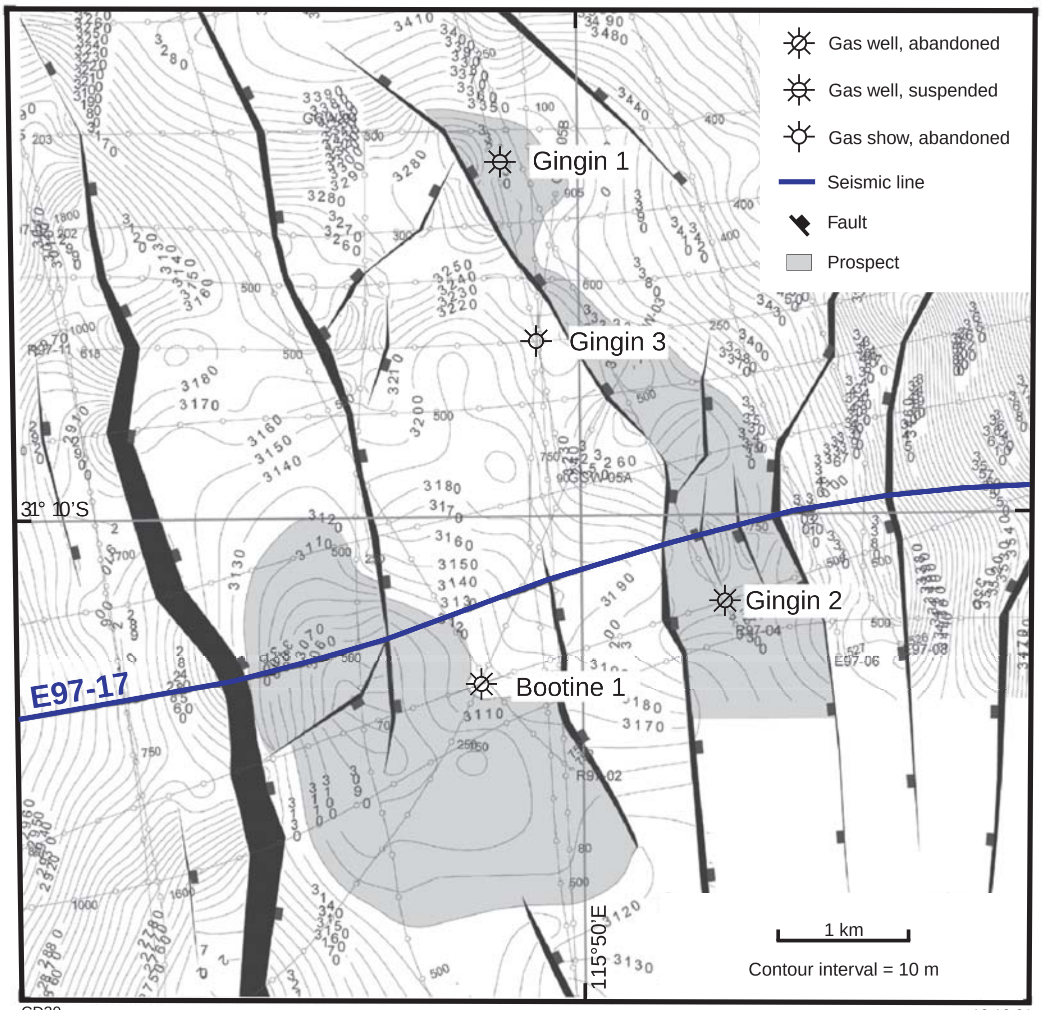
Source	Cattamarra Coal Measures
Seal	Cattamarra Coal Measures (intraformational)
Production	3169 kL (19.9 Mbbl) condensate, 0.049 Gm^3 (1.7 Bcf) gas
Original in place	13.5 Gm^3 (477 Bcf) gas
Hydrocarbon type	0.61 gravity gas (90% CH_4, 1.1% CO_2), 46° API condensate
Average porosity	8%
Average permeability	2–70 mD

The Gingin accumulation lies 105 km north of Perth in exploration permit EP 389 (Fig. 11). In 1965, Gingin 1 intersected a gross interval of about 300 m of gas-saturated sandstone in the Cattamarra Coal Measures. Six DSTs over the interval 3864.9 – 4154.5 m flowed 63–109 km^3/day (2.25 – 3.85 MMcf/day). A further three wells were drilled to test the structure: Gingin 2, in 1965, confirmed the southern extent of the structure; Bootine 1, in 1981, drilled on a separate fault block to the Gingin anticline, failed to produce stabilized gas flow rates; and Gingin 3, in 1998, yielded water with insignificant gas flows. Production commenced in March 1972 with 140 km^3/day (5 MMcf/day) into the Dampier to Bunbury natural gas pipeline (DBNGP), but was terminated in December 1972. In 1971, three producing intervals were fractured in Gingin 1 and, after clean up, the well flowed at 368 km^3/day (13 MMcf/day) on a short test (Jones, 1976). Additional gas was produced at a much reduced rate from June 1975 to January 1976, when production could not be sustained due to low permeability. Cumulative production was 48.561 Mm^3 (0.305 MMbbl) of gas, 3164 m^3 (0.02 MMbbl) of condensate, with 3498 m^3 (0.022 MMbbl) of water.

The Gingin accumulation lies within the Beermullah Trough on the northerly trending Gingin–Bullsbrook trend. At the Cattamarra Coal Measures level is a large, northerly trending anticline faulted along the crest (Fig. 14). Higher porosity and permeability in Gingin 1, compared with Gingin 2, implies that quartz overgrowth was not inhibited in the vicinity of the latter well. Porosity preservation by hydrocarbon emplacement is likely in the Gingin 1 area. Both wells are located on the downthrown side of sealing faults. Gingin 3 intersected the objective 90–130 m updip from Gingin 1, but was water wet and is interpreted to have intersected a separate, upthrown fault block isolated from the gas-bearing sandstones in Gingin 1 and 2. The most significant risk with the Gingin accumulation is the hydraulic continuity of the reservoir (Empire Oil and Gas NL, 1997). Secondary faults in the area may have caused structural offsets of sandstone or localized degradation of permeability in the vicinity of the faults, with the wells demonstrating that only small volumes of effective reservoir are present.

Mondarra gasfield

Operator	Arc Energy NL
Trap type	Faulted anticline
Reservoir	Dongara Sandstone
Source	Kockatea Shale (oil and gas), Irwin River Coal Measures and Caryngingia Formation (gas)
Seal	Kockatea Shale
Production	0.671 Gm^3 (23.9 Bcf) gas, 0.009 GL (0.058 MMbbl) condensate
Original in place	0.722 Gm^3 (25.7 Bcf) gas, 0.019 GL (0.122 MMbbl) condensate
Hydrocarbon type	0.63 gravity gas (91.4% CH_4, 4.1% CO_2), 36° API oil



CD20 10.10.01

Figure 14. Depth contours to the top Cattamarra Coal Measures, Gingin accumulation (after Owad-Jones and Ellis, 2000)

Average porosity	15% (log); 18%, decreasing to 7.4% (core)
Average permeability	127 mD, decreasing to 1.4 mD

The Mondarra gasfield lies about 10 km southeast of the Dongara oil- and gasfield within production licence L1 (Fig. 11). In 1968, Mondarra 1 intersected a 16 m gross hydrocarbon column comprising 11.1 m of net gas pay within the Dongara Sandstone. A DST flowed 283 km^3/day (10 MMcf/day) from this interval. Three appraisal wells were drilled in 1969: Mondarra 2 tested a separate structure to Mondarra 1 and flowed at 85 km^3/day (3 MMcf/day) from a 2 m-thick interval of tight Dongara Sandstone. This structure has been named the Nutsyia prospect (see **Nutsyia prospect**) by Arc Energy NL. Mondarra 3 and 4 both intersected tight Dongara Sandstone downdip from Mondarra 1, but neither well was within structural closure. Nevertheless, a small quantity of oil was recovered from the Dongara Sandstone in Mondarra 3, implying a thin oil leg. Gas and condensate were produced between April 1972 and July 1994 from Mondarra 1 and 2. CMS Gas Transmission of Australia is now using the field for gas storage.

The Mondarra 1 structure is a northerly trending fault block at top Dongara Sandstone level within the Beharra Springs Terrace (Fig. 15). The crest of the field is updip from the well. The Mondarra 2 structure is on the eastern flank of a separate northeasterly trending fault block (Fig. 16). Dip closure has been mapped to the northwest and southeast for both structures.

Mount Horner oilfield

Operator	Petroenergy Pty Ltd
Trap type	Tilted fault block with rollover
Reservoir	Arranoo Member, Cattamarra Coal Measures, Irwin River Coal Measures, Dongara Sandstone
Source	Kockatea Shale
Seal	Carynginia Formation, Cattamarra Coal Measures (intraformational), Kockatea Shale, Eneabba Formation
Production	0.263 GL (1.654 MMbbl) oil
Reserves remaining	0.019 GL (0.120 MMbbl) oil
Hydrocarbon type	Cattamarra Coal Measures 'B sand': 25.2° API oil Cattamarra Coal Measures 'F sand': 35.5 – 37.4° API oil

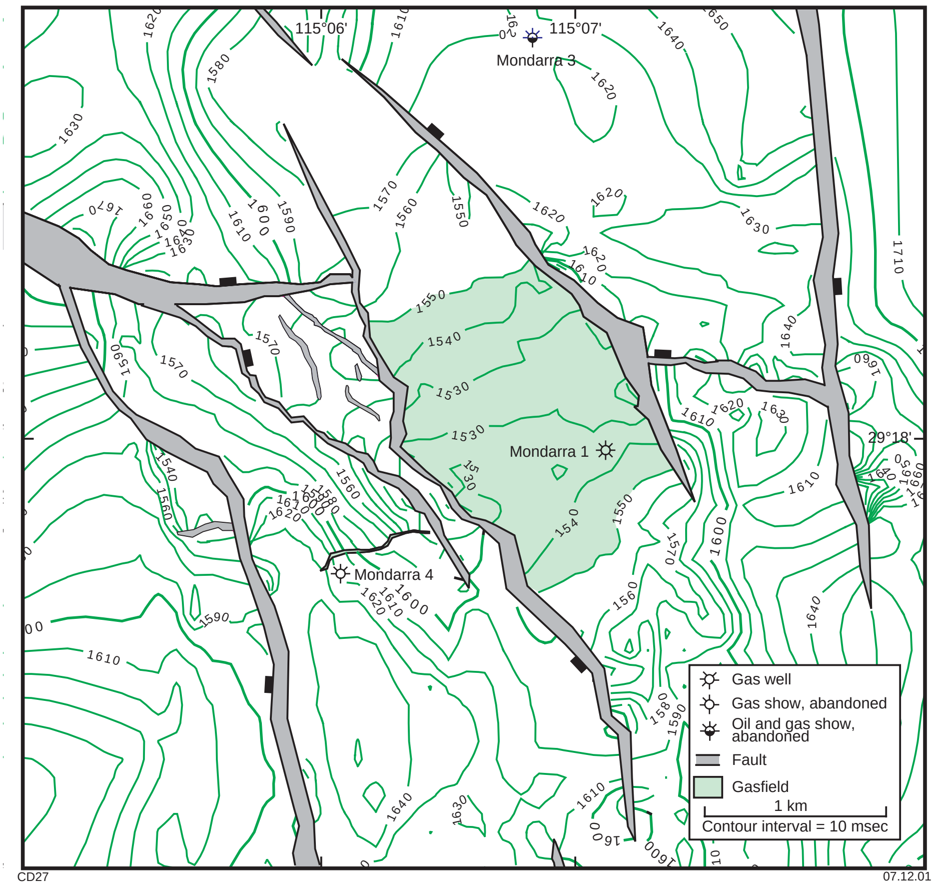


Figure 15. Two-way time contours to the top Dongara Sandstone, Mondarra gasfield (after Owad-Jones and Ellis, 2000)

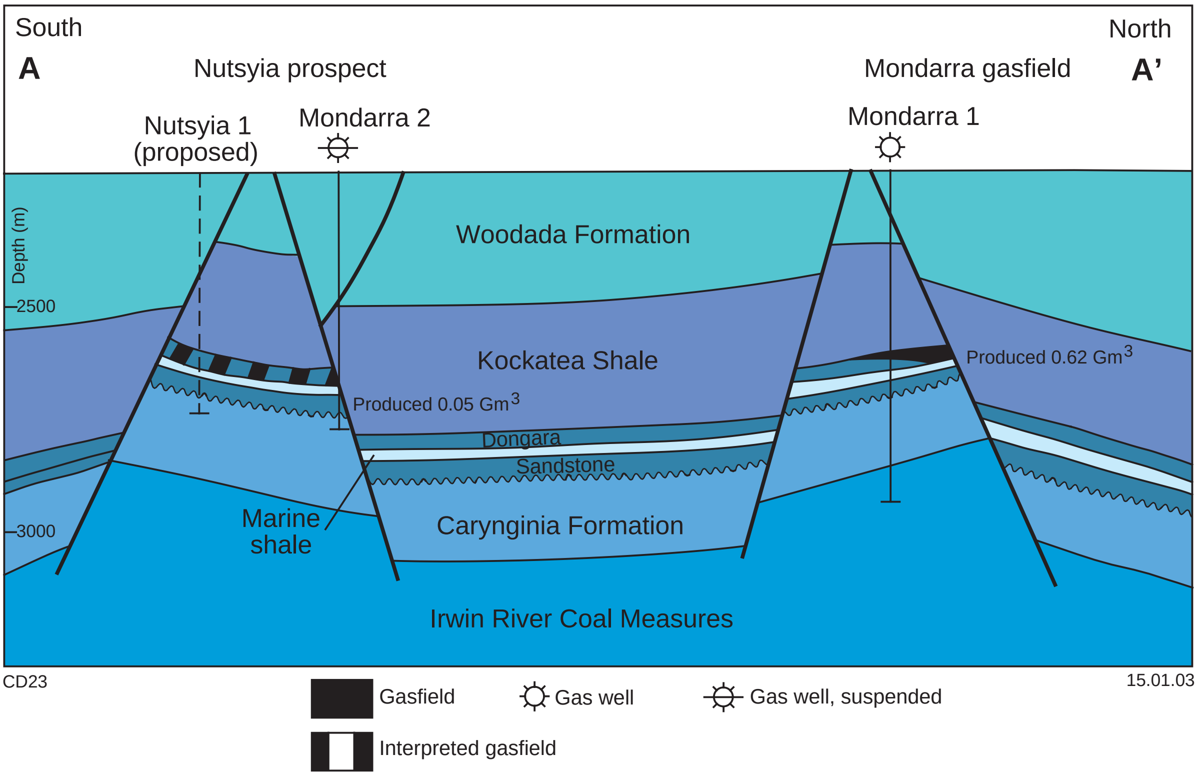


Figure 16. Cross section of the Mondarra 1, Mondarra 2, and Nutsyia structures (modified from Arc Energy NL, 2001, written comm.). The location of the section is shown in Figure 59

Average porosity	Cattamarra Coal Measures 'B sand': 25%
	Cattamarra Coal Measures 'F sand': 20%
	Cattamarra Coal Measures 'K sand': 23%
	Cattamarra Coal Measures 'L sand': 19%
	Arranoo Member: 15%
	Irwin River Coal Measures: 22.4%
Average permeability	Cattamarra Coal Measures 'F sand': 86–380 mD
	Cattamarra Coal Measures 'L sand': average 1170 mD
	Arranoo Member: 10 mD

The Mount Horner oilfield lies about 30 km east of Dongara within production licence L7 (Fig. 11). Mount Horner 1 was drilled in 1965 to test a tilted fault block and intersected oil pay in the Arranoo Member, with oil shows in the section from the Cattamarra Coal Measures to the Irwin River Coal Measures. A production test flowed oil and water at 6.4 kL/day (40 bbl/day) for 42 days. Mount Horner 4 and 5 intersected oil in the Irwin River Coal Measures, and Mount Horner 5 also confirmed the presence of oil in the 'B sand' of the Cattamarra Coal Measures. A production test of Mount Horner 5 over the interval 1158–1162 m flowed at 5.7 kL/day (36 bbl/day). Mount Horner 7 intersected a 9 m gross oil column comprising 7.5 m of net pay in the 'F sand' of the Cattamarra Coal Measures. A DST in Mount Horner 7 recovered 6.2 kL (39 bbl) of 36.5° API oil. A production test in Mount Horner 13 flowed at 18.6 kL/day (117.3 bbl/day) of oil and 2.7 kL/day (16.8 bbl/day) of water from the 'K sand' of the Cattamarra Coal Measures. Sixteen wells have been drilled in the Mount Horner oilfield. Production began in May 1984, with the main phase commencing in late 1987, and is currently in decline.

The Mount Horner oilfield lies within the Allanooka Terrace (Fig. 2). At the intra-Cattamarra Coal Measures level, the field is a northwesterly trending, elongate anticline on the northeastern, downthrown side of the Mount Horner Fault (Figs 17 and 18). At the top Arranoo Member (Fig. 19) and Irwin River Coal Measure level, it is a titled fault-block bounded to the northeast by the Mount Horner Fault.

North Yardanogo accumulation

Operator	Australian Worldwide Exploration Ltd
Trap type	Rollover on the Mountain Bridge Fault
Reservoir	Cattamarra Coal Measures
Source	Kockatea Shale
Seal	Cattamarra Coal Measures (intraformational)
Production	295 kL (1925 bbl) oil
Original in place	1590 kL (10 000 bbl) oil
Hydrocarbon type	34° API oil
Average porosity	22.5%
Average permeability	518 mD

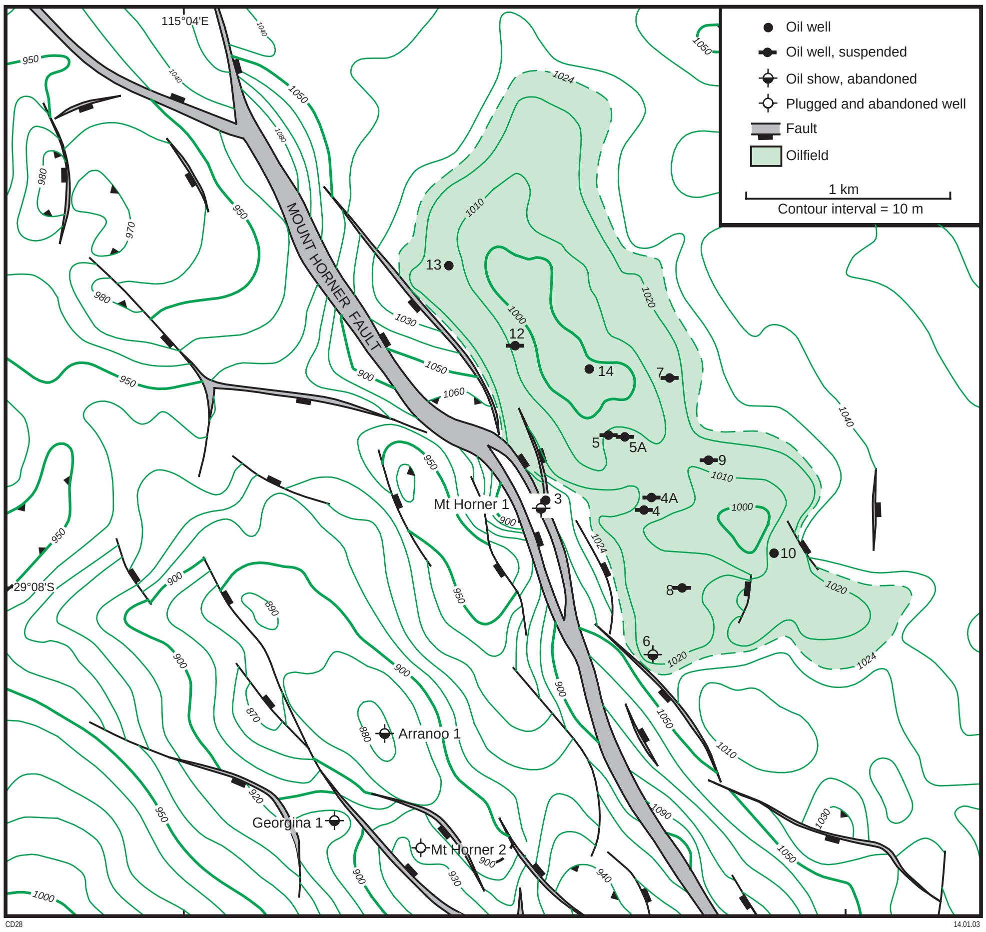


Figure 17. Depth contours to the top ‘F sand’ body within the Cattamarra Coal Measures, Mount Horner oilfield (after Owad-Jones and Ellis, 2000)

The North Yardanogo accumulation lies about 25 km southeast of Dongara and 5 km west of the Beharra Springs gasfield within production licence L11 (Fig. 11). North Yardanogo 1 tested a small, faulted anticline in 1990, and intersected a 1 m hydrocarbon column at 1640 m as well as a number of shows also within the Jurassic Cattamarra Coal Measures. A DST flowed at 191 kL/day (1200 bbl/day) for 34 minutes. About 295 kL (1925 bbl) of oil was subsequently produced before the well was shut in. South Yardanogo 1 was subsequently drilled in 1990 on a similar rollover 3.5 km to the south, but no significant hydrocarbons were intersected.

The North Yardanogo accumulation lies within the Beharra Springs Terrace (Fig. 2). At the intra-Cattamarra Coal Measures level, the trap is a rollover on the Mountain Bridge Fault (Figs 20 and 21). The structure is small (~0.8 km^2) and did not warrant further appraisal.

Walyering accumulation

Operator	Ausam Resources NL
Trap type	Faulted anticline
Reservoir	Cattamarra Coal Measures
Source	Cattamarra Coal Measures, Caryngininia Formation, Irwin River Coal Measures
Seal	Cattamarra Coal Measures (intraformational)
Production	7377 m^3 (0.26 Bcf) gas, 237 kL (1.49 Mbbl) condensate
Original in place	4.81 Gm^3 (170 Bcf) gas
Hydrocarbon type	0.611 gravity gas (93.6% CH_4, 1% CO_2), 44.9° API condensate
Average porosity	11% (log)
Average permeability	2.5 – 5 mD

The Walyering accumulation lies 129 km north of Perth in exploration permit EP 414 (3) (Fig. 11), and was first drilled in 1971 to test an anticlinal feature delineated by late 1960s vintage seismic surveys. Walyering 1 intersected a 125 m gross hydrocarbon column with 39 m of net pay in the Cattamarra Coal Measures. Gas flowed from two sandstones at 382 km^3/day (13.5 MMcf/day) from a DST taken at 3367 m. Gas production commenced in March 1972. The well was shut-in four months later as production and pressure declined rapidly. Walyering 2, designed to test the northern extension of the anticline, intersected the same gas-bearing sandstones as the

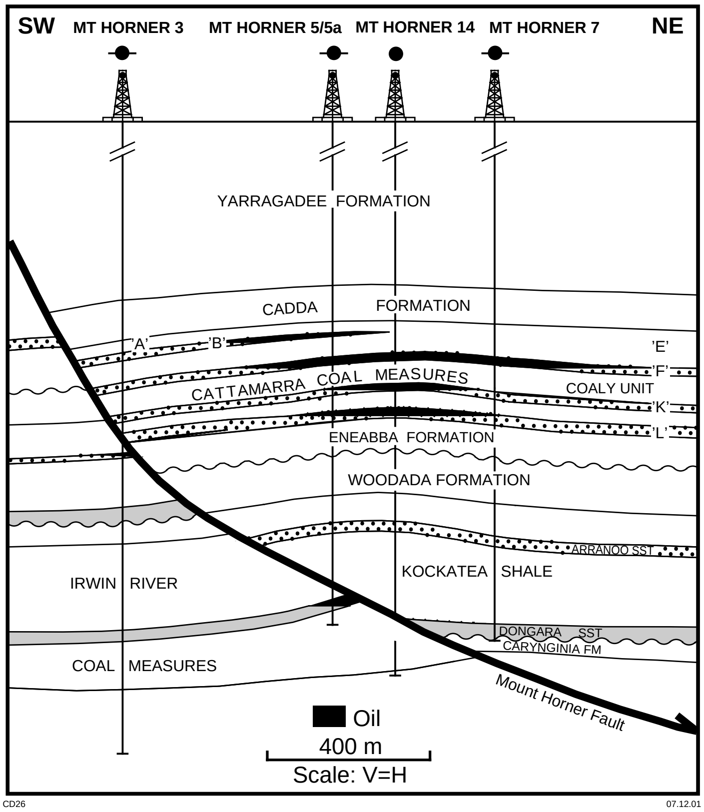


Figure 18. Geological cross section of the Mount Horner oilfield (after Owad-Jones and Ellis, 2000)

discovery well, but yielded non-commercial rates. A further well (Walyering 3) investigated the potential of uplifted fault blocks to the southeast, but the two zones of interest proved to be water wet. A deeper sandstone in this well yielded 17 000 m^3/day (0.6 MMcf/day). Recent mapping suggests that Walyering 2 and 3 did not test a valid trap. In December 2001 the structure was re-evaluated by Walyering 4 at a location about 150 m updip of Walyering 1. Strong gas readings and fluorescence were noted, but the well was plugged and abandoned as a dry well.

The Walyering accumulation is in the Coomallo Trough, along the western side of the Dandaragan Trough, and is a northerly trending, complexly faulted anticline at top Cattamarra Coal Measures level (Fig. 22) with low permeability and porosity reservoirs. Pressure build-up data indicate a complex permeability system and formation damage in the first three wells (Ausam Resources NL, 2000). The field is discussed in more detail in **Walyering 4**.

Woodada gasfield

Operator	Phoenix Energy Pty Ltd
Trap type	Structural with stratigraphic control
Reservoir	Beekeeper Formation
Source	Kockatea Shale, Carynginia Formation, Irwin River Coal Measures
Seal	Kockatea Shale, Beekeeper Formation
Production	1.20 Gm^3 (42.2 Bcf) gas, 0.009 GL (56.6 Mbbl) condensate
Remaining reserves	0.85 Gm^3 (30 Bcf) gas, 0.01 GL (62.9 Mbbl) condensate
Hydrocarbon type	0.64 gravity gas (89.7% CH_4, 4.1% CO_2), 53.6° API condensate
Average porosity	7.5% (range = 3–13%, log), range = 1.3 – 2.5% (core)
Average permeability	Woodada wells: 5 mD East Lake Logue wells: 460 mD

The Woodada gasfield is located 12 km west of Eneabba within production licences L4 and L5 (Fig. 11). Woodada 1 was drilled in 1980 to test Lower Permian and Lower Jurassic objectives, and intersected a 7 m gas column in carbonate of the Beekeeper Formation (originally assigned to the Carynginia Formation). Gas flowed at 190 km^3/day (6.7 MMcf/day) from a DST, which increased to 945.8 km^3/day (33.4 MMcf/day) after acid stimulation. A total of 20 wells have been drilled within the field. Gas production commenced in May 1982, but the field was shut-in for most of 1987 with production being limited until December 1989 when the gas market ceased to be regulated. The most recent development of the field was the drilling of Woodada 17–19 between December 2001 and April 2002.

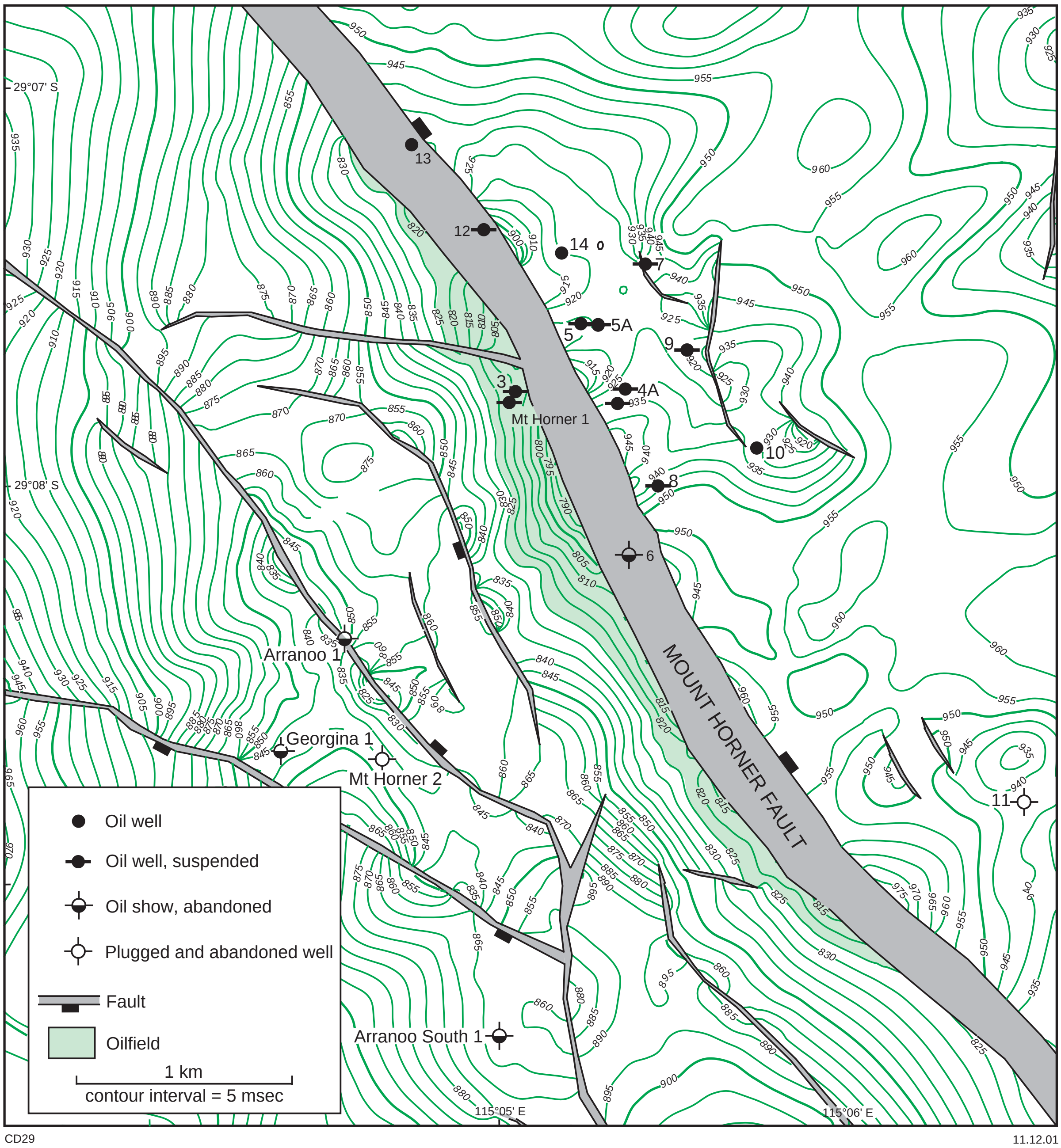


Figure 19. Two-way time contours to top Kockatea Shale, near the top of the Arranoo Member, Mount Horner oilfield (after Owad-Jones and Ellis, 2000)

The Woodada gasfield lies on the Cadda Terrace between the Beagle Ridge and Dandaragan Trough (Fig. 2) and forms a northerly plunging anticline at the top reservoir level (Beekeeper Formation; Fig. 23). Closure is to the north, east, and west, and the reservoir facies pinches out to the west and south (Fig. 24). The gasfield contains two pools (Woodada and East Lake Logue) that are separated by northerly trending faults. The Woodada pool is less rich in nitrogen. Permeability in the East Lake Logue pool is much higher, possibly due to the higher degree of fracturing in the Beekeeper Formation, but the pressure is lower than that of the Woodada pool.

Yardarino oil- and gasfield

Operator	Arc Energy NL
Trap type	Faulted anticline
Reservoir	Dongara Sandstone (oil and gas), Caryngínia Formation and Irwin River Coal Measures (gas)
Source	Kockatea Shale (oil), Carynginia Formation and Irwin River Coal Measures (gas)
Seal	Kockatea Shale (Dongara Sandstone); cross-fault seal

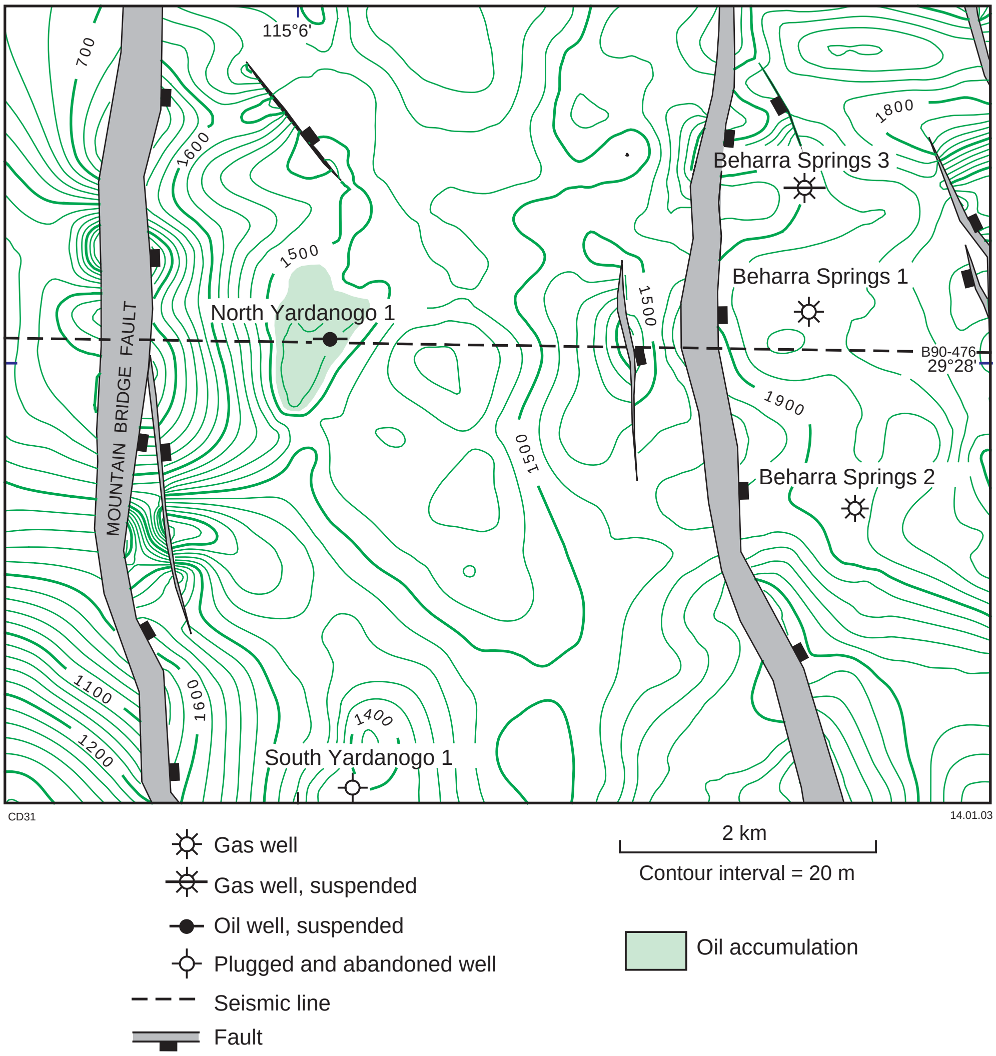


Figure 20. Depth contours to the intra-Cattamarra Coal Measures for the North Yardanogo accumulation (after Owad-Jones and Ellis, 2000)

	provided by intraformational seals with dip closure (Caryngina Formation and Irwin River Coal Measures)
Production	0.003 GL (0.016 MMbbl) oil and condensate (Dongara Sandstone), 0.134 Gm^3 (4.8 Bcf) gas solution and gas cap (Dongara Sandstone)
Original in place	0.101 GL (0.639 MMbbl) oil and condensate (Dongara Sandstone), 0.396 Gm^3 (15 Bcf) gas solution and gas cap (Dongara Sandstone), 0.014 Gm^3 (0.50 Bcf) gas (Carynginia Formation/Irwin River Coal Measures)
Hydrocarbon type	Gas (96.2% CH_4, 3.5% CO_2), 35 – 36.5° API oil
Average porosity	Dongara Sandstone: 13% (range = 11–15% log, 11.9 – 12.7% core); Carynginia Formation/ Irwin River Coal Measures: 14%
Average permeability	Dongara Sandstone: 120 mD (range = 110–200 mD)

The Yardarino oil- and gasfield lies 3 km east of the Dongara oil- and gasfield within production licence L2 (Fig. 11), and was the first commercial discovery in the basin. Drilled in 1964, Yardarino 1 intersected a 19.5 m gross hydrocarbon column comprising 4 m of net oil pay and 14 m of net gas pay in the Dongara Sandstone. A DST yielded up to 430 km^3/day (15.3 MMcf/day) of gas and recovered 1.43 kL (9 bbl) of 36.5° API oil. Three appraisal wells were drilled in 1964 to evaluate the field. Yardarino 2 found only traces of oil and gas. Yardarino 3 intersected 12.5 m of gross hydrocarbon pay, and flowed at 318 kL/day (2000 bbl/day) from a DST in the Dongara Sandstone. The Dongara Sandstone was faulted out in the third appraisal well, Yardarino 4, which was a dry hole. Recent mapping indicates that the three

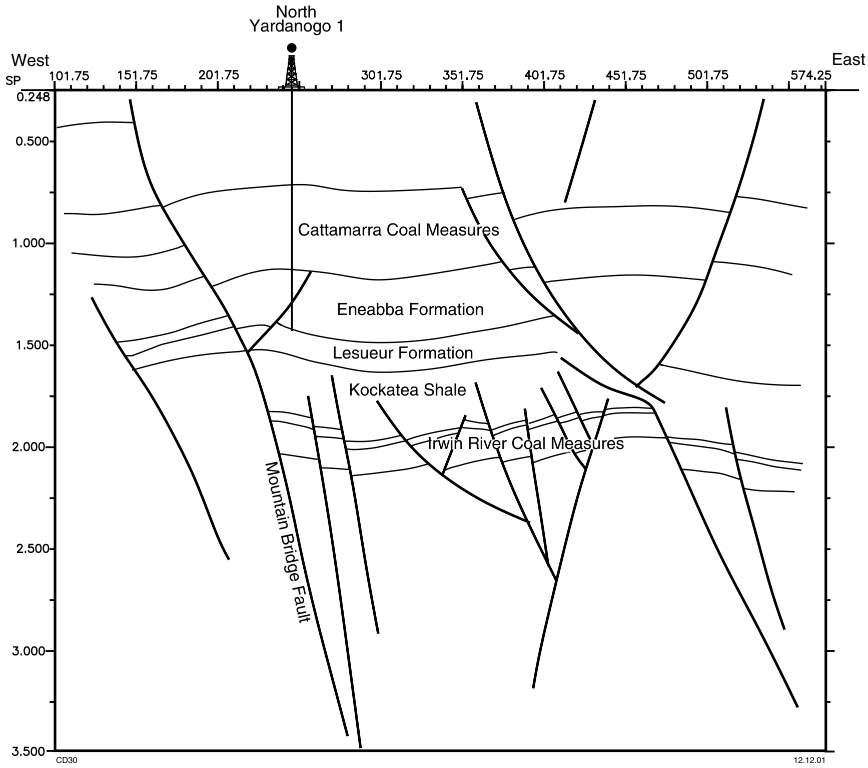


Figure 21. Seismic section B90-476 showing the structure of the North Yardanogo accumulation (after Owad-Jones and Ellis, 2000)

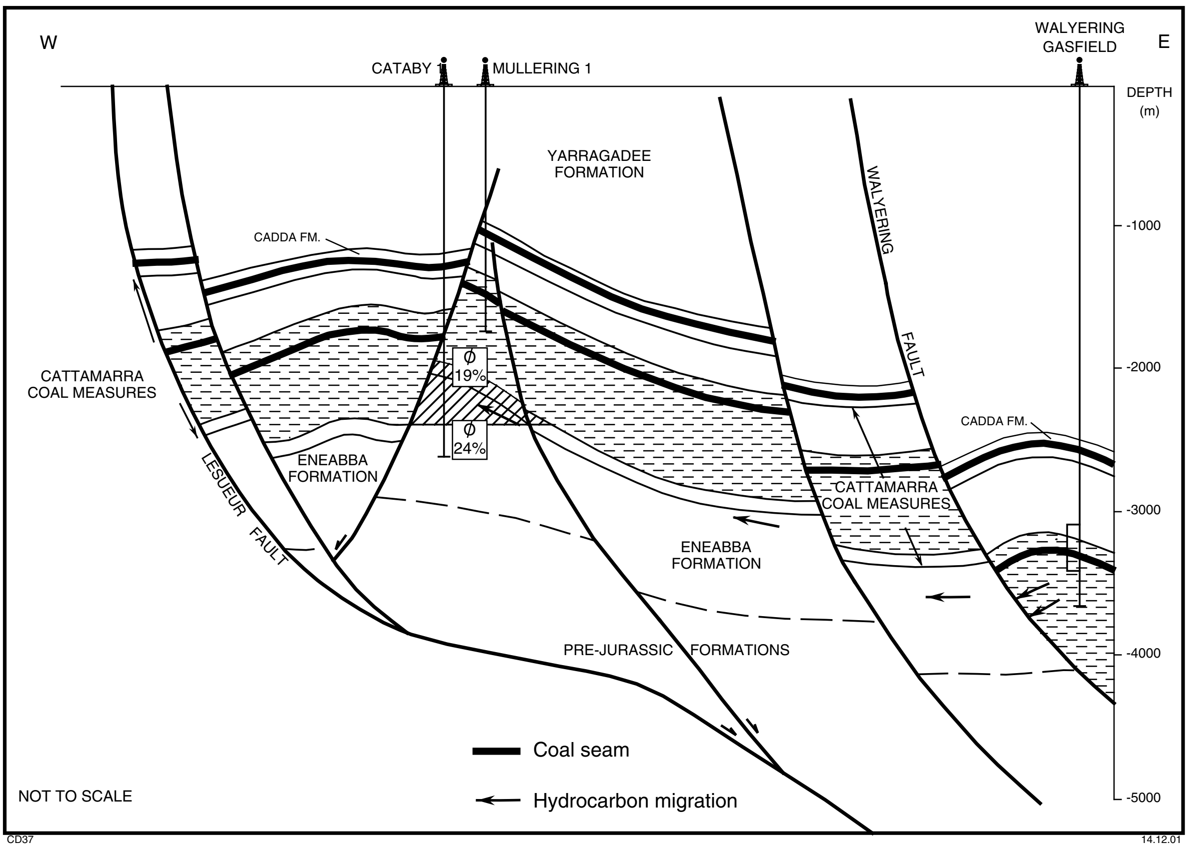


Figure 22. Schematic cross section from the Walyering accumulation to Cataby 1 (after Owad-Jones and Ellis, 2000)

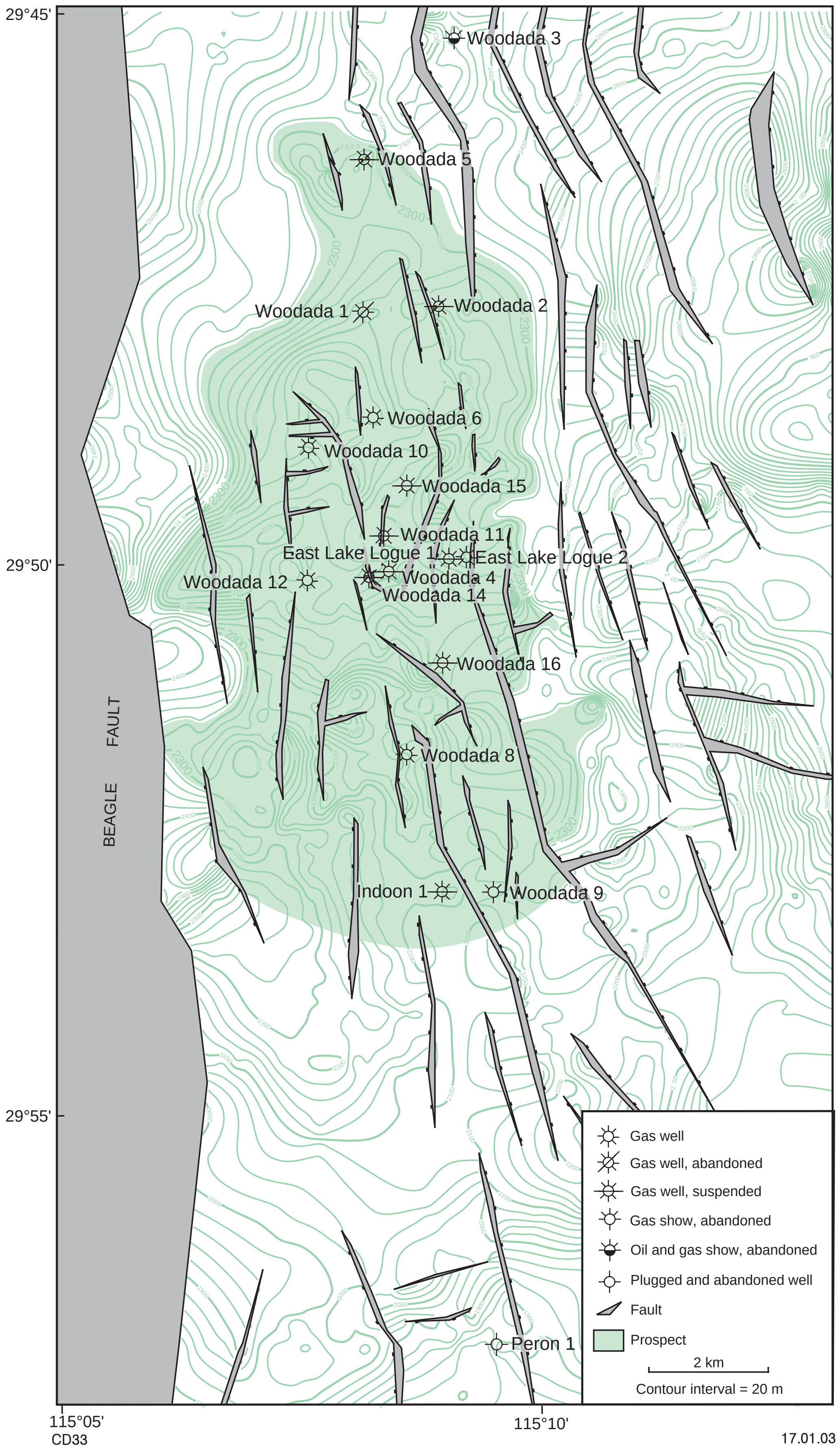


Figure 23. Depth contours to the top Beekeeper Formation, Woodada gasfield (after Owad-Jones and Ellis, 2000)

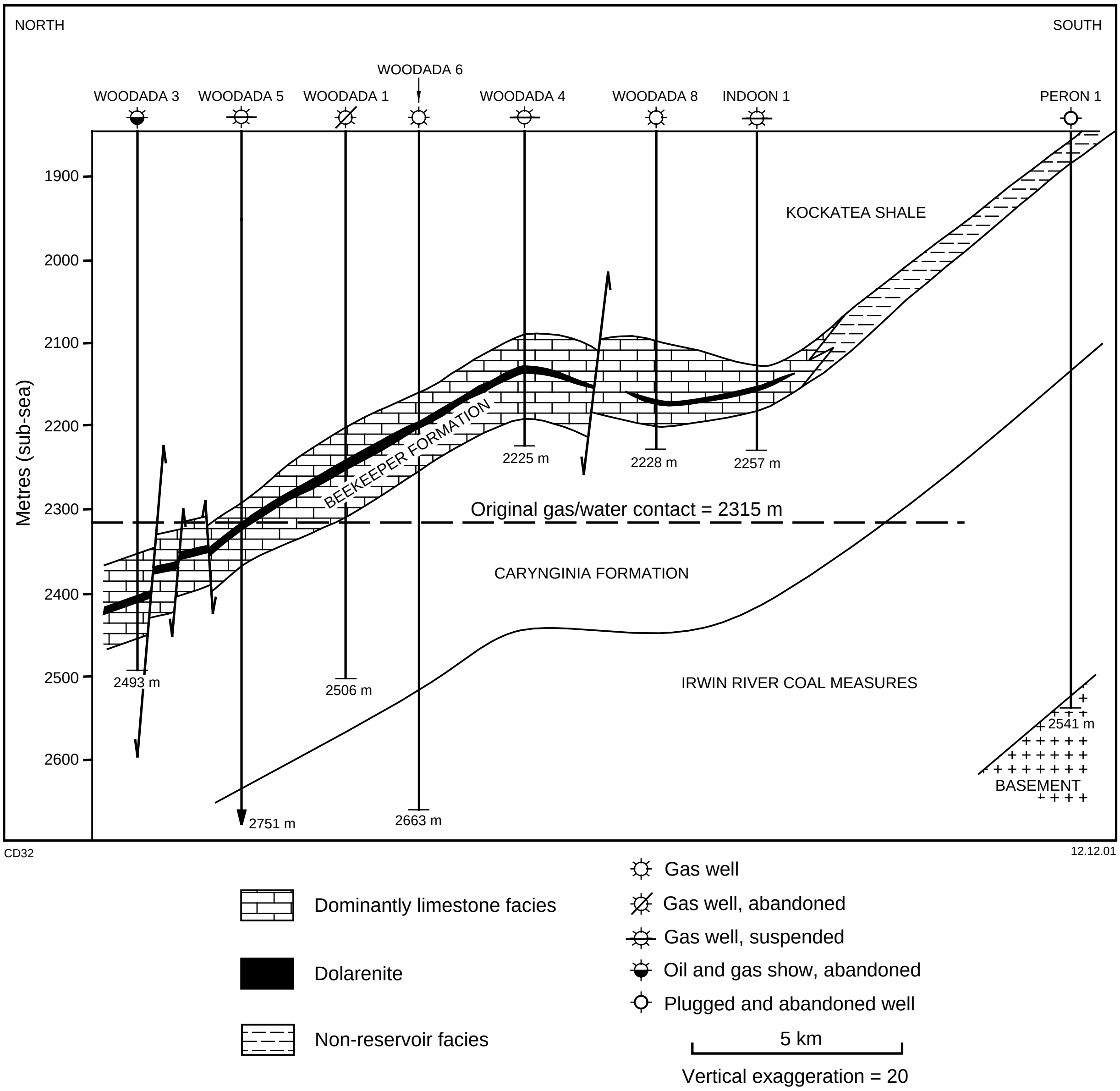


Figure 24. Geological cross section through the Woodada gasfield (after Owad-Jones and Ellis, 2000)

appraisal wells were drilled off structure. Yardarino 5, drilled in 2001, had excellent gas shows in the Dongara Sandstone and has been suspended as a potential producer.

The Elegans pool was discovered when Yardarino 1 was deepened in 1999 (Fig. 25). This well is currently producing 28.3 km^3/day (1 MMcf/day) from the Carynginia Formation and Irwin River Coal Measures. Hakia 1, drilled in 1999 to determine the extent of the Elegans pool, intersected a 13 m gas zone in the Dongara Sandstone. However, a DST showed moderate formation damage and low permeability. North Yardarino 1 and Central Yardarino 1 tested two other structural culminations, but neither was drilled on a valid closure at the Dongara Sandstone level. Gas and oil production from the Dongara Sandstone began in October 1978 and ended in May 1989 due to excessive water production. Gas production from the Carynginia Formation and Irwin River Coal Measures began in June 1999.

The Yardarino oil- and gasfield lies on the Beharra Springs Terrace on the downthrown side of the Mountain Bridge Fault (Fig. 2). At the Dongara Sandstone level, the Yardarino anticline is eliptical in plan view and is cut by small northwesterly trending faults (Fig. 26). At the Carynginia and Irwin River Coal Measures level, a broad closure is formed by the Mountain Bridge Fault to the west, and the Allanooka Fault to the north (Fig. 27). However, the extent and quality of the sandstone reservoir may also control the closure.

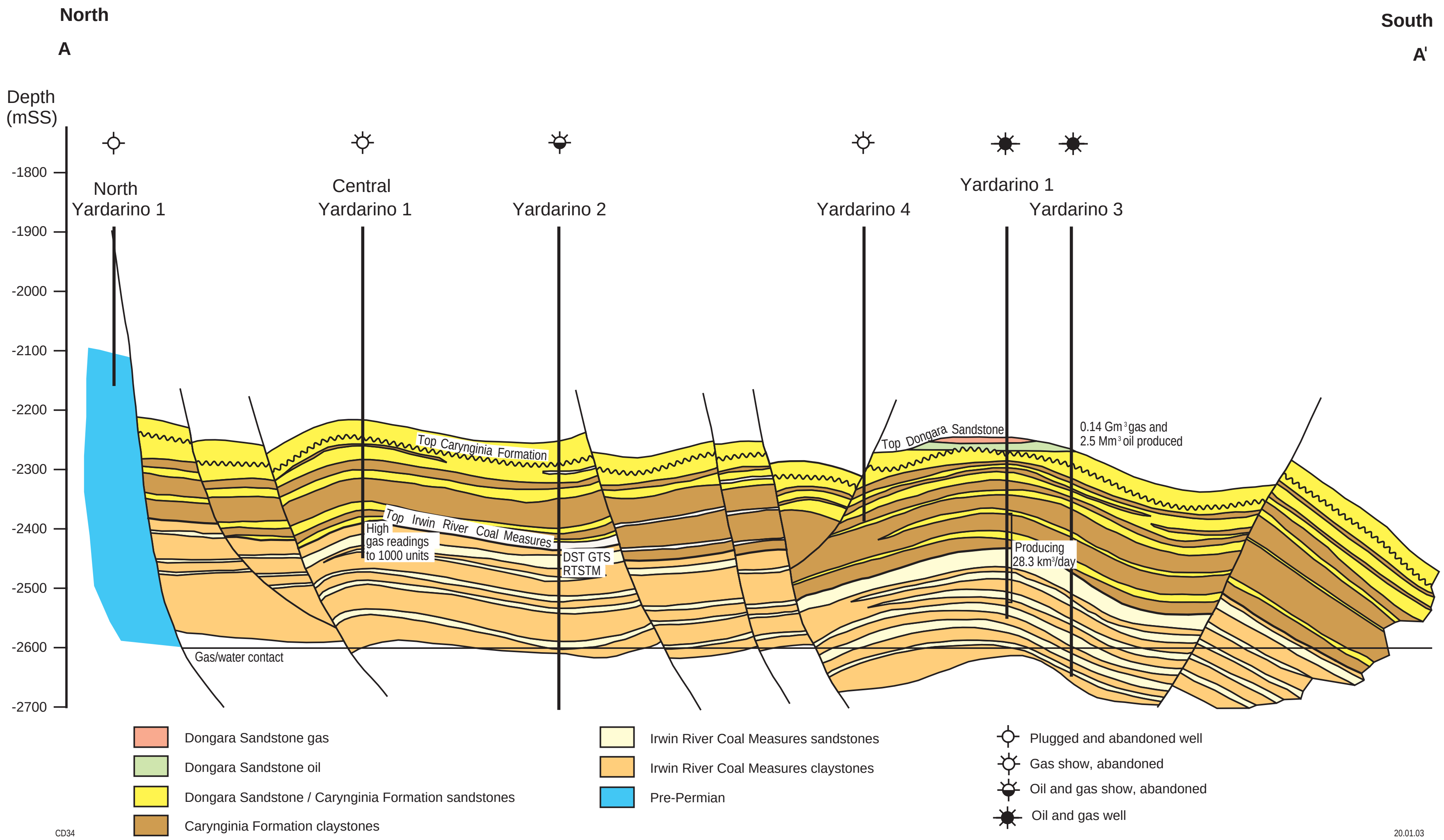


Figure 25. Cross section of the Yardarino oil- and gasfield showing the reservoirs and general structure in the area (after Owad-Jones and Ellis, 2000). The location of the section is shown in Figure 26

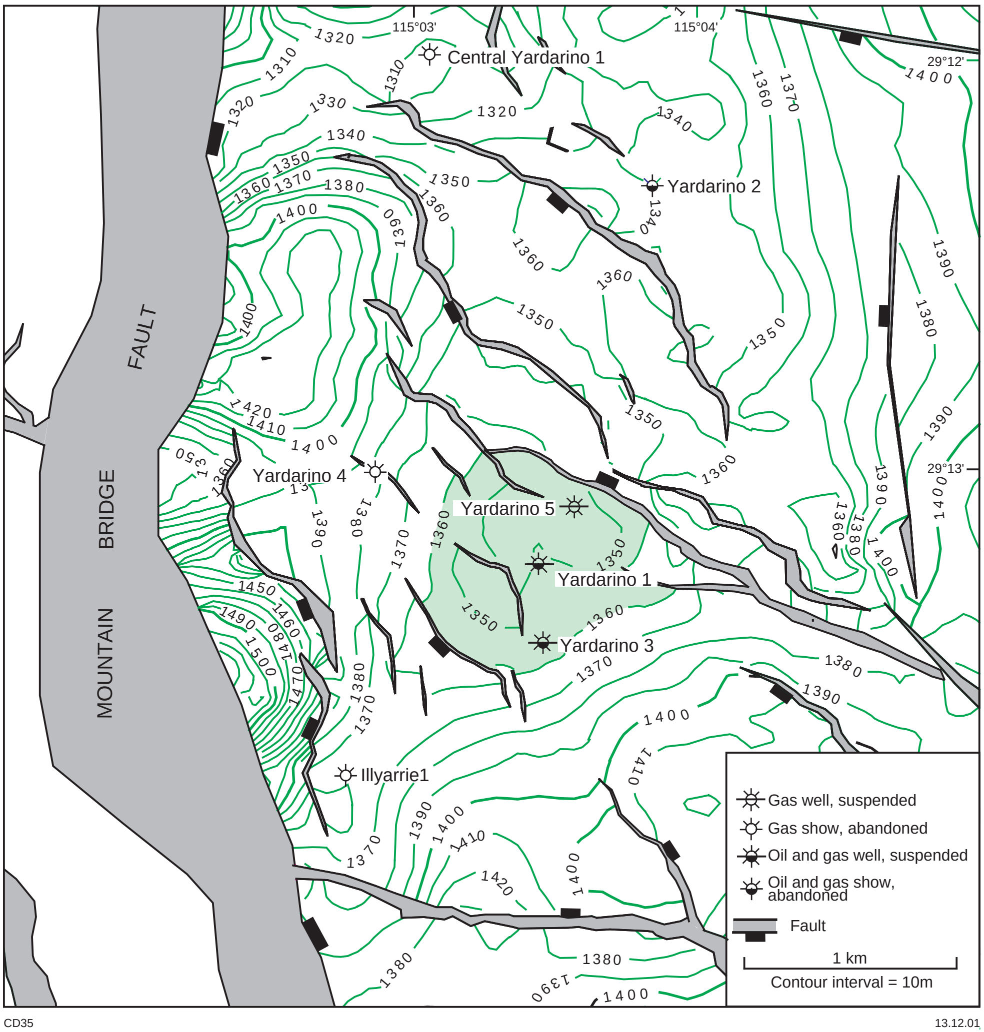


Figure 26. Two-way time contours to the base Kockatea Shale, near top Dongara Sandstone, Yardarino oil- and gasfield (after Owad-Jones and Ellis, 2000)

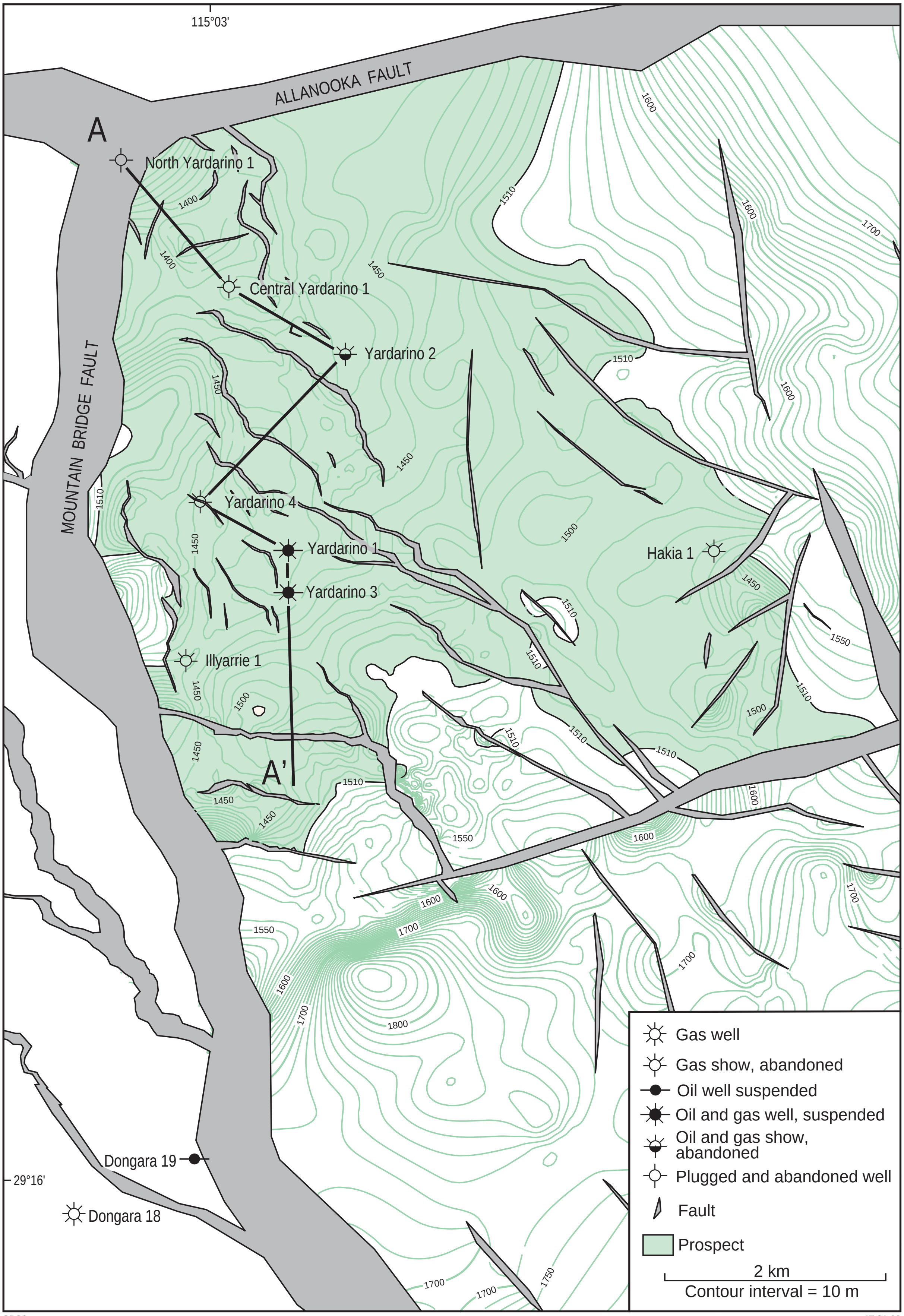


Figure 27. Two-way time contours to the top Irwin River Coal Measures, Yardarino oil- and gasfield (after Owad-Jones and Ellis, 2000)

Recent discoveries

Beharra Springs North

Operator	Origin Energy Developments Pty Ltd
Trap type	Faulted anticline
Reservoir	Dongara Sandstone
Source	Irwin River Coal Measures, Kockatea Shale
Seal	Tight intervals in the Upper Permian
Original in place	0.5 Gm^3 (17.7 Bcf) gas

Beharra Springs North is 3.5 km north of the Beharra Springs gasfield and about 30 km south-southeast of Dongara within production licence L11 (Fig. 11). The discovery well was drilled in August 2001 and intersected a 28.5 m-thick interval of gas-saturated sandstone in the Dongara Sandstone at 3358 m (Australian Worldwide Exploration Ltd, 2001b,c; Origin Energy Developments Pty Ltd, 2001a). Gas shows were recorded throughout the objective formation. A production test between 3370.5 and 3395.2 m flowed 849.6 km^3/day (30 MMcf/day) through a 19 mm (¾") choke, which is comparable with the nearby Beharra Springs gasfield.

Beharra Springs North has dip closure to the west and fault closure in the other directions at the Permian levels. It is interpreted to be a faulted, tilted horst block west of the Beharra Springs Fault and south of a northeasterly trending fault (Fig. 28). Beharra Springs North is on the downthrown side of a northern bounding fault, which juxtaposes the Dongara Sandstone reservoir with the Carynginia Formation and Irwin River Coal Measures. The Beharra Springs Fault, which is the eastern boundary of the prospect, provides adequate seal against the Kockatea Shale, as does the southern bounding fault, which is upthrown to the north.

Cliff Head

Operator	Roc Oil Company Ltd
Trap type	Fault trap
Reservoir	Irwin River Coal Measures
Source	Kockatea Shale or Irwin River Coal Measures
Seal	Kockatea Shale
Original in place	12.7 GL (~80 MMbbl) oil
Hydrocarbon type	31.6° API oil
Average porosity	Cliff Head 1: 23% (up to 28%) in Irwin River Coal Measures

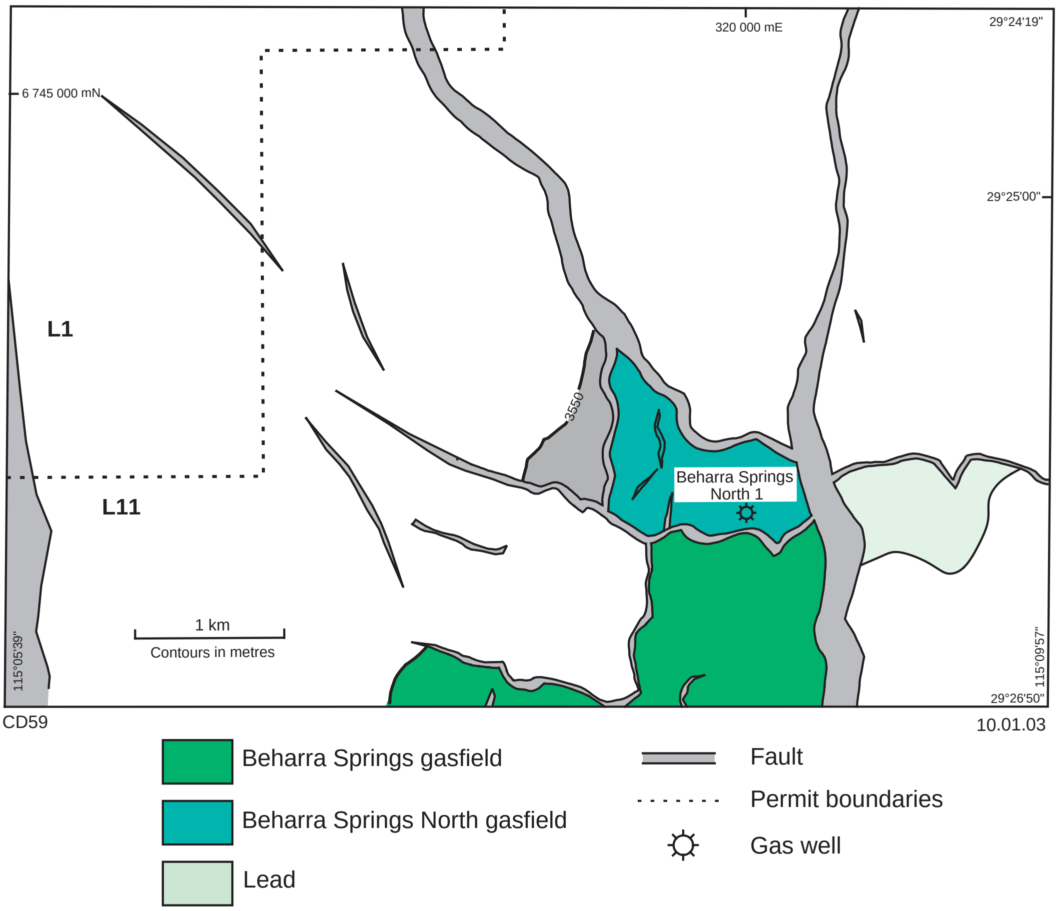


Figure 28. Depth contours to the top Dongara Sandstone, Beharra Springs North 1 (modified from Australian Worldwide Exploration Ltd, 2001, written comm.)

	Cliff Head 2: 18% in Irwin River Coal Measures

Cliff Head lies within 15–20 m of water about 20 km south-southwest of Dongara on the eastern flank of the Abrolhos Sub-basin within exploration permit WA-286-P (Fig. 29). Cliff Head 1 was completed in December 2001 and was drilled to a total true vertical depth below sea level (TVD) of 1473 m (1499 mRT). The well intersected a 5 m oil column between 1253.3 and 1258.3 mTVDSS (1279 and 1284 mRT) in the Irwin River Coal Measures, immediately beneath the Kockatea Shale. Cliff Head 1 was plugged back to 429 mRT and a sidetrack hole, Cliff Head 2, was drilled at 60° to intersect the same oil-bearing reservoir at a higher structural position (Roc Oil Company Ltd, 2001; Voyager Energy Ltd, 2001). The bottom of Cliff Head 2 lies about 1.1 km north-northeast of the vertical discovery hole.

Cliff Head 2 was completed in January 2002 and drilled to a total depth of 2020 mRT (1307 mTVDSS). The well intersected a gross oil column of 28.5 m between 1896.5 and 1960 mRT (1229.8 – 1258.3 mTVDSS), with a net to gross ratio between 60 and 65% (Roc Oil Company Ltd, 2002). The oil column in Cliff Head 2 is 23.5 m higher than in Cliff Head 1. About half of the gross reservoir section consists of moderate- to good-quality, net reservoir sandstone (Roc Oil (WA) Pty Ltd, 2002). The 31.6° API waxy crude oil recovered is similar to other oils within the basin, and has a high viscosity (8 cp at reservoir pressure). The oil-water contact (OWC) identified at 1960 mRT (1283.5 mTVDSS) in Cliff Head 2 corresponds to that in Cliff Head 1 (Roc Oil (WA) Pty Ltd, 2002). There is further updip potential from Cliff Head 2.

Cliff Head is a complexly faulted antiform at base Kockatea Shale level within a tilted fault block on the upthrown side of the northerly trending Geraldton Fault. Vertical and cross-fault seals are provided by the Kockatea Shale, which is about 170 m thick in this area. The lower part of the Woodada Formation may contain an additional 100 m of sealing lithologies (Roc Oil (WA) Pty Ltd, 2000a,b). Faulting in the area has divided Cliff Head into two separate structures (Figs 30 and 31). A northwesterly oriented, conjugate fault pair bounds the top part of the Cliff Head structure. Wrench reactivation has created a tight, northwesterly trending syncline between the two blocks (Fig. 30). The other part of the structure, now called the 'Mentelle structure', may contain a further 3.2 – 4.8 MMkL (20–30 MMbbl) of oil, with a further 15.9 MMkL (100 MMbbl) of original oil in place (OOIP) if this structure is not connected to Cliff Head (Australian Worldwide Exploration Ltd, 2002a).

Preliminary analyses to evaluate the commercial viability are currently underway for Cliff Head. The strategy for the oilfield includes exploration, appraisal, and, if warranted, development wells.

Hovea

Operator	Arc Energy NL and Origin Energy Developments Pty Ltd
Trap type	Fault trap
Reservoir	Dongara Sandstone
Source	Kockatea Shale
Seal	Kockatea Shale
Original in place	3.17 GL (20 MMbbl) oil, potentially up to 12.8 GL (80 MMbbl)
Hydrocarbon type	41.6° API oil

Hovea lies 3 km south of the Dongara oil- and gasfield and 14 km southeast of Dongara within production licence L1 (Figs 32 and 33). Drilled in October 2001, the well intersected the primary target, the Dongara Sandstone, at 1996 m. A moveable oil column, with a gross thickness of 8 m, was intersected within the Dongara Sandstone with excellent oil and gas shows recorded over the interval 1996–2015 m (Origin Energy Developments Pty Ltd, 2001d). A DST between 1995 and 2002 m flowed 19.3 kL (122 bbl) of 41.6° API oil at an average of 150 kL/day (950 bbl/day) through a 12.7 mm (½") choke. An extended production test in February 2002 produced oil up to 299 kL/day (1880 bbl/day). A 30% recovery factor has been estimated from a series of production tests, which represents recoverable oil volumes ranging from 0.95 to 3.8 GL (6–24 MMbbl). Hovea 1 appears to have intersected the reservoir downdip from the crest of the structure implying there is a substantial volume of high-quality reservoir updip from the discovery well (Arc Energy NL, 2002a). Hovea 2 tested the structure closer to the crest. In this well, the Dongara Sandstone is water-bearing as it is below the oil–water contact in Hovea 1. A DST over the High Cliff Sandstone (2370–2419 m) flowed 500 000 m^3/day (16.5 MMcf/day) through a 19 mm (¾") choke (Arc Energy NL, 2002b). Hovea 3, drilled in 2002, intersected a 29 m oil column within the Dongara Sandstone. Production from this well commenced in October 2002 with a current flow rate in excess of 318 kL/day (2000 bbl/day). Further appraisal is necessary to evaluate the structure, which appears to be compartmentalized by small faults. Hovea 4, 800 m north of Hovea 1, was drilled in December 2002, and intersected a 47 m oil column in the Dongara Sandstone.

Hovea is located on the Dongara Ridge within a tilted horst block that formed as a result of the interaction between northerly (Mountain Bridge Fault) and northwesterly trending fault systems (Fig. 33). The field has fault closure to the east and dip closure in all other directions (Fig. 32). Closure was mapped at Permian levels only.

Jingemia

Operator	Origin Energy Developments Pty Ltd
Trap type	Fault trap
Reservoir	Dongara Sandstone
Source	Kockatea Shale
Seal	Kockatea Shale
Original in place	1.59 – 4.77 GL (10–30 MMbbl)
Hydrocarbon type	31.6° API oil

Jingemia was drilled in October 2002 and tested a fault-dependent structure similar to Hovea, 5 km to the northeast. Jingemia 1 intersected a 33 m oil column of

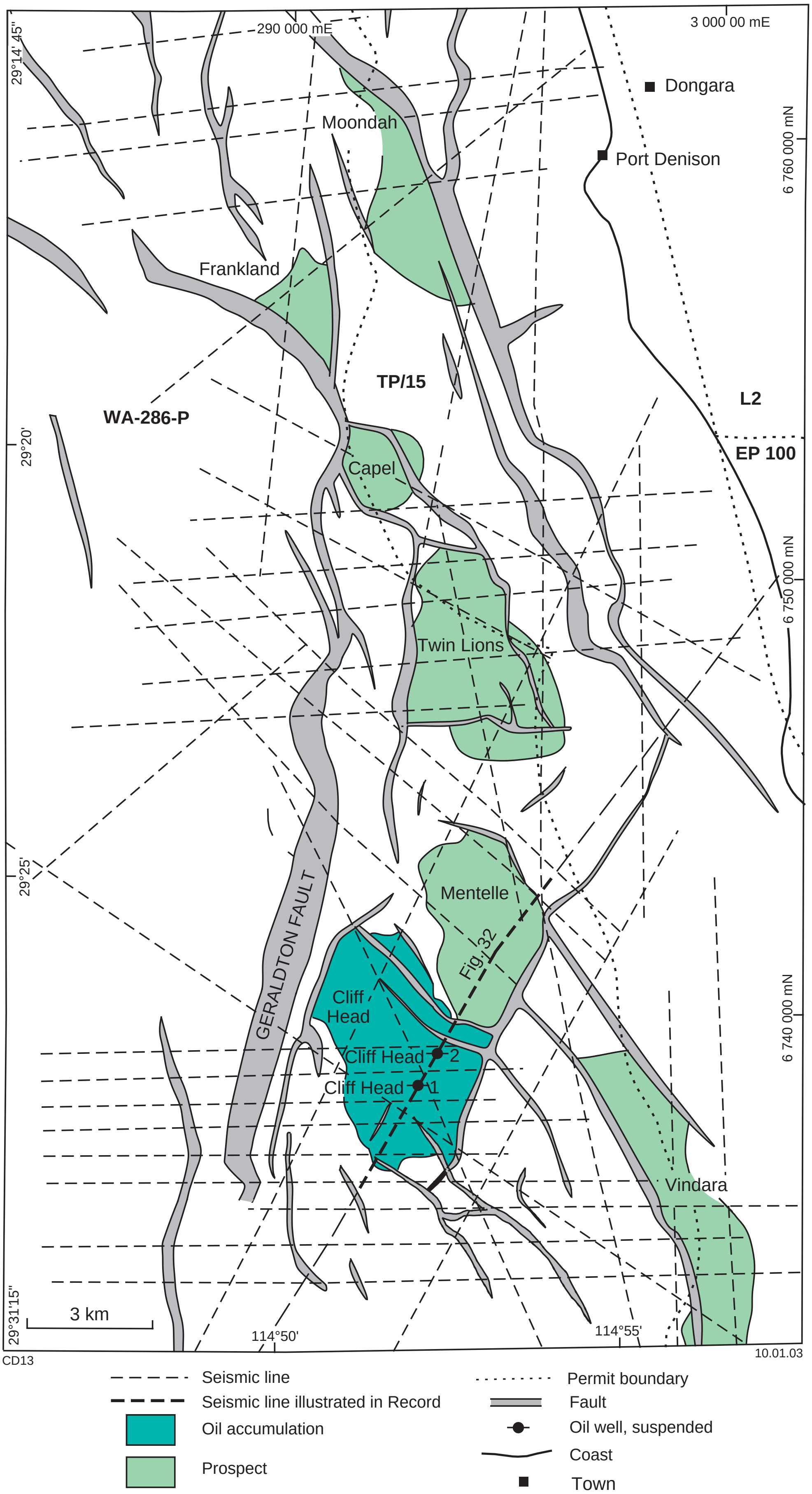


Figure 29. Prospects and leads of the Cliff Head trend (modified from Roc Oil (WA) Pty Ltd, 2000a)

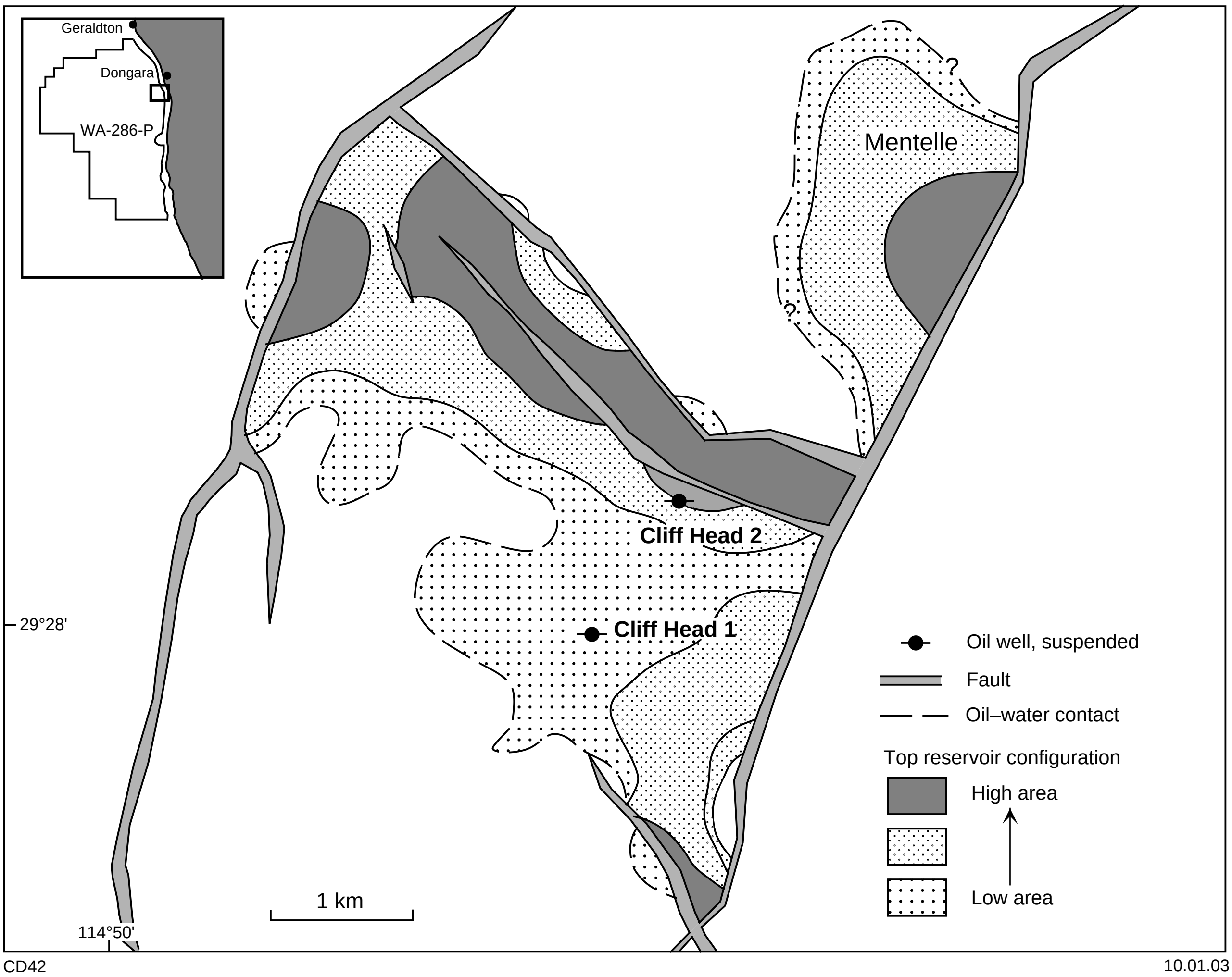


Figure 30. Reservoir contours of the Cliff Head oilfield and Mentelle (modified from Roc Oil Company Pty Ltd, 2002, written comm.)

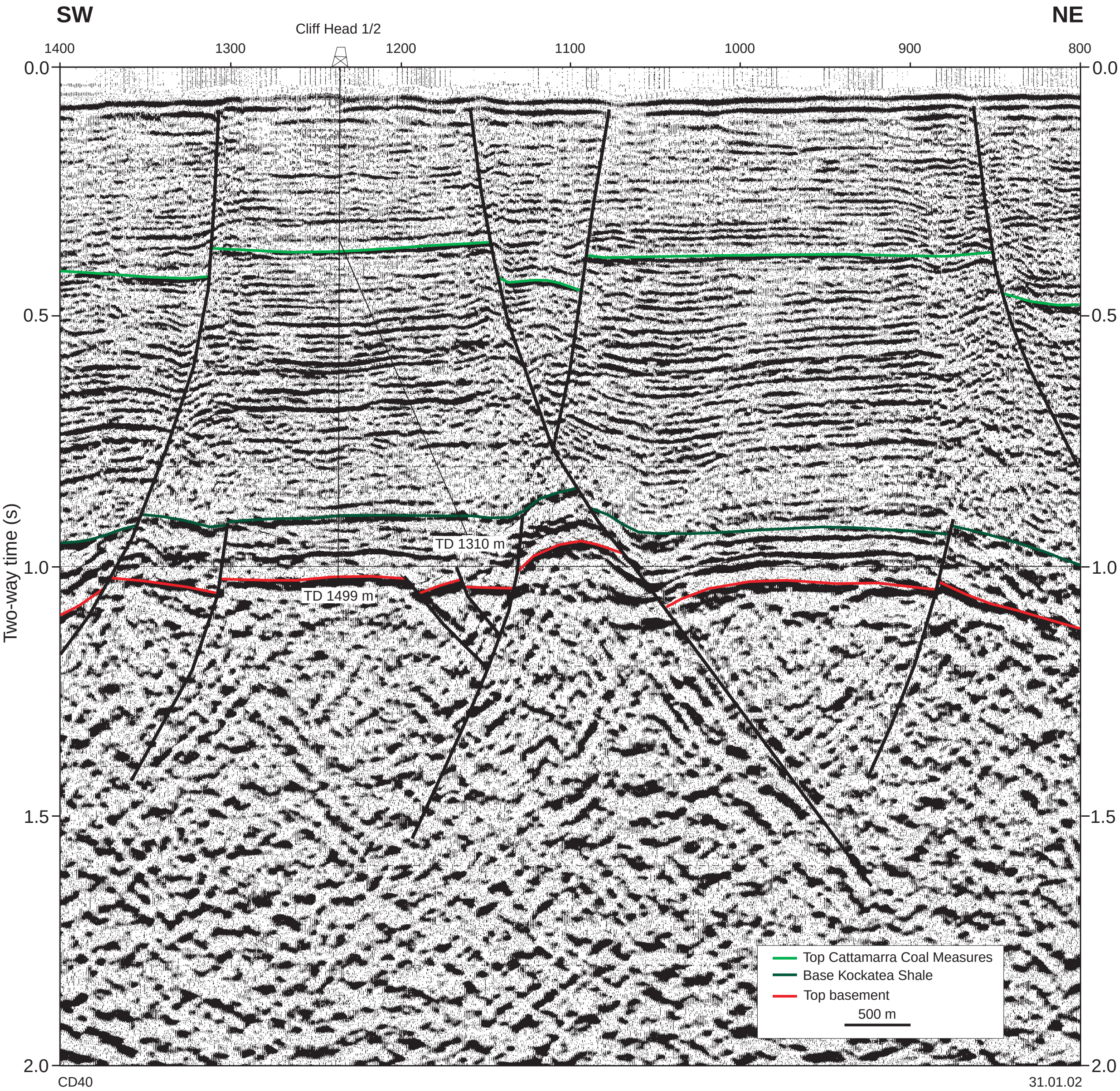


Figure 31. Seismic section PM99-42 showing the structure of the Cliff Head oilfield

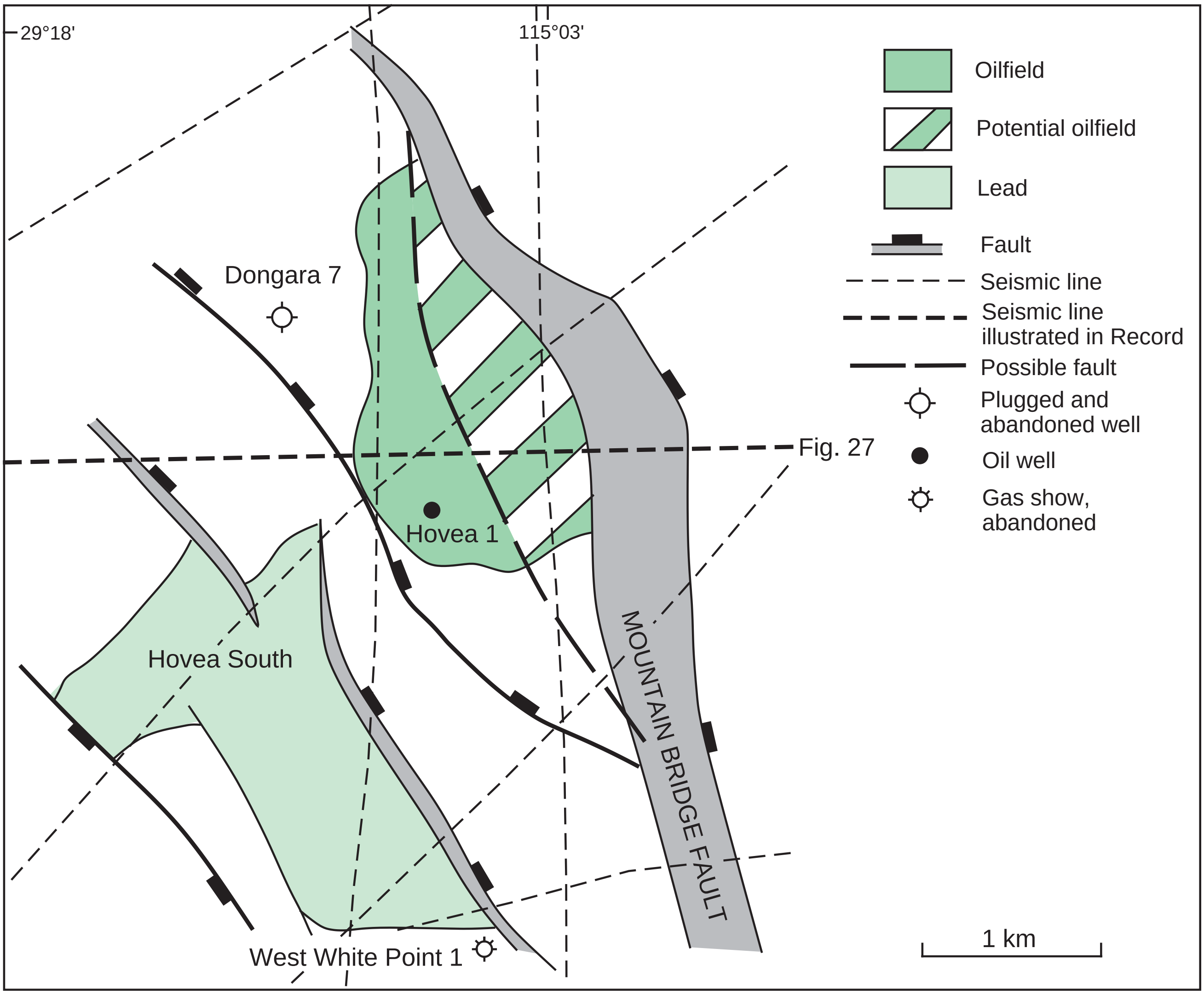


Figure 32. Outline of the top Dongara Sandstone for Hovea and Hovea South (modified from Arc Energy NL, 2002, written comm.)

good to excellent reservoir-quality Dongara Sandstone. A DST between 2414.5 and 2419.5 m flowed 381.6 kL/day (2400 bbl/day) of 37° API oil through a 25.4 mm (1") choke (Australian Worldwide Exploration Ltd, 2002b). Data collected during the DST indicates sustainable flow rates. Further appraisal of the structure is scheduled.

Petroleum prospectivity

Six commercial fields have been discovered in the northern Perth Basin (Table 1), of which Dongara is by far the largest with original gas in-place (OGIP) of 15.19 Gm^3 (539.7 Bcf) and OOIP of 13.8 GL (86.8 MMbbl). Several gas accumulations within tight reservoirs are also known and a number of new discoveries await further appraisal. The major hydrocarbon fields lie along the western margin of the Allanooka Terrace and Dandaragan Trough. Wells drilled in the deeper Dandaragan Trough mostly have poor porosity and tight reservoirs.

Suprabasinal petroleum supersystems that include the Perth Basin are defined as Gondwanan, which is dominated by Permian terrestrial facies, and Austral, which is associated with breakup (Longley et al., 2001). The naming of individual petroleum systems using source and reservoir stratigraphic names as set out by Magoon and Dow (1994) is not attempted here because of the uncertainties of determining the source and the large number of reservoir units present. However, much of the terminology in this report follows that of Magoon and Dow (1994).

Mature source rocks are widespread, reservoirs are abundant, and there are many suitable structures for hydrocarbon entrapment in the northern Perth Basin. The major risk factor is the relationship of depth with porosity, and the timing of hydrocarbon charge relative to trap formation. The risk of seal integrity below the thick Lower Triassic regional seal is mostly low, but within the post-Lower Triassic succession seal can be a major risk factor, due to intense faulting and a high sandstone/shale ratio.

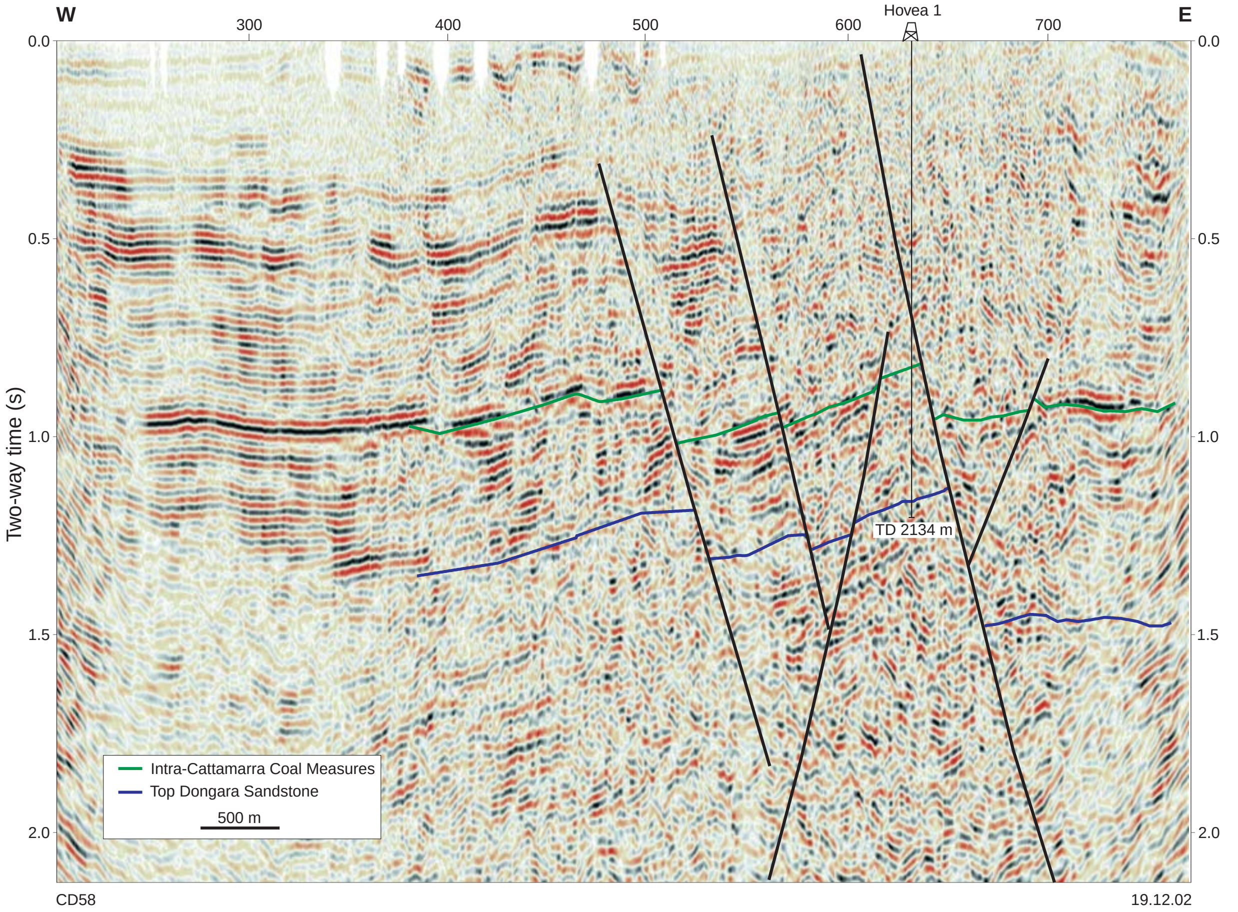


Figure 33. Seismic section A98-EW1-R showing the structure of Hovea 1

The main source for oil and gas is the basal marine facies of the Lower Triassic Kockatea Shale, with the most significant reservoirs in Upper Permian and Jurassic sandstone. The Lower Permian Irwin River Coal Measures, Carynginia Formation, and, to a lesser extent, the Jurassic Cattamarra Coal Measures are also gas sources (Boreham et al., 2001a,b). The present rate of commercial success of wells drilled in the northern part of the basin is approximately one in ten. Major play types include Permian–Triassic and Jurassic anticlines as well as tilted fault blocks and stratigraphic traps.

The stratigraphic distribution of source rocks, reservoirs, and seals is summarized in Table 2.

Source rocks and maturity

The most detailed discussions on the source-rock potential of the northern Perth Basin are by Thomas (1979, 1982, 1984), Thomas and Brown (1983), and Summons et al. (1995). The main source rocks within the onshore northern Perth Basin are terrestrial facies within the Lower Permian Irwin River Coal Measures, marine mudstone of the Lower Permian Carynginia Formation and Lower Triassic Kockatea Shale, and coaly and carbonaceous facies in the Lower Jurassic Cattamarra Coal Measures. In the adjacent offshore part of the basin, the main source rocks are within the Woodada Formation, Cadda Formation, Cattamarra Coal Measures, Yarragadee Formation (Crostella, 2001), and possibly the Irwin River Coal Measures and Kockatea Shale.

The Kockatea Shale has long been considered the primary source for oil and gas resources within Permian, Triassic, and Jurassic sandstone reservoirs in the northern Perth Basin. Boreham et al. (2001a) have positively identified Permian, Triassic and, to a lesser extent, Jurassic sources for oil and gas, and confirmed from carbon isotopes that the Kockatea Shale is the principal and highest quality source of oil and gas in the onshore part of the basin. Offshore, the Kockatea Shale has diminished potential for oil generation, but still may have yielded gas.

Maturity maps (Thomas and Brown, 1983; Mory and Iasky, 1996, figs 56–57) show that the Triassic and Permian section in the northern part of the basin is within the oil-maturation window. Maturation increases to the southeast where the Triassic lies within the oil window and the Permian is within the gas-generative window. In the Dandaragan Trough, the Kockatea Shale and Permian units are now within the gas-maturation window. Jurassic source rocks at shallow depths are largely immature, but the Cattamarra Coal Measures are mature in the deeper parts of the basin (Dandaragan and Coomallo Troughs). The lower part of the Yarragadee Formation is marginally mature.

Table 2. Summary of the petroleum potential of the northern Perth Basin

Unit	*Source*	*Hydrocarbon type*	*Reservoir*	*Seal*	*Comments*
Cretaceous–Jurassic					
Parmelia Group	yes	oil	high ϕ and k	?intraformational Otorowiri Member	offshore source
Jurassic					
Yarragadee Formation	yes	gas and oil from coals	high ϕ and k	uncertain	offshore source
Cadda Formation	yes		no	regional	offshore source
Cattamarra Coal Measures	yes	gas and oil from coaly intervals	high ϕ and k	intraformational	Gingin, Walyering, Mount Horner, North Yardanogo
Eneabba Formation	no		high ϕ and k	?intraformational	
Triassic					
Lesueur Sandstone	no		high ϕ and k	no	
Woodada Formation	yes		moderate ϕ and k	uncertain	offshore source
Kockatea Shale	yes	gas and oil from basal marine mudstones	Arranoo Member, low ϕ and k	regional	Dongara, Mount Horner
Upper Permian					
Dongara Sandstone	no	oil and gas	high ϕ and k	no	Beharra Springs, Dongara, Woodada, Mount Horner, Mondarra, Yardarino
Beekeeper Formation	?	oil and gas	fractured limestone and thin sandstone	possible	Beharra Springs, Woodada
Wagina Sandstone	yes	gas	?ϕ and k	no	Dongara, Mondarra
Lower Permian					
Carynginia Formation	yes	gas	minor sandstone	possible intraformational	Dongara
Irwin River Coal Measures	yes	gas (coaly intervals) oil (offshore)	low ϕ and k	intraformational	Dongara, Yardarino, Mount Horner Cliff Head
High Cliff Sandstone	no		low ϕ and k	no	
Holmwood Shale	?		minor sandstone	possible	
Nangetty Formation	?		basal sandstone	possible	

NOTES: ϕ: porosity
k: permeability

Maturation varies significantly across the basin

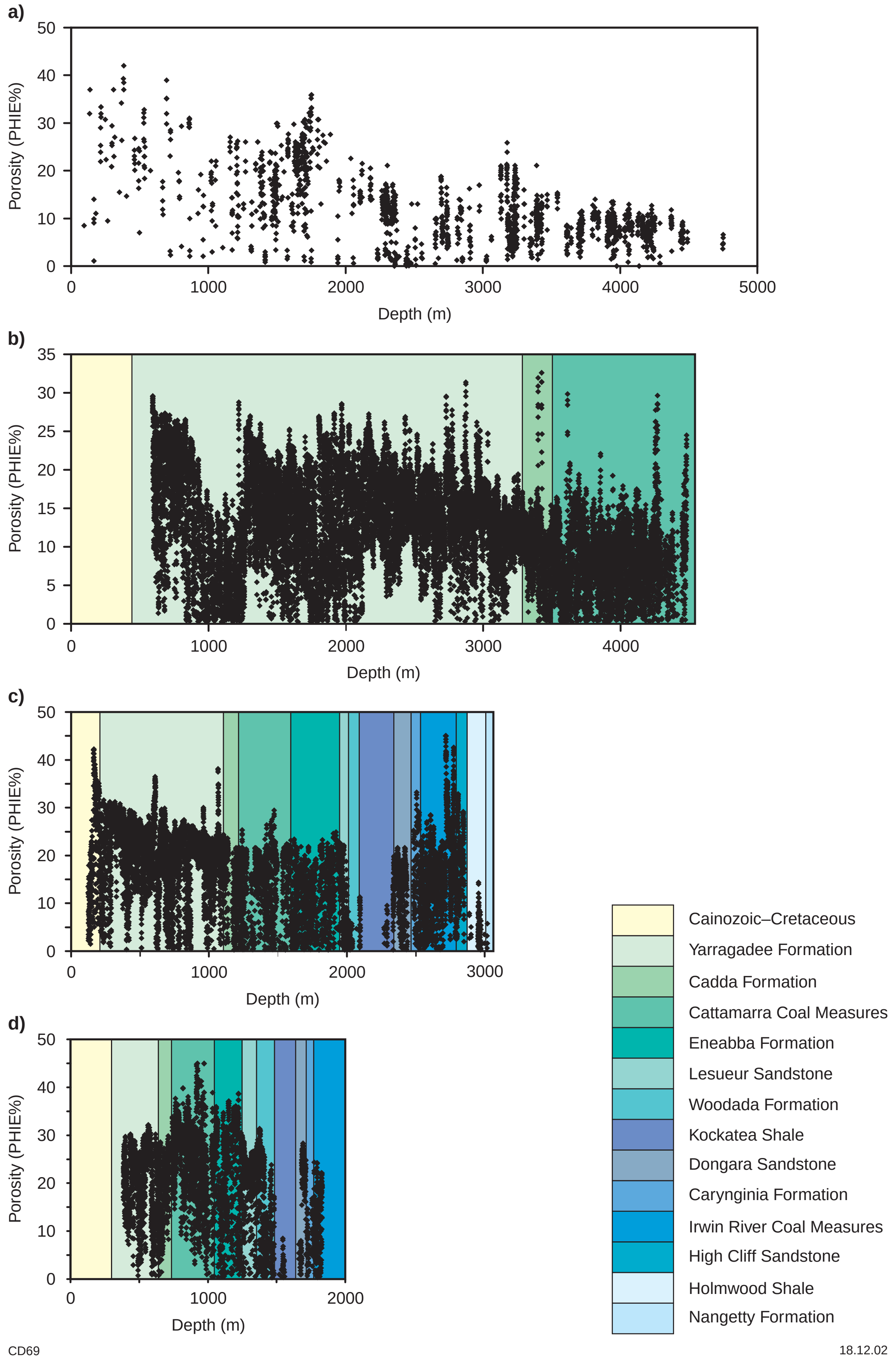


Figure 34. Porosity data from the northern Perth Basin: a) porosity measured from core versus depth for all wells; b) Gingin 2 log porosity versus depth; c) Yardarino 2 log porosity versus depth; d) Dongara 11 log porosity versus depth

Reservoirs

Reservoir units in the northern Perth Basin are present from the Lower Permian through to the Jurassic. The Upper Permian Dongara Sandstone and Beekeeper Formation are the best quality and most studied reservoirs in the northern Perth Basin, and contain the bulk of the hydrocarbons discovered to date. The Irwin River Coal Measures and Carynginia Formation have produced gas in several fields. Minor accumulations are recorded from the Arranoo Member and Cattamarra Coal Measures.

Permian, Triassic, and Jurassic reservoirs have good porosity and permeability at shallow depths. Porosity decreases with depth in all these reservoirs, and at depths greater than 2700 m porosity degradation becomes a major risk factor (Fig. 34a). Local variations of reservoir composition, timing and depth of burial, and hydrocarbon charge affect porosity. The volume and timing of hydrocarbon charge presumably also affected porosity, as it is anomalously high relative to the depths of the reservoirs in the Beharra Springs and Mondarra gasfields, for example.

In general, the porosity and permeability of Upper Permian reservoirs decreases with depth due to mechanical compaction and silicification. Two mechanisms for porosity preservation have been proposed: preservation of pore volume by chlorite coating (Tupper et al., 1994), and by hydrocarbon emplacement (Rasmussen et al., 1989; Rasmussen and Glover, 1996).

Mondarra 1 is a key well in the analysis of the Dongara Sandstone because it has a gas-charged reservoir with good porosity directly above a water-wet section with degraded porosity. The boundary between the two zones has been referred to as the porosity floor. One possibility is that quartz overgrowths halted once hydrocarbons migrated into the trap at Mondarra 1. In this process porosity is preserved because hydrocarbons take up pore space, thereby reducing the fluid available to transport aqueous silica (Bjørkum et al., 1998). Given favourable timing, it is likely that porosity could be preserved at depth by early charging oil. Such a scenario may be responsible for the reasonable porosity values (14–19% in pay zone interval: 2685–2696 m; 5–10% immediately below) in the Mondarra gasfield, as the porosity floor in this well is deeper than predicted from other wells. Areas of porosity preserved in this manner are likely to be completely isolated from any aquifer because they are completely surrounded by impermeable, silicified sandstone. Furthermore, the reduction of the pore space due to cementation displaces water, which, if it cannot escape, may create abnormal formation pressure such as the slight overpressure initially shown by the reservoir at Mondarra 1. Gingin and Yardarino also show porosity preservation with depth due to inhibition of silica overgrowths (Figs 34b,c). By comparison, the Dongara oil- and gasfield is not deep enough to clearly illustrate such preservation (Fig. 34d).

Early diagenetic development of chlorite and illite coatings can also preserve porosity (Tupper et al., 1994; Salem et al., 2000). Tupper et al. (1994) identified several depositional facies in the northern Perth Basin and related them to three diagenetic compositions: chlorite–illite, kaolin, and carbonate. Authigenic chlorite and illite in Mondarra 1 and Beharra Springs 2 and 3 are present within the pay zone in these wells. At Beharra Springs, gas saturation extends below the zone of good porosity suggesting porosity degradation is not related to hydrocarbon charge or there was more than one charge of gas. Assuming porosity preservation is facies dependent, then facies identification and modelling should allow a better assessment of the reservoir risk.

Porosity increases with decreasing density of stylolites because the stylolite-quartz interface provides the source of the precipitated cement (Bjørkum et al., 1989). Stylolites have been noted in Mount Adams 1 (Philips and Cathro, 1991), but do not appear to be common.

Where timing of migration, entrapment, and diagenesis are favourable, good porosity is predicted within the Dongara Sandstone. However, it is difficult to determine these factors in sufficient detail to make valid predictions at the scale of individual leads and prospects. Therefore, it is difficult to be specific about reservoir risk apart from the general degradation with depth.

Seals

Seals exist regionally throughout the northern Perth Basin. The laterally extensive Lower Triassic Kockatea Shale is the primary regional seal for the northern Perth Basin. In the Permian succession, the Holmwood Shale seals the Nangetty Formation, reservoirs in the Irwin River Coal Measures are sealed intraformationally or by the shales of the Carynginia Formation, and reservoirs in the Carynginia Formation are sealed intraformationally. In the Jurassic, the Cadda Formation may provide an effective seal for the Cattamarra Coal Measures, which can also be sealed intraformationally. In the deeper parts of the Dandaragan Trough, the Yarragadee Formation is sealed either intraformationally or by the Otorowiri Formation.

Traps

The most prospective plays are anticlines, fault-controlled traps, and stratigraphic traps. An unfaulted anticline obviously is the best play within the area, but the presence of the Kockatea Shale at the depth of the objective within a fault-controlled trap would also be effective (Crostella, 1995; Mory and Iasky, 1996). The best potential for a stratigraphic trap is near to where the Dongara Sandstone pinches out below the Kockatea Shale.

The majority of traps in the northern Perth Basin formed during the Neocomian prior to the separation of Australia from Greater India, coinciding with or just pre-dating the peak period of hydrocarbon expulsion. In most parts of the basin, source rocks reached the oil-generating window during the Late Jurassic episode of rapid subsidence (Mory and Iasky, 1996).

Prospects and leads inventory

The operating companies within the northern Perth Basin have approved the leads and prospects outlined in this Record for public distribution. Other information has been obtained from published reports or open-file data from statutory petroleum exploration reports held by MPR. All well information has come from unpublished well completion reports; relevant wells and the corresponding reports are given in Appendices 4 and 5. Only the prospects that have been worked on by companies are included in this Record.

Leads and prospects have been given a maturity ranking and also assessed for geological risk. Leads have low to medium maturity and prospects have high maturity. Low maturity means that several risk elements lack firm assessment. Medium maturity means that further geological work is required to confirm risk assessment, whereas high maturity means that the prospect is ready to drill as further work is unlikely to reduce geological risk.

Geological risk is an evaluation of the chance of recovering hydrocarbons at the surface. No commercial considerations are included in this assessment. In this Record, geological risk has been assessed using four elements, for which a measure of probability is assigned: trap, source, migration and timing, and reservoir. There are two main benefits to including geological risk. Firstly, all leads and prospects are assessed in a consistent manner. Secondly, the description of the risk elements provides key information on the weaknesses and strengths of each lead or prospect.

Economic assessment is left to commercial operators who regularly deal with production and development scenarios, drilling costs, and oil price fluctuations. Given such fluctuations, this sort of assessment dates rapidly, and is therefore not included. The volumetrics used in this Record were provided by the permit operators.

The potential for increasing reserves in existing fields is considered developmental and has not been included. A detailed description of producing fields and the potential for further work within them is available in Owad-Jones and Ellis (2000).

Beagle–Dongara Ridge

EP 413

Permit EP 413 is adjacent to the Beharra Springs gasfield and about 8 km south of the Dongara oil- and gasfield. Most of the permit is on the Beagle–Dongara Ridge, but the eastern-most part lies on the Cadda Terrace. EP 413 is dominated by the Mountain Bridge Fault and by other smaller, north-northwesterly trending faults (Fig. 35). The permit contains three prospects, Freshwater Point, Jingemia, and Stockyard, and four leads (Aiyennu, Freshwater Point North, Uniwa, and Weelawadji) of which three are bounded by a major fault, and the rest by smaller faults parallel to the major fault (Fig. 35).

Freshwater Point prospect

Hydrocarbon type	Gas
Permit	EP 413 R1
Operator	Origin Energy Developments Pty Ltd
Maturity	Low–medium
Geological risk	1:6.6
Depth to objective	1350 m
TD	2000 m AMSL (Australian mean sea level) — 50 m into crystalline basement
Volumetrics P_{50}	2.2 Gm^3 (77 Bcf) recoverable reserves
Surface area	3.64 km^2
Play type	Fault trap
Primary objective	High Cliff Sandstone and Irwin River Coal Measures
Secondary objective	Sandstones within the Holmwood Shale
Key strengths	Limited burial has resulted in retention of primary porosity
Key weaknesses	Poor top seal and untested charge
Proposed well location	Latitude 29°33'38.5"S Longitude 114°59'51.7"E Seismic line SB84-03 at SP 5774
Seismic coverage	Numerous lines of various vintages

Summary

The Freshwater Point prospect lies 4 km southwest of Robb 1 on an upthrown block on the western side of the Mountain Bridge Fault (Fig. 35). The primary reservoirs are the Irwin River Coal Measures and High Cliff Sandstone. Sandstones within the Holmwood Shale are secondary objectives. The top seal is provided by intraformational seals in the Irwin River Coal Measures and Carynginia Formation.

Nearby wells

Arramall 1, Arrowsmith 1, Beharra 1 and 2, Mountain Bridge 1, North Yardanogo 1, Robb 1, and Woodada 1.

Assessment of geological risk elements

• Trap: fault block similar to Dongara oil- and gasfield	0.6
• Source: proven source for oil and gas in area	0.7
• Migration and timing: similar to proven play types	0.6
• Reservoir: Permian reservoirs thin towards coast	0.6
Probability of recovering hydrocarbons to the surface	1:6.6

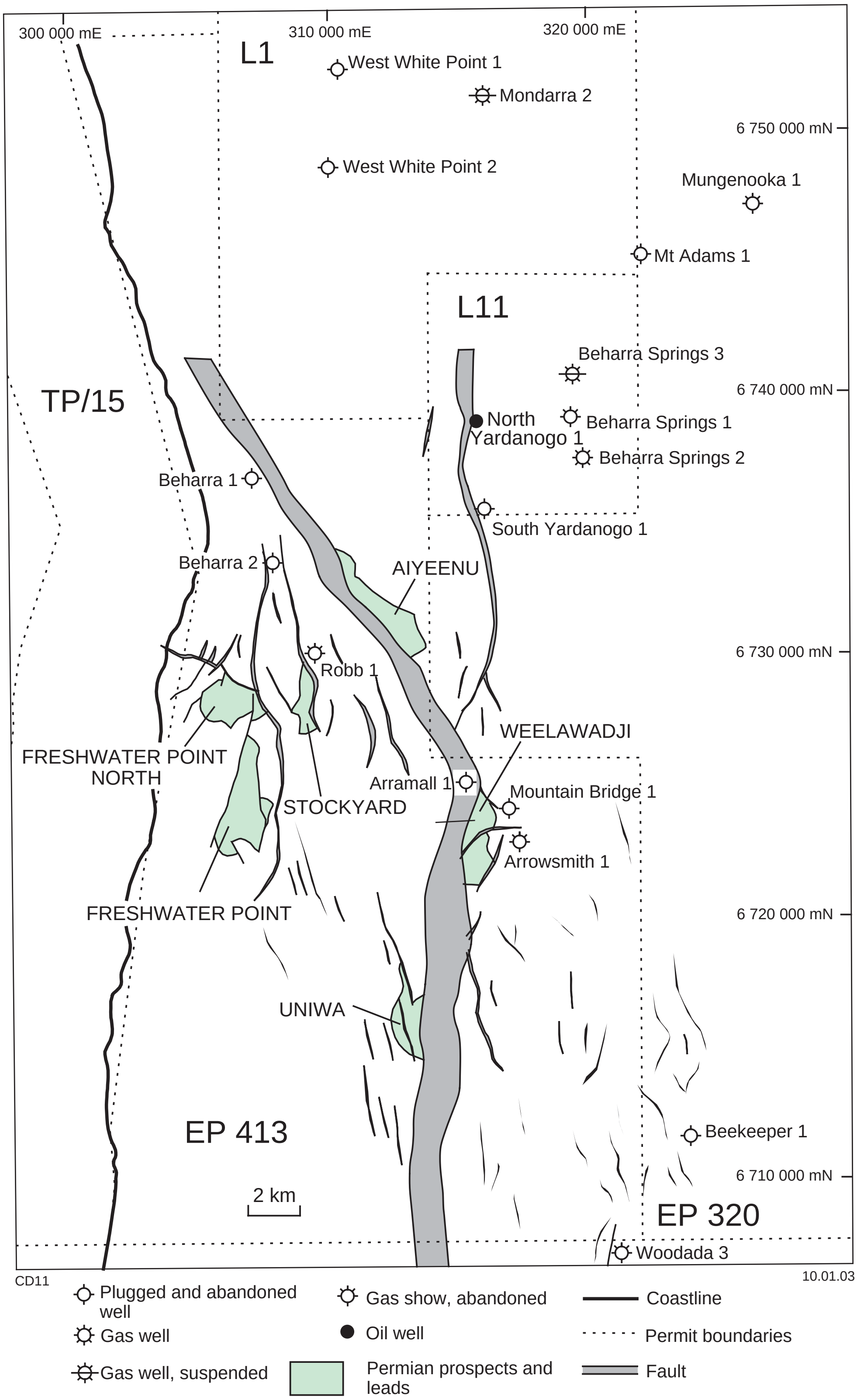


Figure 35. Prospects and leads of EP 413 (after Origin Energy Resources Ltd, 2000)

Trap

The structure is an upthrown, tilted fault block on the western side of a splay from the Mountain Bridge Fault (Fig. 36). The structure at Freshwater Point requires two faults to seal it. The fault throw, on seismic line SB93-02, is in the order of 150 msecs (Fig. 37). The cross-fault seal is probably the Kockatea Shale, which is about 400–500 m thick (180 msecs; Mory and Iasky, 1996) in this prospect. Similar cross-fault seals are effective in a similar structural setting at the Dongara oil- and gasfield. The Holmwood Shale is expected to seal the secondary objective.

Source

The Kockatea Shale probably provides the main oil-prone source and the Irwin River Coal Measures the gas-prone source for the Freshwater Point prospect. The source pod is interpreted to lie east of the Mountain Bridge – Beagle Fault.

Migration and timing

Migration possibly took place in the Late Jurassic, most likely from the east across the Mountain Bridge – Beagle Fault, but this pathway is currently untested.

Reservoir

The primary reservoirs for the Freshwater Point prospect are the High Cliff Sandstone and Irwin River Coal Measures, with sandstones within the Holmwood Shale forming the secondary target. Robb 1, 4 km from the proposed well, displays excellent reservoir quality at all these targets. Limited burial on the Beagle Ridge has permitted the retention of good prosity in the Upper Permian reservoirs. The Lower Permian High Cliff Sandstone and Irwin River Coal Measures also thin onto the Beagle Ridge and may be less than 50 m thick within the Freshwater Point prospect.

Stockyard prospect

Hydrocarbon type	Gas
Permit	EP 413 R1
Operator	Origin Energy Developments Pty Ltd
Maturity	Low–medium
Geological risk	1:5.7
Depth to objective	1837 m
TD	2000 m AMSL — 50 m into crystalline basement
Volumetrics P_{50}	0.57 – 0.85 Gm^3 (20–30 Bcf) OGIP
Surface area	5.04 km^2
Play type	Fault/dip
Primary objective	Sandstones within the Holmwood Shale
Secondary objectives	High Cliff Sandstone and Irwin River Coal Measures
Key strengths	Good reservoir quality
Key weaknesses	Charge and seal integrity
Proposed well location	Latitude 29°33'16.31"S Longitude 115°01'57.31"E Seismic line HP82-211 at SP 246
Seismic coverage	Various vintages, poorly defined

Summary

The Stockyard prospect is a three-way dip-closed structure on the western side of the Mountain Bridge Fault, about 0.3 – 2.5 km south of Robb 1 (Fig. 35), and relies on fault closure to the east. The prospect shows closure at the Holmwood Shale, High Cliff Sandstone, and Irwin River Coal Measures levels.

Nearby wells

Arramall 1, Arrowsmith 1, Beharra 1 and 2, Mountain Bridge 1, and Robb 1.

Assessment of geological risk elements

• Trap: three-way structural feature	0.6
• Source: proven source for oil and gas in area	0.7
• Migration and timing: Robb 1, just to the north, had a small gas show	0.7
• Reservoir: Permian reservoirs thin towards the coast	0.6
Probability of recovering hydrocarbons to the surface	1:5.7

Trap

The Stockyard prospect is a tilted fault block on the upthrown side of the Mountain Bridge Fault, and has dip closure at the Permian objective level. The Kockatea Shale and Caryngiinia Formation most likely provide top and lateral seals at this prospect. The weak gas show in Robb 1, which lies at a structurally lower level, implies this trap is more likely to have been charged.

Source

The two primary sources proposed for the Stockyard prospect are the Kockatea Shale and Irwin River Coal Measures. The Irwin River Coal Measures are probably the dominant gas source at the Beharra Springs and Woodada gasfields, and Dongara oil- and gasfield. The formation contains high proportions of black, highly carbonaceous material, which grade into lenticular coals. Oil within the basin is probably predominantly from the Kockatea Shale, with the Mount Horner oilfield and North Yardanogo accumulation being geochemically linked to this unit. In EP 413, the Kockatea Shale is dominantly composed of medium- to light-grey claystones.

Migration and timing

Maturity modelling indicates that the two potential source horizons are not mature for generation west of the Beagle Fault in EP 413; however, maturity has been reached east of the fault. Therefore, it is proposed that migration from 3.5 – 4 km to the east across the Beagle Fault is the most likely pathway.

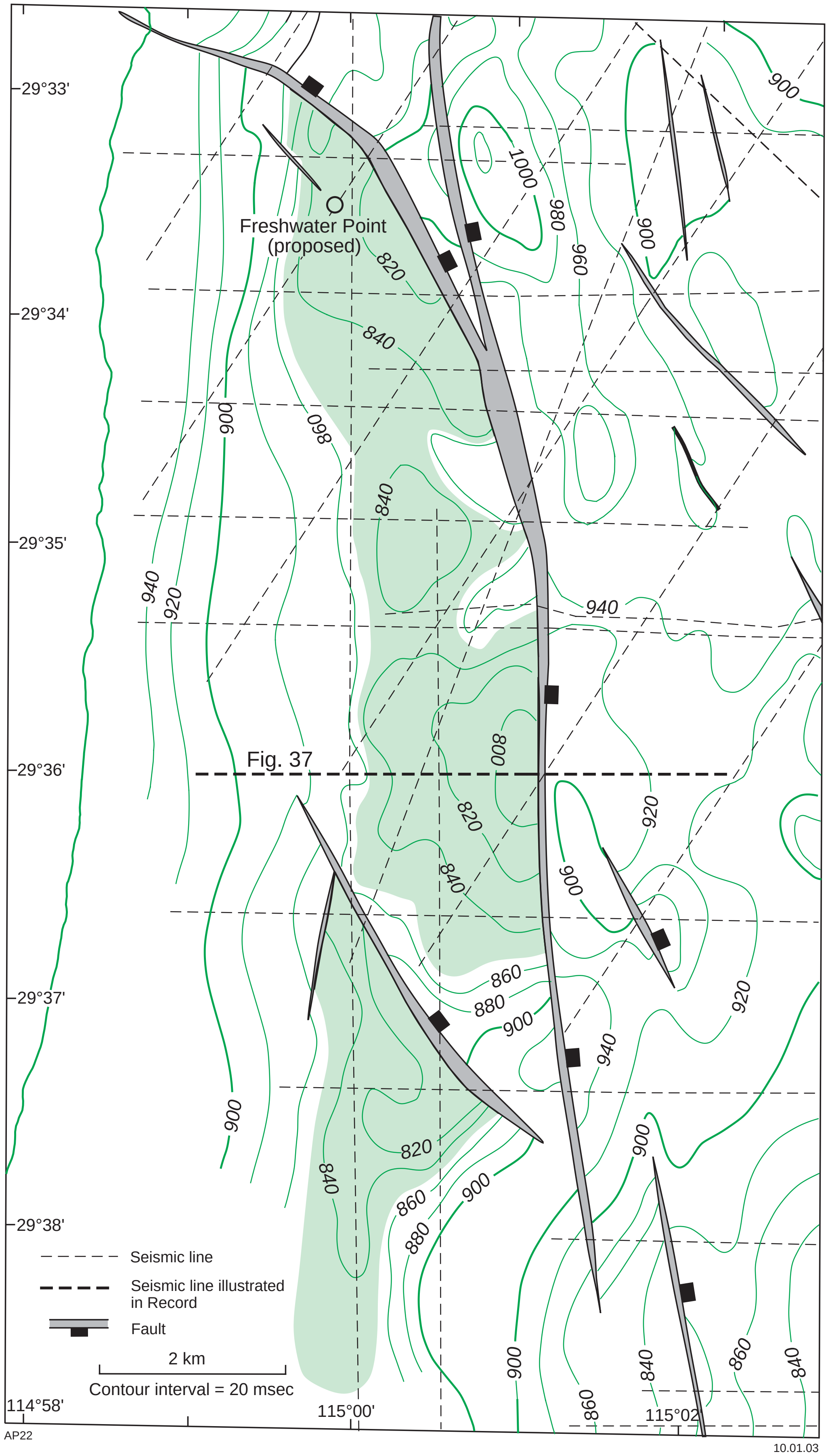


Figure 36. **Two-way time contours of the basal Triassic horizon, Freshwater Point prospect (after Premier Oil Australia Pty Ltd, 1998)**

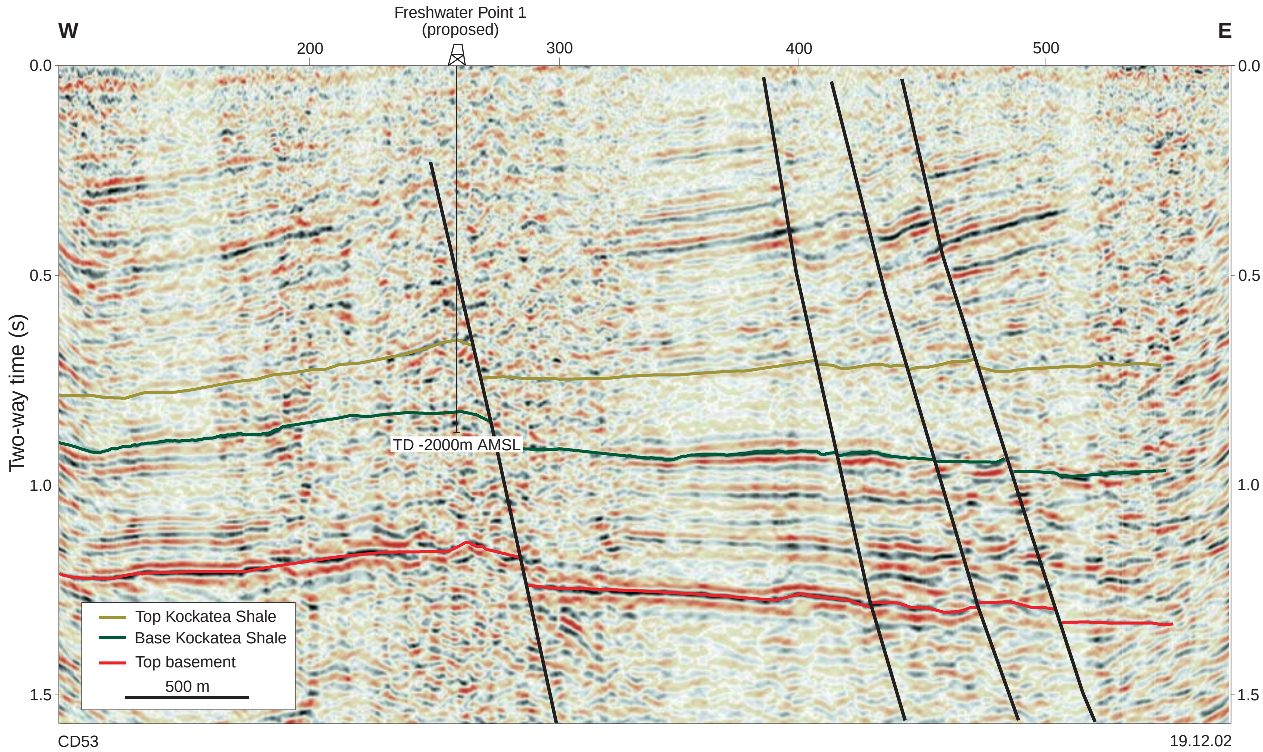


Figure 37. Seismic section SB93-02 showing the structure of the Freshwater Point prospect. The depth to the objective is 1350 m

Reservoir

Primary pore space has been retained down to basement in the section west of the Beagle Fault. This is primarily due to lesser burial in the western areas compared to the tight sections east of the Beagle Fault within EP 413. The primary reservoir target is a sandstone within the Holmwood Shale, which is 21 m thick in Robb 1. Excellent reservoir potential has been calculated from that well and adjacent wells west of the Beagle Fault. Potential secondary reservoir targets are the High Cliff Sandstone and the basal part of the Irwin River Coal Measures.

Cliff Head trend

The Cliff Head trend lies within territorial waters southwest of Dongara and extends about 30 km along the eastern flank of the Abrolhos Sub-basin. Within this area basement is less than 2000 m below the seabed. The Cliff Head trend is a series of rotated northerly trending horst blocks with several discrete closures (Roc Oil (WA) Pty Ltd, 2000a). The trend is bounded to the west by a major northerly trending, westerly dipping normal fault, the Geraldton Fault, and to the east by a series of north-westerly trending faults. The Cliff Head area contains one proven oilfield, and six prospects — Capel, Mentelle, Frankland, Moondah, Twin Lions, and Vindara (Fig. 30). Several smaller leads are present to the south, most of which have their western boundary as a small fault subparallel to the Geraldton Fault. The Cliff Head trend has the potential to contain both oil and gas as the structures in the area were formed before the main phase of oil generation (Australian Worldwide Exploration Ltd, 2001a). The proximity of existing infrastructure at Dongara and the Parmelia Pipeline should distinctly enhance the likelihood of their development.

The Cliff Head structure is the largest of the structures along the Cliff Head trend, and was selected to demonstrate the prospectivity of the entire Cliff Head trend with the drilling of Cliff Head 1 and 2. These wells are discussed in **Recent discoveries**.

L1 and L2

The L1 and L2 production licences next to the town of Dongara are about 400 km north of Perth, and lie within an oil- and gas-prone area containing the Dongara oil- and gasfield — the largest onshore field found so far on mainland Western Australia — as well as several other smaller fields (Fig. 38). The two licences straddle the Dongara Ridge and the Beharra Springs Terrace.

Production within the area is primarily from Permian sandstone, especially the Dongara Sandstone capped by the Kockatea Shale, at depths commonly less than 2000 m. Most of the existing fields, prospects, and leads lie on the western margin of the Dandaragan Trough and Allanooka Terrace, implying that the main source pod is in the downthrown southeastern quadrant of the Mountain Bridge and Allanooka Faults. Proven sources of oil and gas within this region are the Kockatea Shale, Irwin River Coal Measures, and Carynginia Formation. Traps within the region formed in the Early Cretaceous coincident with,

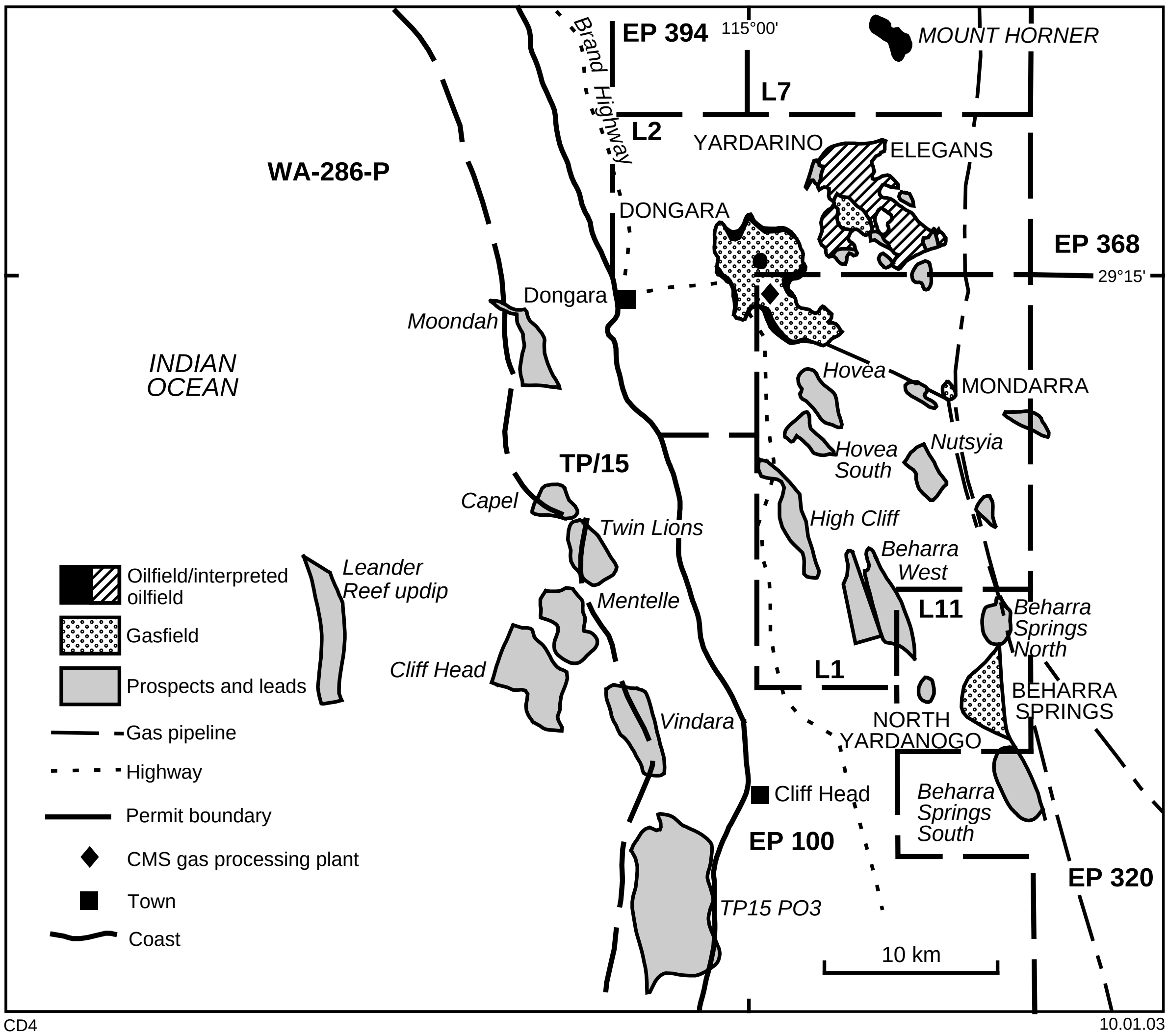


Figure 38. Prospects and leads of L1 and L2 (after Arc Energy NL, 2002, written comm.)

or just pre-dating, the peak period of hydrocarbon expulsion. The main source rocks within L1 and L2 probably reached the oil-generation window during the period of rapid subsidence in the Late Jurassic to earliest Cretaceous (Yarragadee Formation and Parmelia Group) immediately prior to this event (West Australian Petroleum Pty Ltd, 1996).

Any prospects and leads within the L1 and L2 licences are considered to be relatively low risk in terms of gas and oil migration and charging of traps. The proximity of current infrastructure, such as the Parmelia and DBNGP pipelines and the Dongara plant and compression facilities, is a significant economic advantage for the commercialization of any new oil and gas discoveries in this area.

Beharra West lead

Hydrocarbon type	Gas
Permit	L1
Operator	Arc Energy NL
Maturity	Low–medium
Geological risk	1:4.3
Play type	Fault trap
Primary objective	Reservoir at base Kockatea Shale level
Key strengths	Proximity to the Beharra Springs gasfield
Key weaknesses	Depth of reservoir
Seismic coverage	Sparse data of several vintages of varying quality

Summary

The Beharra West lead is located in the south of L1, 2 km north of North Yardanogo 1 (Fig. 38). The primary objective is likely to be the Dongara Sandstone interfingering with carbonate of the Beekeeper Formation. Such interfingering may form part of the trap. The proximity of this lead to the Beharra Springs gasfield, at the same stratigraphic level, implies similar reservoir characteristics.

Nearby wells

Beharra Springs 1, 2, and 3, Mount Adams 1, North Yardanogo 1, and West White Point 2.

Assessment of geological risk elements

• Trap: tilted fault block	0.7
• Source: close to known gas accumulation at Beharra Springs gasfield	0.8
• Migration and timing: potential for porosity to degrade prior to charge	0.6
• Reservoir: reservoir sandstone present in area	0.7
Probability of recovering hydrocarbons to the surface	1:4.3

Trap

The lead is mapped as a 6 × 3 km, fault-bound anticline on the western flank of the Dandaragan Trough. The majority of faulting on the western flank of the Dandaragan Trough is down to the east and trends north-northwest. The lead is on the upthrown side of such a fault west of the Beharra Springs gasfield and should be shallower than this field. The objective is likely to be about -2900 m AHD, as the base of the Kockatea Shale is at -3528 m AHD in Mount Adams 1 and ~3283 m AHD in Beharra Springs 1.

Source

The Beharra Springs gasfield is sourced from the Lower Permian Irwin River Coal Measures, possibly with a small contribution from the Carynginia Formation. The Beharra West lead is likely to have the same sources. Gas generation from the Irwin River Coal Measures and Carynginia Formation in the Dandaragan Trough was in the Middle Jurassic. In this region, these formations are currently marginally mature for gas generation.

Migration and timing

The timing of the gas charge to trap formation is demonstrably favourable in this area. However, the relative timing of porosity degradation and charge in the region are poorly constrained.

Reservoir

The Dongara Sandstone thins to the west and interfingers with the Beekeeper Formation, but still should provide adequate reservoir sandstone.

High Cliff lead

Hydrocarbon type	Gas
Permit	L1
Operator	Arc Energy NL
Maturity	Low–medium
Geological risk	1:5.7
Play type	Tilted fault block
Primary objective	Permian–Triassic
Key strengths	Hydrocarbon migration
Key weaknesses	Structure and reservoir
Seismic coverage	Sparse data of several vintages of varying quality

Summary

The High Cliff lead is located 10 km southwest of the Mondarra gasfield and 10 km northwest of the Beharra Springs gasfield (Fig. 38), and is a tilted fault block on the western upthrown side of the Mountain Bridge Fault. In this area the objective sandstone (Dongara Sandstone) thins to the west and interfingers with carbonate of the Beekeeper Formation.

Nearby wells

West White Point 1 and 2.

Assessment of geological risk elements

• Trap: tilted fault block	0.6
• Source: close to known gas accumulation at Beharra Springs gasfield	0.7
• Migration and timing: potential for porosity to degrade prior to charge	0.6
• Reservoir: reservoir sandstone present in area	0.7
Probability of recovering hydrocarbons to the surface	1:5.7

Trap

The High Cliff lead is probably a tilted fault block on the upthrown side of the southern extension of the Mountain Bridge Fault, as the area is dominated by fault blocks tilted to the west and bounded by northerly trending normal faults.

Source

The Kockatea Shale and the Irwin River Coal Measures are the source of most oil and gas generated in this area. Minor hydrocarbons have also been generated from the Carynginia Formation.

Migration and timing

The timing of the gas charge relative to trap formation is demonstrably favourable in this area, as shown by the Beharra Springs, Dongara, and Mondarra fields.

Reservoir

The Dongara Sandstone thins to the west and interfingers with the Beekeeper Formation, but still should provide adequate reservoir sandstone.

Hovea South lead

Hydrocarbon type	Oil and gas
Permit	L1
Operator	Arc Energy NL
Maturity	Low–medium

Geological risk	1:5.7
Play type	Upthrown tilted fault block
Primary objective	Dongara Sandstone
Key strengths	Source, reservoir
Key weaknesses	Seismic coverage
Seismic coverage	Sparse, poor-quality seismic allows for the potential to drill off structure Vintage of seismic: 1989

Summary

The Hovea South lead (formerly Jacaranda lead) is about 500 m southwest of Hovea (Fig. 28) and lies in an area containing a series of fault blocks tilted to the west. The lead is close to the Dongara oil- and gasfield (Fig. 38) and could be developed quickly, but requires further seismic data to reduce the trap risk. If a competent trap can be demonstrated, the geological risk will be low as all other risk elements are favourable.

Nearby wells

Dongara 7 and West White Point 1.

Assessment of geological risk elements

• Trap: upthrown fault block	0.4
• Source: close to Dongara oil- and gasfield	0.9
• Migration and timing: uncertain, but probably similar to Dongara	0.7
• Reservoir: nearby wells have good quality reservoir	0.7
Probability of recovering hydrocarbons to the surface	1:5.7

Trap

The Hovea South lead is within an upthrown, tilted fault block (Fig. 27). The potential for the faults to seal has not been assessed, but it is likely that the Dongara Sandstone may be juxtaposed across the fault, increasing the fault risk.

Source

The Kockatea Shale is the known source of oil and gas in this area. The charge is likely to be dominantly oil with a low possibility of gas, as no gas cap is associated with the nearby Hovea structure.

Migration and timing

The Hovea South lead probably formed at a similar time as the Dongara oil- and gasfield, and therefore the timing of charge relative to trap formation should be favourable. Long-range migration is not necessary as the main reservoir (Dongara Sandstone) lies directly below the regional source and seal (Kockatea Shale).

Reservoir

Good quality reservoir, comparable to that in the Dongara oil- and gasfield and West White Point 1, is likely to be present. Hovea South is shallower than West White Point 1 and so should have better porosity.

Beermullah Trough

EP 389 — Gingin–Bullsbrook trend

Permit EP 389 is dominated by the northerly trending Gingin–Bullsbrook trend, within the Beermullah Trough (formerly part of the Dandaragan Trough; Fig. 39). Over 1400 line kilometres of seismic data are available within the permit, but some date back to 1965. Significant areas of structural closure are present along the axis of the Gingin–Bullsbrook trend (Fig. 39) and are probably the result of the convergence of the Cervantes and Turtle Dove Transfer Zones, which bound the Beermullah Trough to the northeast and southwest respectively (Crostella and Backhouse, 2000). The Gingin–Bullsbrook trend probably formed during the Early Cretaceous wrenching tectonism associated with continental break-up, and extends south into permit EP 415. The Brand Highway and the Dampier–Bunbury and Parmelia (Dongara–Pinjara) natural gas pipelines cross through EP 389. Most leads and prospects in this trend lie between 5 and 10 km from the pipelines, thereby allowing ready transportation of any new gas to Perth, 50 km to the south.

Eclipse prospect

Hydrocarbon type	Gas
Permit	EP 389
Operator	Empire Oil Company Ltd
Maturity	Medium
Geological risk	1:7.3
Depth to objective	3055 m
TD	3875 m
Volumetrics P_{50}	15.77 Gm^3 (557 Bcf) OGIP
Surface area	8 km^2
Play type	Anticline
Primary objective	Cattamarra Coal Measures
Key strengths	Structure and known hydrocarbons generated in area
Key weaknesses	Porosity and permeability
Proposed well location	Latitude 31°25'55.20"S Longitude 115°52'30.00"E Seismic line 99BBN-04 at SP 343
Seismic coverage	7 seismic lines Vintage of seismic: 1972, 1997, and 1999

Summary

The Eclipse prospect (formerly Bullsbrook North Downdip prospect) lies 27 km south of the Gingin accumulation and 4 km northwest of Bullsbrook 1 (Fig. 39). It is an unfaulted anticline with four-way dip closure at the Cattamarra Coal Measures level (Fig. 40). The structure is about 500 m higher than the Gingin accumulation and 400 m higher than Bootine 1. Empire Oil Company Ltd plan to test at least three gross sandstone packages that show potential to hold gas (Fig. 41). Due to its proximity to a likely deep source area immediately

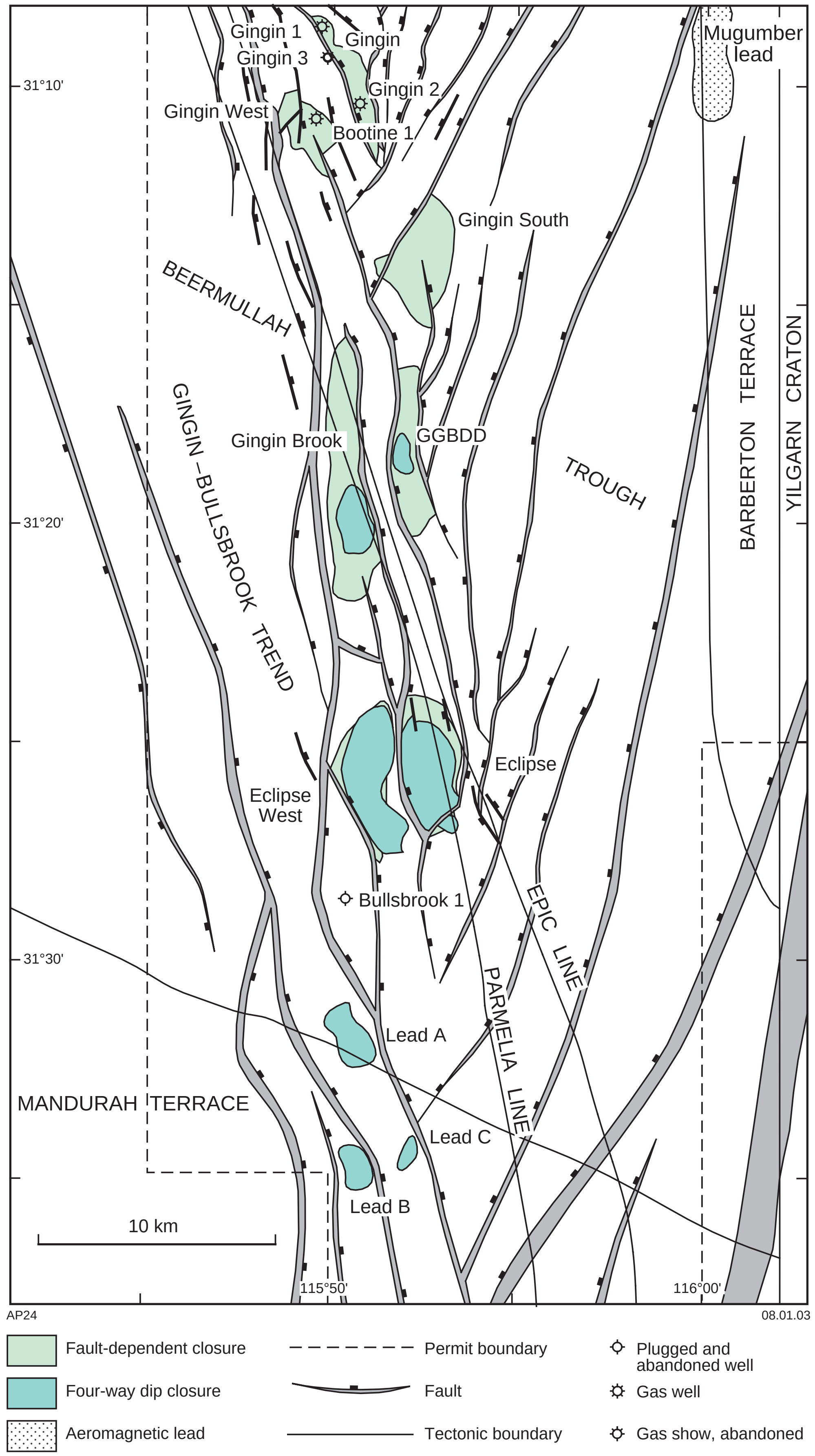


Figure 39. Prospects and leads along the Gingin–Bullsbrook trend, EP 389 (modified from Empire Oil Company Ltd, 2000)

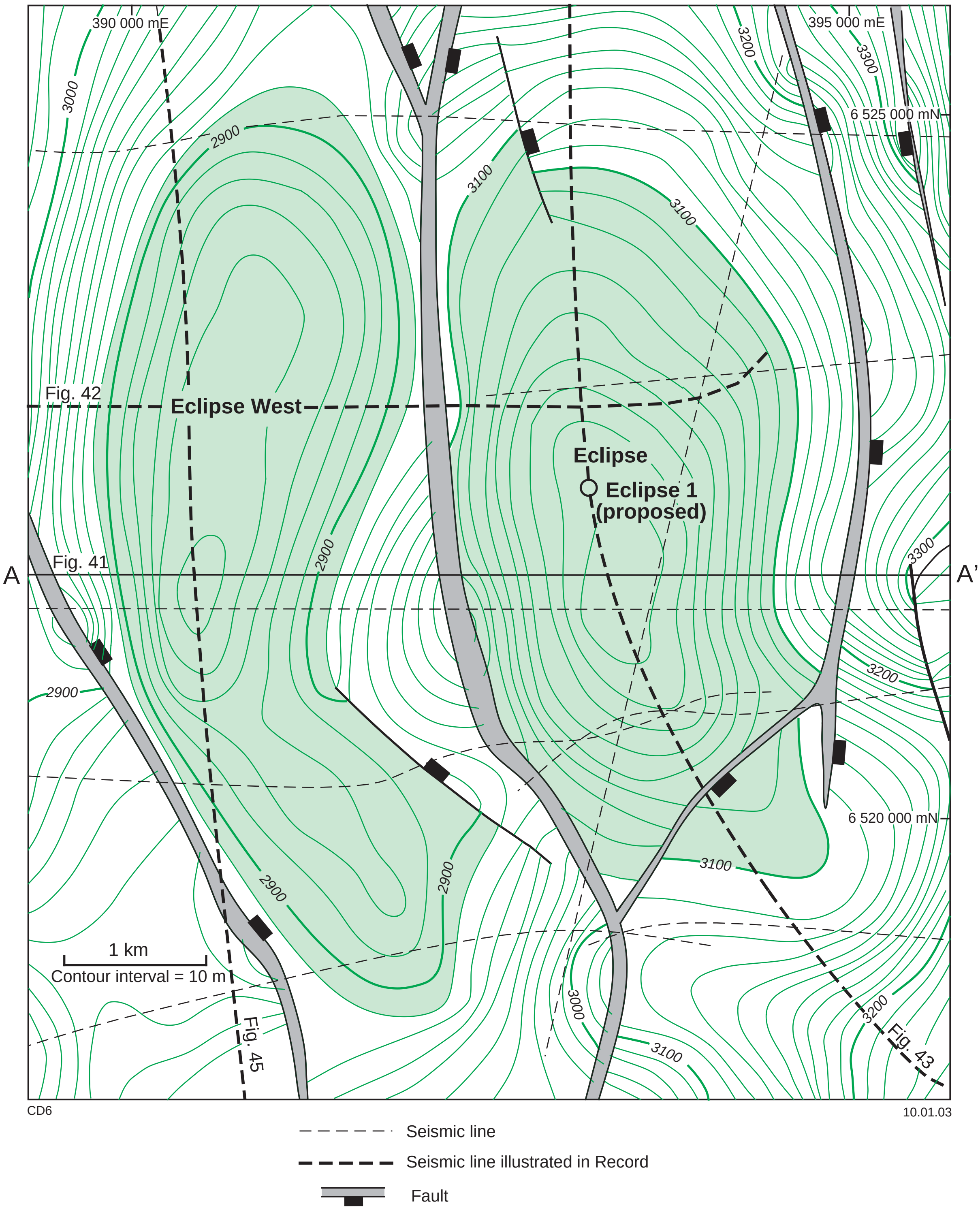


Figure 40. Depth contours to the top Cattamarra Coal Measures for the Eclipse and Eclipse West prospects (modified from Empire Oil and Gas NL, 2001)

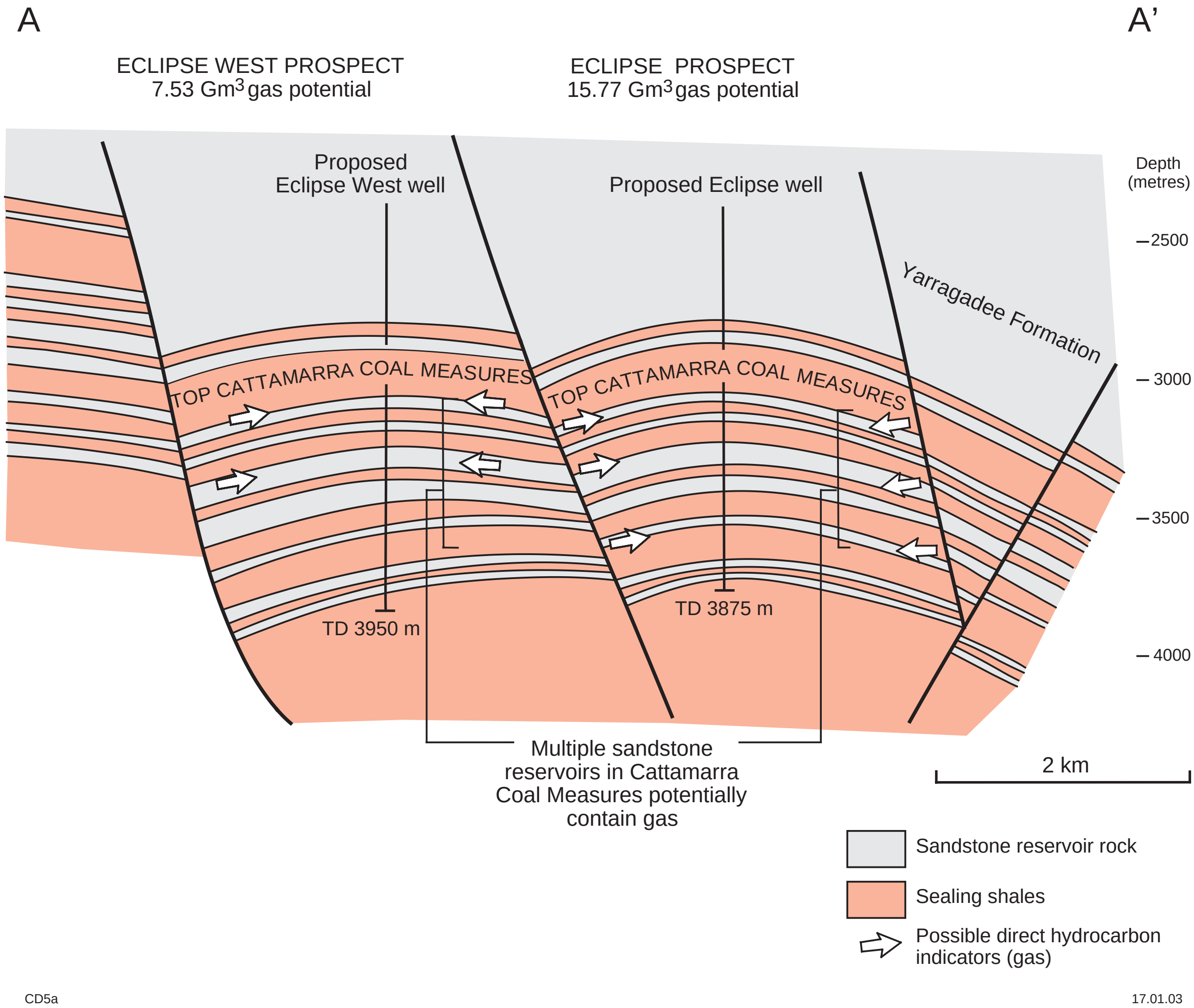


Figure 41. Cross section over the Eclipse and Eclipse West prospects (after Empire Oil and Gas NL, 2001). The location of the section is shown in Figure 40

to the east, the Eclipse prospect was probably one of the first structures in the Gingin–Bullsbrook trend to be charged, and will be drilled prior to Eclipse West.

Nearby wells

Bootine 1, Bullsbrook 1, and Gingin 1, 2, and 3.

Assessment of geological risk elements

- Trap: low risk trap as mapped 0.7
- Source: proven hydrocarbon generation in area 0.7
- Migration and timing: potential for porosity to degrade prior to charge 0.4
- Reservoir: potential for good porosity at objective level 0.7

Probability of recovering hydrocarbons to the surface 1:7.3

Trap

The Eclipse prospect is a four-way, dip-closed structure requiring little or no fault seal (Fig. 40), and has been mapped with several vintages of seismic data. The top and lateral seals are provided by the upper Cattamarra Coal Measures and possibly the Cadda Formation (Figs 41–43). The trap is ranked highly, as four-way dip closure persists throughout the entire Cattamarra Coal Measures. Consequently, there is the potential for gas within stacked reservoir sandstone over an interval of 770 m. The Cattamarra Coal Measures have demonstrated seismic amplitude anomalies, which are interpreted as direct indications of gas.

Regional thickening of the Cattamarra Coal Measures towards the west in the Gingin area (Crostella and Backhouse, 2000, figs 6 and 7) could weaken the western structural closure of the prospects and leads within EP 389, and implies a minor seal risk.

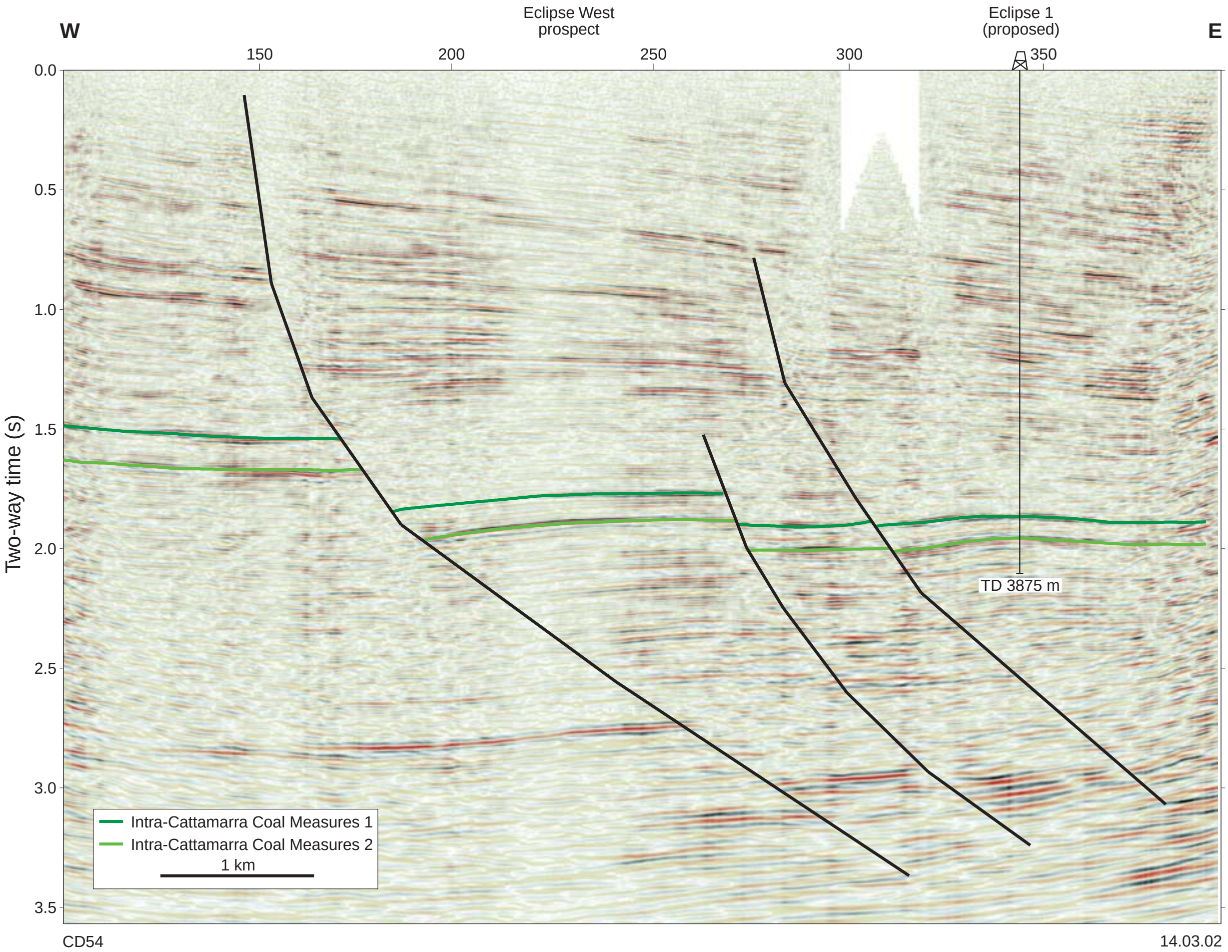


Figure 42. Seismic section 99BBN-02 showing the structure of the Eclipse and Eclipse West prospects

Source

The active source in this area is most likely carbonaceous material within the Cattamarra Coal Measures in the Dandaragan Trough, and is the likely source of gas shows in Bullsbrook 1 (interpreted to be close to spill point), Gingin 1 and 2, and Bootine 1. Maturation data indicate that within the Dandaragan Trough the Cattamarra Coal Measures were mature for oil generation in the Late Cretaceous to Early Cainozoic (Owad-Jones and Ellis, 2000).

Migration and timing

The major risk is the timing of the hydrocarbon charge relative to the onset of porosity degradation. Bullsbrook 1 may not have been properly charged as the local geothermal gradient is lower than in surrounding wells, suggesting that the source may not be mature in this well. However, source rocks within the Dandaragan Trough, north of the Gingin–Bullsbrook trend, could have progressively supplied hydrocarbons along the trend into the Eclipse anticline. If this is the case, the Gingin accumulation, which lies within the Gingin–Bullsbrook trend, indicates there was an effective migration pathway.

The Eclipse prospect probably developed in the Early Cretaceous during the regional peak period of hydrocarbon expulsion, and thereby allowed hydrocarbons to migrate into the structure between the Late Cretaceous and Early Cainozoic.

Reservoir

Empire Oil Company Ltd concluded from Gingin 3 that the lower sandstone intervals of the Cattamarra Coal Measures contain the best quality reservoir and greatest potential for trapping hydrocarbons within the area. Porosities in the Cattamarra Coal Measures for the Eclipse prospect, extrapolated from Bullsbrook 1, are estimated at between 11 and 16%. The individual sandstone units within the unit are estimated to be between 10 and 20 m thick.

Eclipse West prospect

Hydrocarbon type	Gas
Permit	EP 389
Operator	Empire Oil Company Ltd
Maturity	Medium
Geological risk	1:7.3

Depth to objective	2850 m AMSL
TD	3950 m
Volumetrics P_{50}	7.53 Gm^3 (266 Bcf) OGIP
Surface area	9 km^2
Play type	Anticline
Primary objective	Cattamarra Coal Measures
Key strengths	Structure
Key weaknesses	Porosity charge
Proposed well location	Not available
Seismic coverage	5 seismic lines, 500 m to 1 km apart in the dip direction, and 1 strike line Vintage of seismic: 1972, 1997, and 1999

Summary

The Eclipse West prospect (formerly Bullsbrook North prospect) is 27 km south of the Gingin accumulation, and is immediately adjacent to the Eclipse prospect, which has the same structural style — an elongate, unfaulted anticline with four-way dip closure at the Cattamarra Coal Measures level (Fig. 40). At the level of the primary objective the structure is 170 m higher than in the Eclipse prospect.

Nearby wells

Bootine 1, Bullsbrook 1, and Gingin 1, 2, and 3.

Assessment of geological risk elements

- Trap: four-way dip closed trap 0.7
- Source: low geothermal gradient at Bullsbrook 1 0.7
- Migration and timing: potential for porosity to degrade prior to charge 0.4
- Reservoir: potential for good porosity at objective level 0.7

Probability of recovering hydrocarbons to the surface 1:7.3

Trap

Most of the Eclipse West structure has four-way dip closure; however, the maximum closure is bound to the west by a small down-to-the-east fault, which so far is shown by only one seismic line (Fig. 40). The structure is otherwise well defined by six seismic lines. The top and lateral seals are provided by the upper Cattamarra Coal

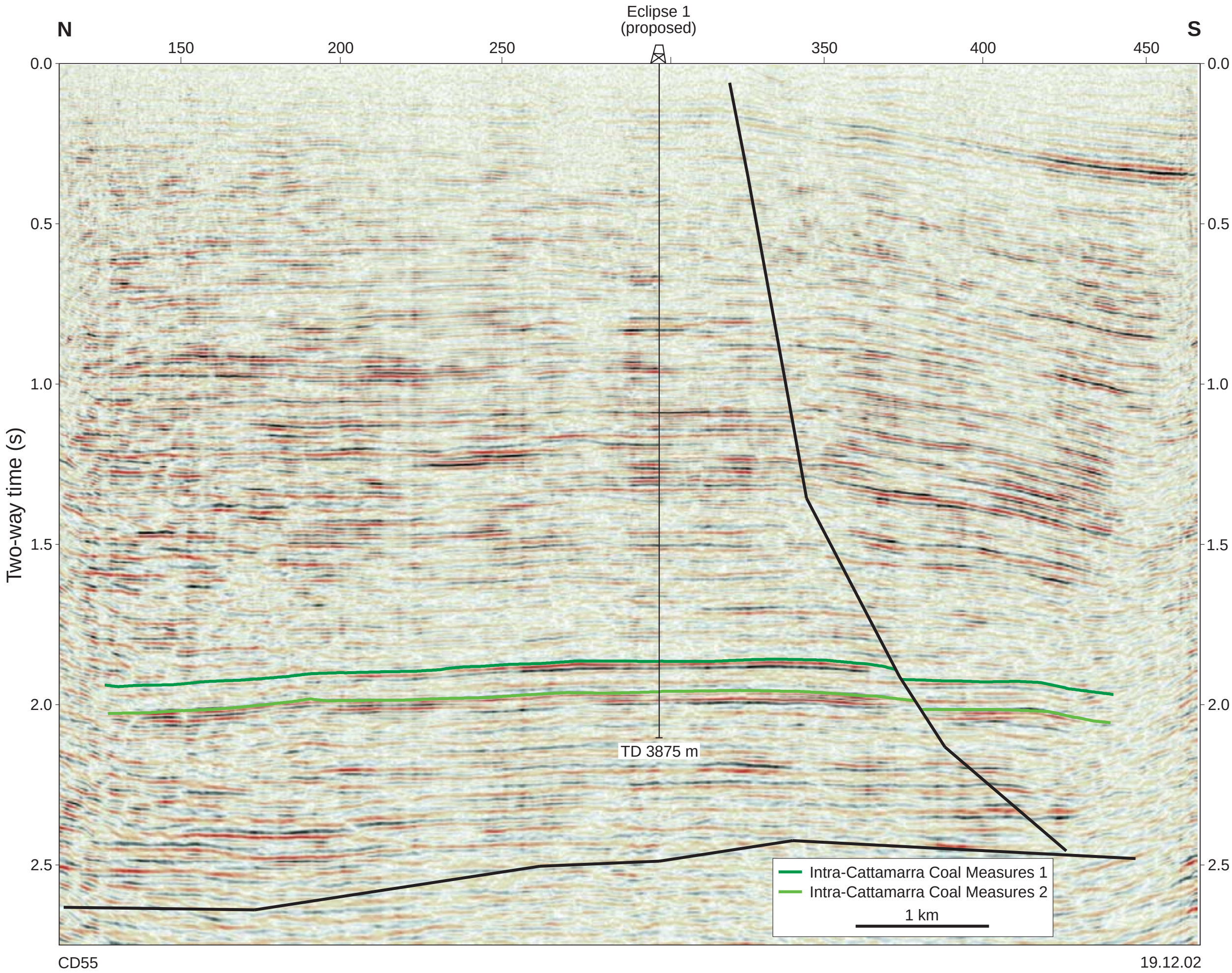


Figure 43. Seismic section 99BBN-04 showing the structure of the Eclipse prospect (longitudinal section)

Measures (Figs 41 and 42). The multiple sandstone reservoirs within the Cattamarra Coal Measures at the Eclipse prospect also are inferred to be present in the Eclipse West prospect.

Source

In this area, carbonaceous material within the Cattamarra Coal Measures is probably an active source, as shown by gas shows in Bullsbrook 1 (interpreted to be near spill point), Gingin 1 and 2, and Bootine 1. Maturation data indicate hydrocarbon generation from the Cattamarra Coal Measures in the Late Cretaceous to Early Cainozoic in the Dandaragan Trough (Owad-Jones and Ellis, 2000).

Migration and timing

The major risk is the timing of the hydrocarbon charge to the onset of porosity degradation. The low geothermal gradient in Bullsbrook 1 suggests lack of a local charge may be a further risk. However, the main source pod is inferred to lie within the Dandaragan Trough to the north, from which hydrocarbons should have migrated down the Gingin–Bullsbrook trend and into the Eclipse West anticline. The Eclipse West prospect probably developed at the same time as the Eclipse prospect, and therefore the same migration path and structural timing apply.

Reservoir

Porosity within the Cattamarra Coal Measures in Bullsbrook 1 ranges from 12% at 3109 m AMSL to 10% at 4130 m AMSL. The reservoir in Eclipse West is predicted to be at 2850 m AMSL and, extrapolating from Bullsbrook 1, should have porosities in the order of 15%.

Gingin Brook prospect

Hydrocarbon type	Gas
Permit	EP 389
Operator	Empire Oil Company Ltd
Maturity	Medium
Geological risk	1:8.9
Depth to objective	3040 m AMSL
TD	3600 m
Volumetrics P_{50}	17.93 Gm^3 (633 Bcf) OGIP
Surface area	In excess of 10 km^2
Play type	Tilted fault block
Primary objective	Cattamarra Coal Measures
Key strengths	Structure
Key weaknesses	Porosity charge
Proposed well location	Not available
Seismic coverage	7 seismic lines, 800 m to 2 km apart in the dip direction, and 3 strike lines Vintage of seismic: 1972, 1997, and 1999

Summary

The Gingin Brook prospect is located 10 km north of Bullsbrook 1 and 15 km south of the Gingin accumulation within an elongate, tilted fault block bounded to the east by a down-to-the-east fault (Fig. 44). Although seismically

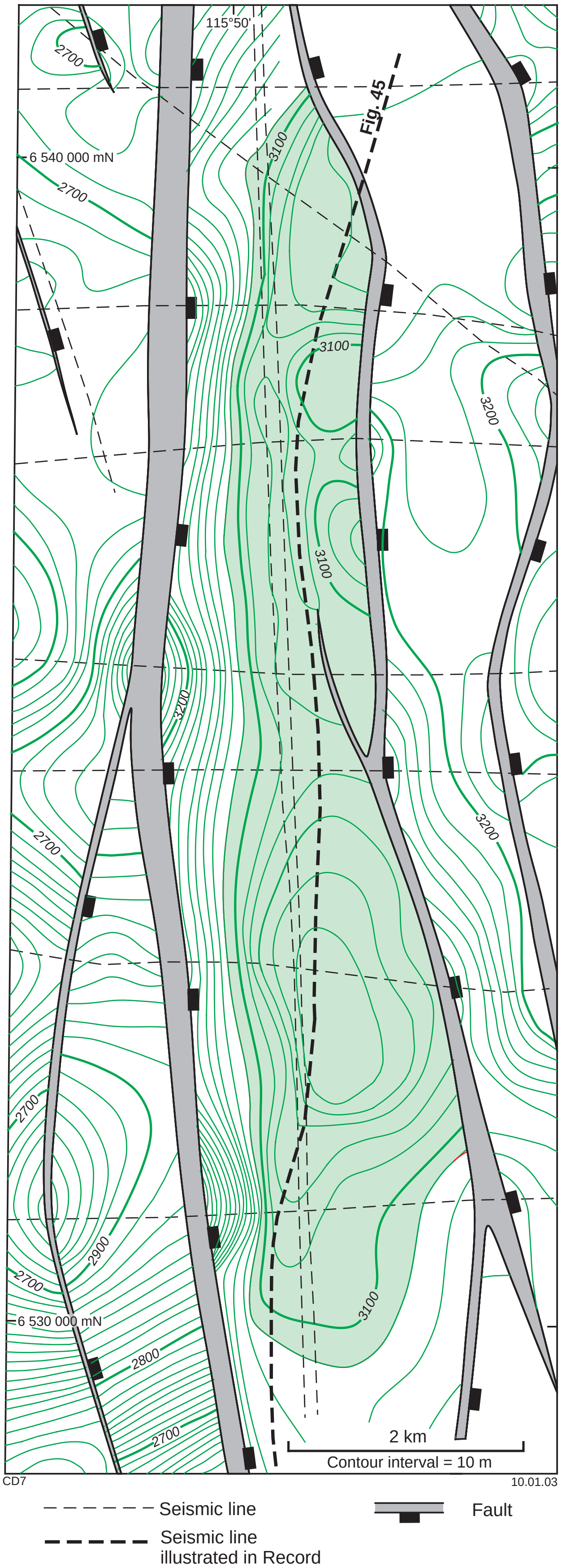


Figure 44. Depth contours to the top Cattamarra Coal Measures, Gingin Brook prospect (after Empire Oil Company Ltd, 2000)

well defined by 10 lines, closure is partially fault dependent.

Nearby wells

Bootine 1, and Bullsbrook 1, and Gingin 1, 2, and 3.

Assessment of geological risk elements

- Trap: tilted fault block 0.5
- Source: close to known gas accumulation at Gingin accumulation 0.8
- Migration and timing: potential for porosity to degrade prior to charge 0.4
- Reservoir: reservoir sandstone present in area 0.7

Probability of recovering hydrocarbons to the surface 1:8.9

Trap

The Gingin Brook prospect is a northerly trending, elongate, tilted fault block at top Cattamarra Coal Measures level with dip closure to the north, south, and west (Fig. 44). The centre of the southern part of the prospect has four-way dip closure. The bounding fault (8 km north of Bullsbrook 1 projected onto Figure 45) should form an effective seal as the top seal (thick shale within the Cattamarra Coal Measures as found in Bootine 1) appears to be juxtaposed against the reservoir along the fault.

Source

The most likely active source in this area is carbonaceous material within the Cattamarra Coal Measures.

Migration and timing

The major risk is the timing of the hydrocarbon charge relative to the onset of porosity degradation. A further risk may be the lack of charge, at least from a local source, implied by the low geothermal gradient in Bullsbrook 1. This risk is lessened by the presence of hydrocarbons in the Gingin anticline, probably derived from source rocks in the Dandaragan Trough to the north.

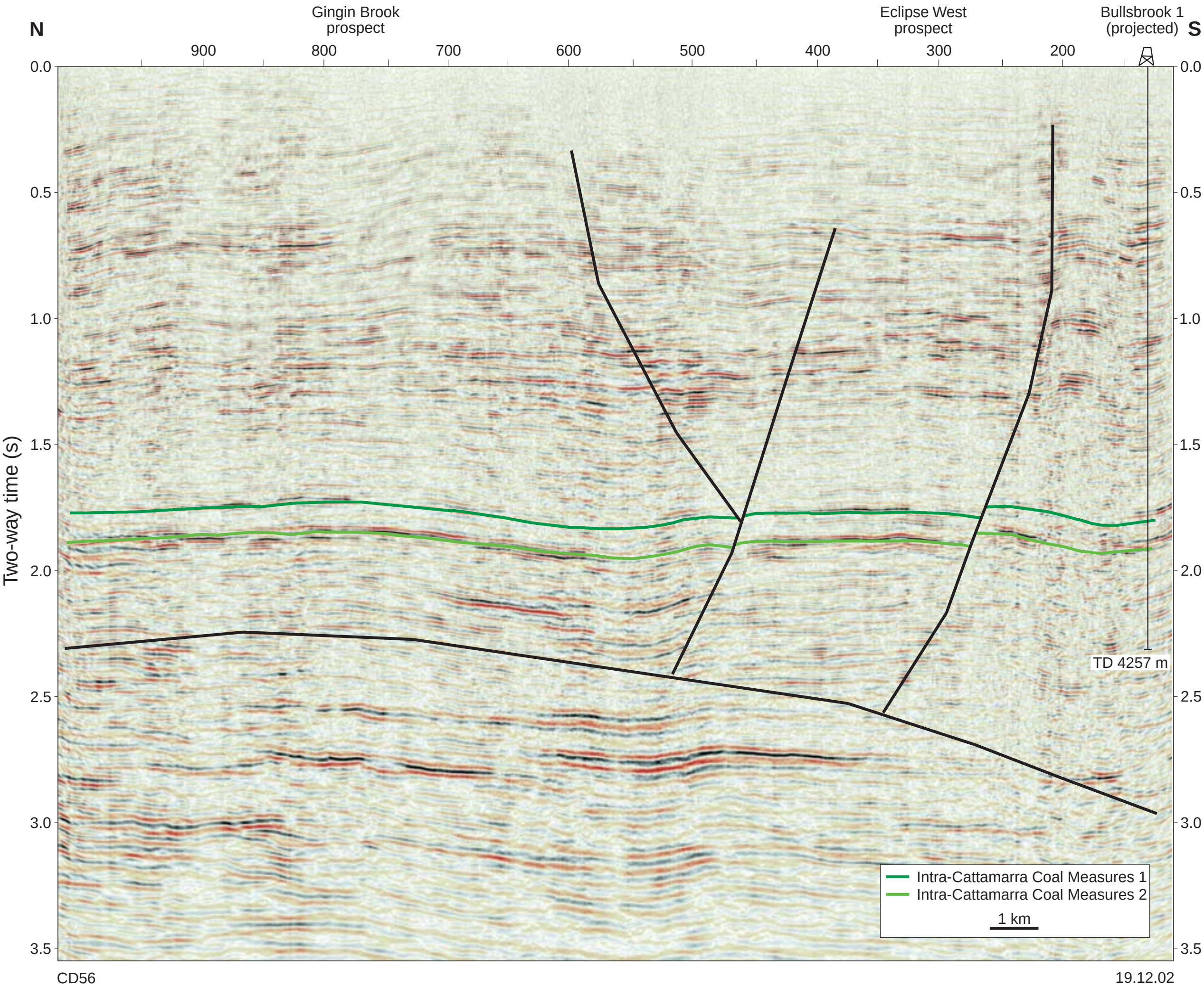


Figure 45. Seismic section 99GG-01 showing the structure of the Gingin Brook prospect

The Gingin Brook prospect probably developed at the same time as the Eclipse and Eclipse West prospects, and therefore a similar migration path and structural timing apply.

Reservoir

Porosity in the Cattamarra Coal Measures in Bullsbrook 1 varies from 12% at 3109 m AMSL to 10% at 4130 m AMSL. By analogy, the shallower reservoir in Gingin Brook should have porosity in the order of 15%.

Gingin South lead

Hydrocarbon type	Gas
Permit	EP 389
Operator	Empire Oil Company Ltd
Maturity	Low
Geological risk	1:12.8
Volumetrics P_{50}	4.47 Gm^3 (158 Bcf) OGIP
Play type	Faulted anticline
Primary objective	Cattamarra Coal Measures
Key strengths	Proximity to Gingin accumulation
Key weaknesses	Reservoir and permeability
Seismic coverage	End of 4 seismic lines Vintage of seismic: 1972, 1997, and 1999

Summary

The Gingin South lead is a simple anticline with minor faulting on the crest and lies about 4 km south of the Gingin accumulation and 25 km north of Bullsbrook 1. The lead is defined by the ends of three seismic lines, with just one line extending to the western side of the structure (Fig. 46).

Nearby wells

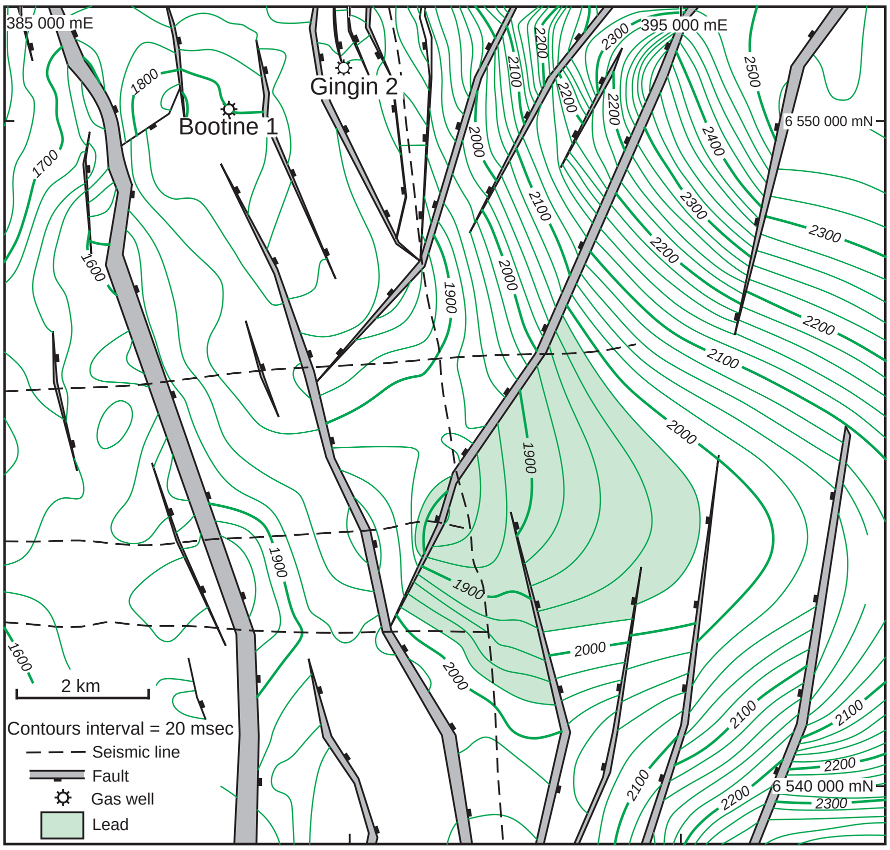
Bootine 1, Bullsbrook 1, and Gingin 1, 2, and 3.

Assessment of geological risk elements

• Trap: poorly controlled	0.4
• Source: proven hydrocarbon generation in area	0.7
• Migration and timing: potential for porosity to degrade prior to charge	0.4
• Reservoir: potential for good porosity at objective level	0.7
Probability of recovering hydrocarbons to the surface	1:12.8

Trap

Gingin South is poorly constrained as it lies at the ends of seismic lines. However, it appears to be a relatively



AP23 08.01.03

Figure 46. Two-way time contours to the top Cattamarra Coal Measures, Gingin South lead (after Empire Oil Company Ltd, 2000)

simple anticline with faulting on the western and partly on the eastern side of the prospect (Fig. 46). Thick, regional shale seals of the Cattamarra Coal Measures were found in Bootine 1, but some are locally thin and possibly discontinuous.

Source

The most likely active source in this area is carbonaceous material within the Cattamarra Coal Measures.

Migration and timing

The major risk is the timing of the hydrocarbon charge to the onset of porosity degradation. However, a further risk may be the lack of charge, due to a low local geothermal gradient in Bullsbrook 1. This risk is lessened by the presence of hydrocarbons in the Gingin anticline probably derived from source rocks in the Dandaragan Trough to the north.

The Gingin South lead would have developed at the same time as the other prospects and leads in EP 389, and therefore the same migration path and structural timing apply.

Reservoir

Poor to good sandstone reservoirs are present within the Cattamarra Coal Measures in Bootine 1, with porosities between 9.6 and 16.1%.

Gingin West prospect

Hydrocarbon type	Gas
Permit	EP 389
Operator	Empire Oil Company Ltd
Maturity	Medium
Geological risk	1:8.5
Depth to objective	3370 m
TD	3700 m
Volumetrics P_{50}	1.53 Gm^3 (54 Bcf) OGIP
Surface area	4.8 km^2
Play type	Anticline
Primary objective	Cattamarra Coal Measures
Key strengths	Proximity to Gingin accumulation
Key weaknesses	Reservoir and permeability
Proposed well location	Latitude 31°11'03.24"S Longitude 115°48'51.64"E Seismic line E97-19 at SP 830
Seismic coverage	Well defined by 0.5 × 0.5 km dip-line grid and strike lines over crest Vintage of seismic: 1997 and 1999

Summary

The Gingin West prospect is located about 2 km southwest of the Gingin accumulation and 50 km north of Bullsbrook 1. Gingin West lies updip from Bootine 1 and is a simple anticline with minor faulting on the crest (Fig. 47), similar to the Mount Horner oilfield, which is also independent of fault seal (Warris, 1988). The reservoir potential of the Gingin West prospect has been calculated from five separate sandstone horizons within the Cattamarra Coal Measures, based on the assumption that Bootine 1 was drilled at, or near, spill point of this prospect.

Nearby wells

Bootine 1 and Gingin 1, 2, and 3.

Assessment of geological risk elements

• Trap: four-way dip-closed anticline, low risk trap	0.6
• Source: proven hydrocarbon generation in area	0.7
• Migration and timing: potential for porosity to degrade prior to charge	0.4
• Reservoir: potential for good porosity at objective level	0.7
Probability of recovering hydrocarbons to the surface	1:8.5

Trap

Most of the Gingin West prospect has four-way dip closure within the Cattamarra Coal Measures, but there is minor faulting along the eastern side of the prospect (Fig. 47). The Cattamarra Coal Measures form semi-regional to local seals within the Gingin accumulation and are likely to also seal within the Gingin West prospect, as similar thick shale units are also present in Bootine 1. However, some of these units are thin and possibly discontinuous. Seismic sections show that the throw of the crestal fault at Gingin West is less than the thickness of the intraformational seals for the main sandstone objectives in the Cattamarra Coal Measures (Figs 48 and 49).

Source

Carbonaceous material within the Cattamarra Coal Measures in the Dandaragan Trough is the likely source of gas shows in Bullsbrook 1, Gingin 1 and 2, and Bootine 1.

Migration and timing

The major risk is the timing of the hydrocarbon charge relative to the onset of porosity degradation. The low geothermal gradient in Bullsbrook 1 indicates the lack of a locally derived hydrocarbon charge may be a further risk. Medium-range migration from a source within the Dandaragan Trough to the north of the Gingin–Bullsbrook trend is necessary to charge the Gingin West anticline.

The Gingin West prospect probably developed at the same time as the Gingin accumulation. Therefore, the presence of gas-bearing sandstone in Gingin 1, Gingin 2, and Bootine 1 indicates that timing is not critical for Gingin West (Empire Oil Company Ltd, 1999) if a similar migration path applies.

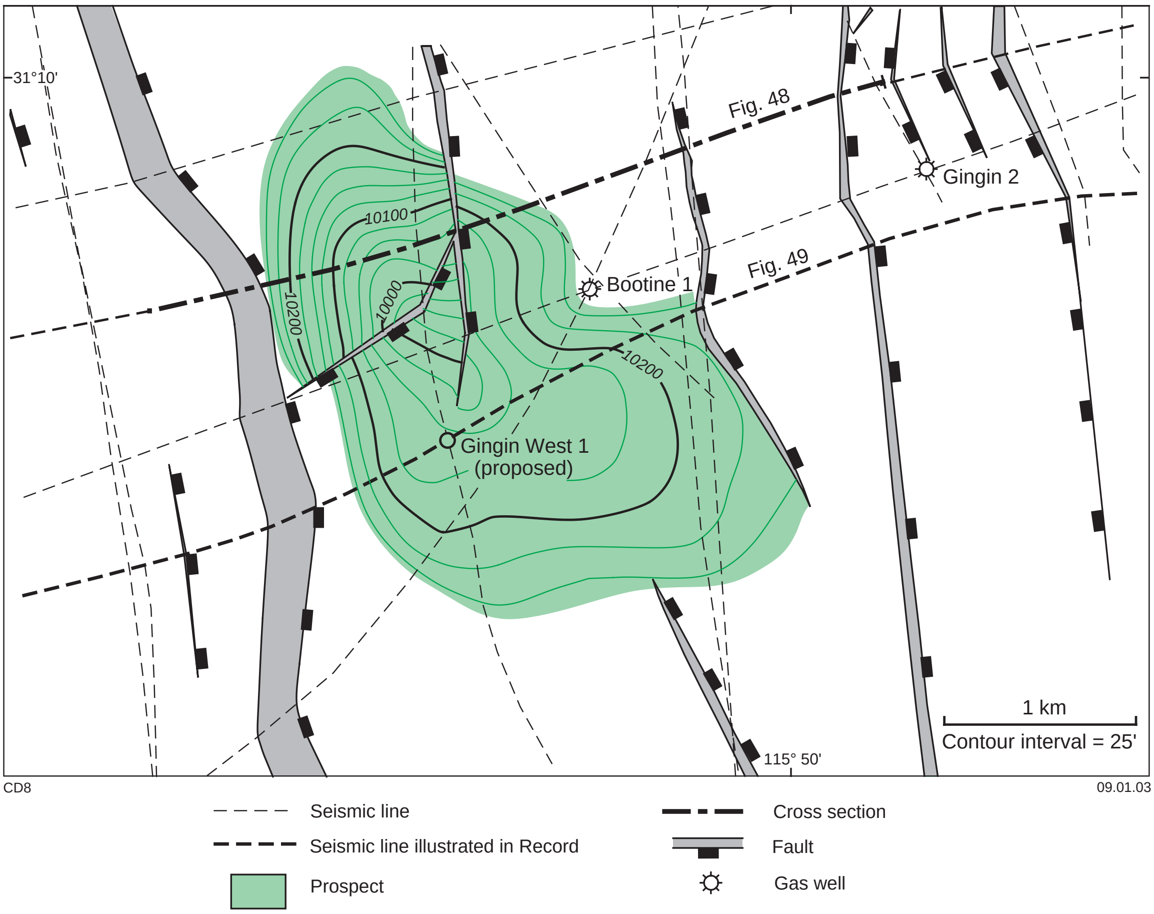


Figure 47. Depth contours to the top Cattamarra Coal Measures, Gingin West prospect (after Empire Oil Company Ltd, 1999)

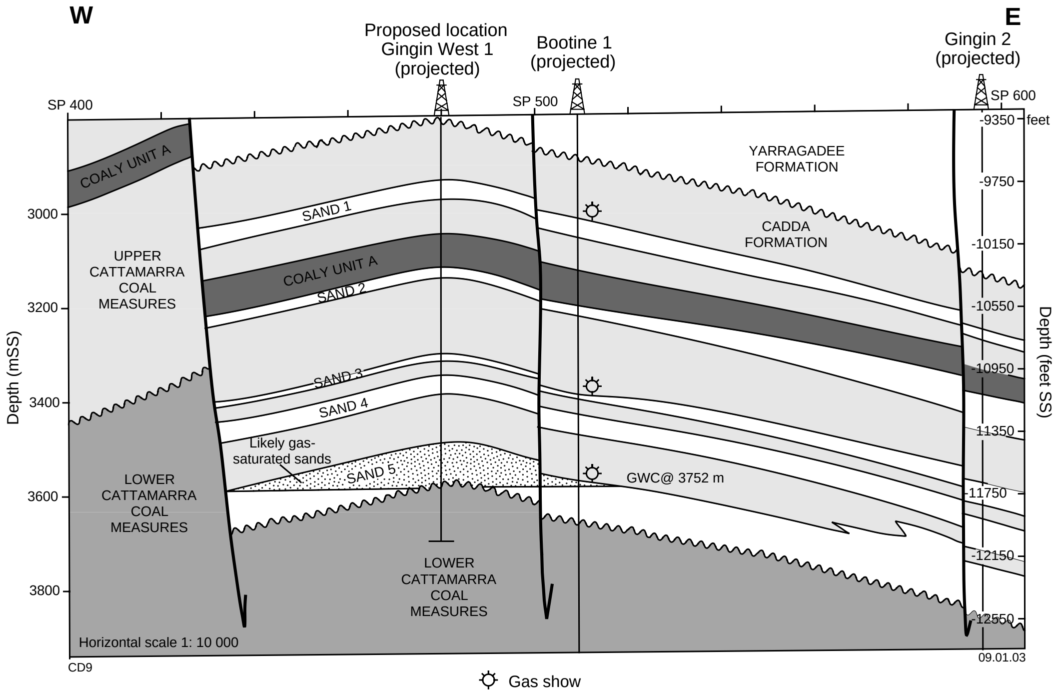


Figure 48. Seismic section E97-17 showing the structure of the Gingin West prospect (after Empire Oil Company Ltd, 1999)

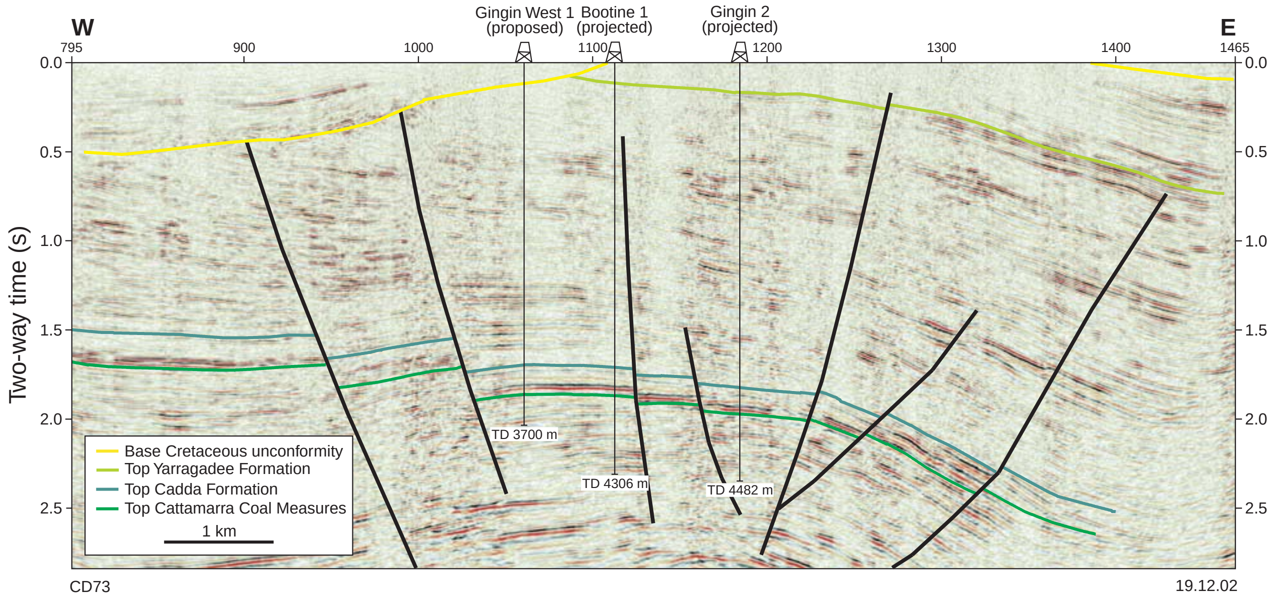


Figure 49. Seismic section E97-19 showing the structure over the Gingin West

Reservoir

There are poor to good sandstone reservoirs within the Cattamarra Coal Measures in Bootine 1, with porosities between 9.6 and 16.1%. The reservoir continuity, however, is a risk as secondary faults may cause structural offsets of sandstone or local degradation of permeability.

Dandaragan and Coomallo Troughs

EP 23

Permit EP 23 in the northern end of the Dandaragan Trough consists of two parts: EP 23 (1) and EP 23 (2). EP 23 (1) lies on the eastern edge of the basin and contains one lead, and EP 23 (2), which lies within the central part of the basin close to current oil and gas production, contains one prospect and several leads (Fig. 50). Depth to basement in EP 23 (2) varies from 4500 m in the west to 5000 m in the east. The structural trend for EP 23 changes from northerly striking faults in the south, to northwesterly and easterly striking faults in the north.

Sundalara prospect

Hydrocarbon type	Gas
Permit	EP 23 (2)
Operator	Australian Worldwide Exploration Ltd
Maturity	Medium–high
Geological risk	1:11.0
Depth to objective	3808 m
TD	3900 m
Volumetrics P_{50}	1.82 Gm^3 (64.1 Bcf) OGIP
Surface area	6.4 km^2
Play type	Fault bounded, dip in three other directions
Primary objective	Dongara Sandstone
Secondary objective	Jurassic
Key strengths	Lead closes on 2D seismic grid
Key weaknesses	Porosity preservation at reservoir depth
Proposed well location	Latitude 29°26'01.41"S Longitude 115°15'37.12"E Seismic line B88-305 at SP 288
Seismic coverage	7 dip lines 1.1 – 0.3 km apart and 1 strike line Vintage of seismic: 1988, 1989, 1990, and 1994

Summary

The Sundalara prospect lies 12.5 km northwest of the Beharra Springs gasfield and 4.8 km west of West Erregulla 1, on the upthrown side of the Eneabba Fault, a major fault on the northwestern flank of the Dandaragan Trough (Fig. 51). The structure is analogous to that of the Beharra Springs gasfield. Sundalara is a Permian play targeting the Dongara Sandstone directly below the regional source (the Kockatea Shale) and is about 115 m structurally higher than West Erregulla 1. A possible secondary target is the Jurassic, as oil was recovered from the Eneabba Formation and Cattamarra Coal Measures in nearby wells. The primary risk element is porosity degradation within the main objective, given its great depth. Although the structure is well constrained by seismic data, acquisition of high-resolution seismic data may provide insights into the risk of porosity degradation in the reservoir, thus reducing reservoir risk. Reprocessing of existing data specifically for amplitude versus offset (AVO) analysis also may help in this respect.

Nearby wells

Erregulla 1 and 2, Mungenooka 1, and West Erregulla 1.

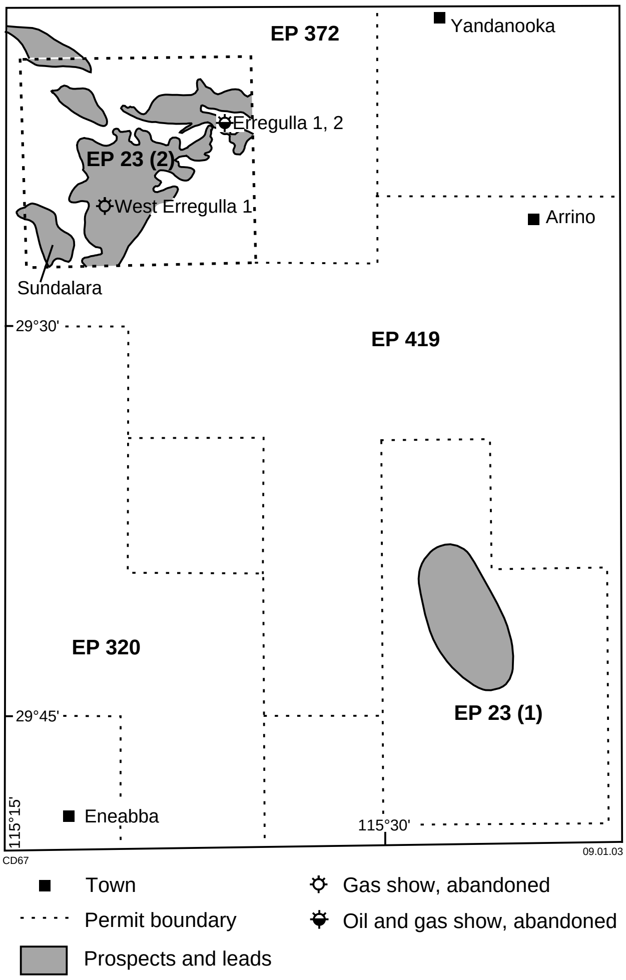


Figure 50. Prospects and leads of EP 23

Assessment of geological risk elements

• Trap: reasonably well constrained by seismic data	0.6
• Source: Kockatea Shale proven source in this area	0.95
• Migration and timing: adequate source, timing not assessed	0.8
• Reservoir: potential for porosity degradation	0.2
Probability of recovering hydrocarbons to the surface	1:11.0

Trap

Closure within the Sundalara prospect is controlled by faults to the southwest and north (Fig. 51). From a trapping perspective, the critical structural feature of Sundalara is the closure against the northwestern fault. The prospect is delineated by seven seismic lines 0.3 to 1.1 km apart in the dip direction, and one strike line. The sealing potential of the Eneabba Fault has not been tested. The Sundalara high continues to the north, creating a separate fault closure that lies wholly within EP 320.

Analysis of the hydrocarbon saturation and pressures in West Erregulla 1 indicates the possibility of a gas column greater than the mapped closure at West Erregulla. If correct, this implies West Erregulla 1 and Sundalara belong to the same gas accumulation given the current structural interpretation. Therefore, facies variations rather than structure may control the effective limits of the accumulation.

The Eneabba Fault at Sundalara swings from a northerly trend to a northwesterly trend, and has a throw of 150 msecs or about 270 m (Fig. 52). The Kockatea Shale at this location is 450–600 m thick and provides vertical and lateral seals across the Eneabba Fault, as it exceeds the fault throw at top Dongara Sandstone level by about 150 m (Fig. 53). The sandstone at the base of the Kockatea Shale is a potential thief zone, but is unlikely to be significant considering the height of the closure mapped at the top of the Dongara Sandstone. Seismic imaging of the top Permian horizon at Sundalara is inferior, as the quality of the data below the Eneabba Fault is poor. Nevertheless, the structure appears sound, but other weak elements include the lack of velocity control and its potential effect on the northern closure, and the untested seal potential of the Eneabba Fault.

Source

The main source for the Dongara Sandstone reservoir at the Sundalara prospect is the Kockatea Shale. Gas shows in West Erregulla 1 and hydrocarbon shows in other nearby wells indicate adequate source within the region. At present, the Kockatea Shale is at the end of peak oil generation and is generating predominantly gas near this prospect (Discovery Petroleum NL, 1996a).

Migration and timing

Thinning of the Kockatea Shale over the Eneabba Fault indicates early structuring at the Sundalara prospect, implying that trap formation commenced in the Early Triassic and the possibility of an early hydrocarbon charge being retained within the Dongara Sandstone (Discovery Petroleum NL, 1996a). Migration would have been from the Dandaragan Trough to the southeast, across the Eneabba Fault. While the timing of trap formation to hydrocarbon migration appears favourable, the relationship between hydrocarbon charge and porosity degradation is uncertain in this area.

Reservoir

Porosity preservation at Sundalara is the primary reservoir risk factor, especially if the hydrocarbon charge was late. The nearest wells to Sundalara, West Erregulla 1, Erregulla 1, and Erregulla 2, have minimal effective porosity. Core analyses in West Erregulla 1 indicate an average porosity of 6% and an average permeability less than 0.1 mD. Testing of this well yielded a minor gas flow of 5.1 km^3/day (0.0l8 MMcf/day). Beharra Springs 3, 12.5 km to the west, has just 5 m of effective reservoir.

Tupper et al. (1994) found that early diagenetic development of chlorite coatings inhibited secondary quartz overgrowths and preserved porosity at greater

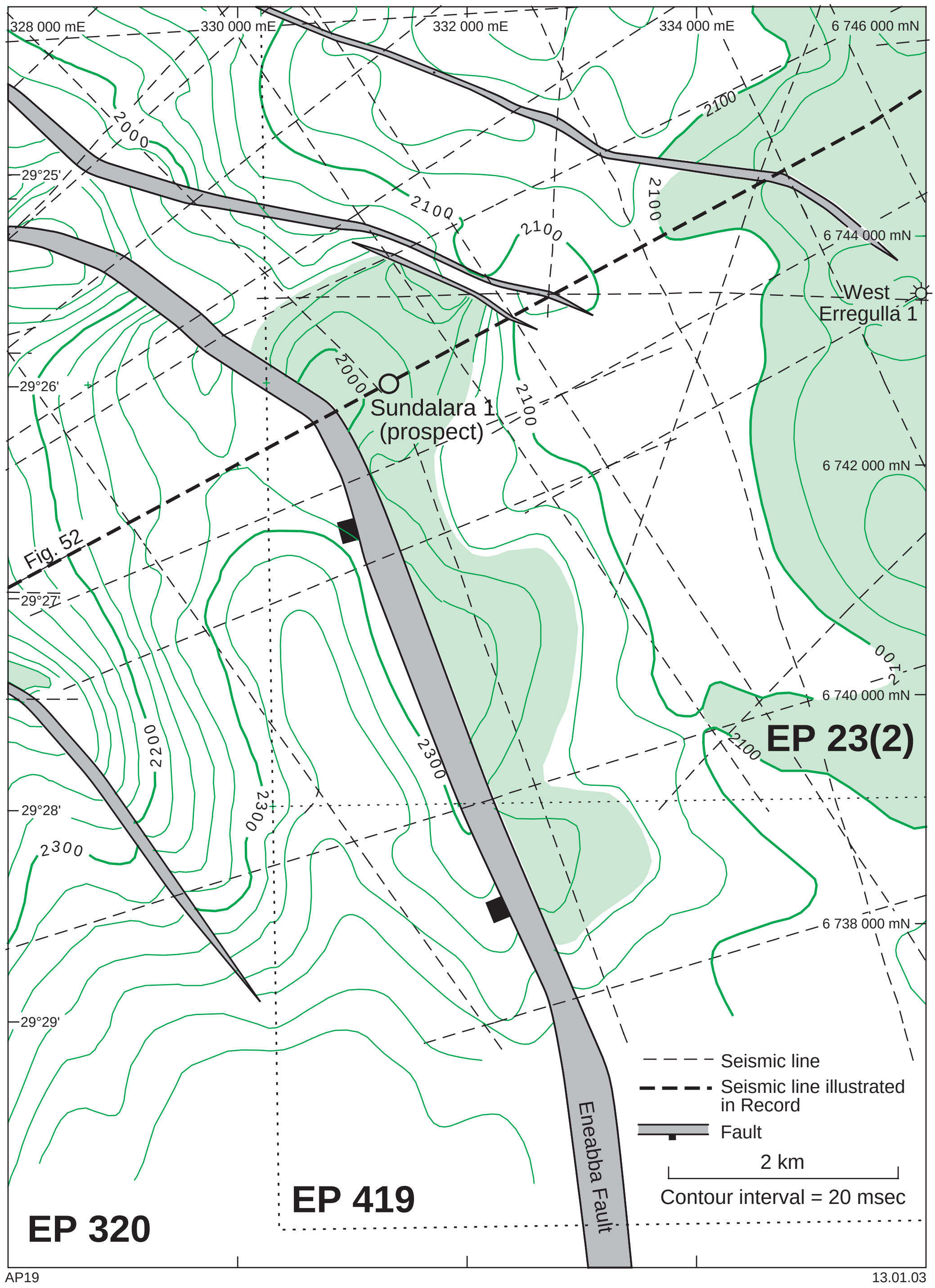


Figure 51. Two-way time contours to the basal Triassic horizon, Sundalara prospect (after Australian Worldwide Exploration Ltd, 2001, written comm.)

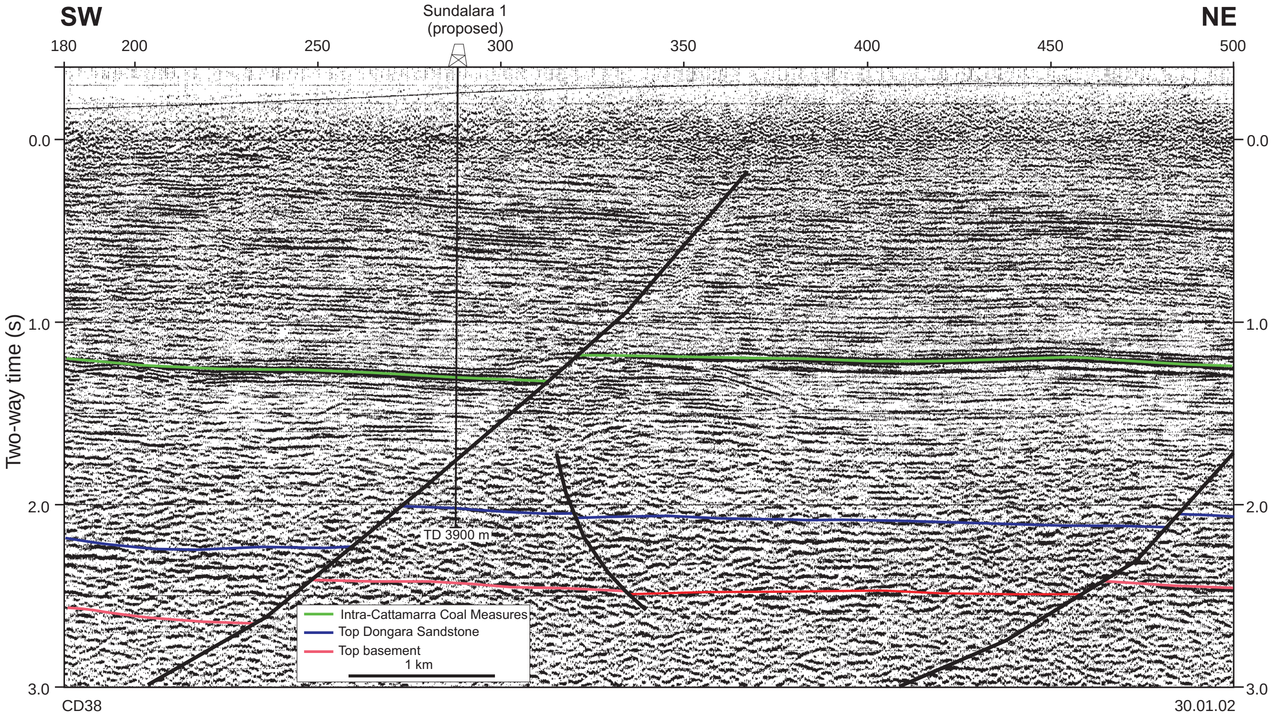


Figure 52. Seismic section B88-305 showing the structure of the Sundalara prospect

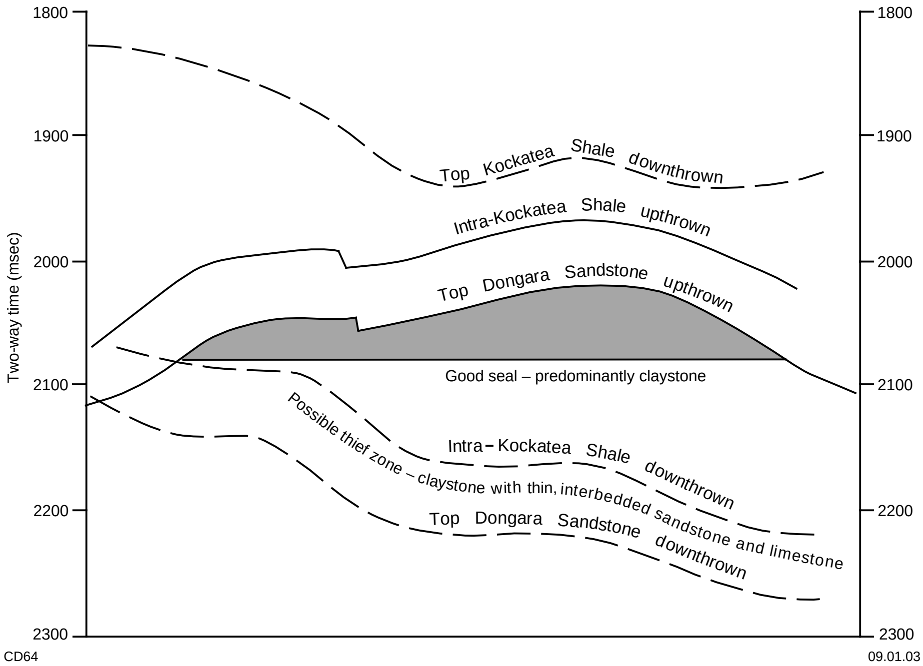


Figure 53. Allan diagram of the Eneabba Fault, Sundalara prospect

depths of burial in the Beharra Springs gasfield. An influx of iron-rich fresh water and relatively shallow water depths are required for chlorite formation. Hence, at this location there is the potential for better porosity in Sundalara than in West Erregulla 1 at the same depth. Also, as the Dongara Sandstone was deposited on a palaeohigh at Sundalara compared to the West Erregulla area, the water depths at the prospect may have been conducive to chlorite precipitation. Furthermore, early structuring and an early hydrocarbon charge should also have prevented reduction in reservoir properties at Sundalara (Discovery Petroleum NL, 1996a).

From well analysis it is extrapolated that if the reservoir sandstone at the Sundalara prospect is cemented by quartz overgrowths, as in West Erregulla 1, the resulting permeability would be so low that a well would be unable to produce commercially. On the other hand, if the sandstone is similar to that intersected in the Beharra Springs gasfield, porosity is likely to range from 7 to 15%.

EP 321

Permit EP 321 sits on the eastern edge of the basin within the Dandaragan Trough. There are several leads and two prospects (Dandaragan Deep and Warro) within EP 321. The Warro prospect straddles the boundary between EP 321 and 407.

Dandaragan Deep prospect

Hydrocarbon type	Gas and possibly oil
Permit	EP 321 (1)
Operator	Ausam Resources NL
Maturity	Low
Geological risk	1:7
Depth to objective	2370 m
TD	3000 m
Volumetrics P_{50}	5.69 – 36.59 Gm^3 (201–1292 Bcf), mean 15.75 Gm^3 (556 Bcf) OGIP; 22.89 – 146.59 GL (144–922 MMbbl), mean 63.12 GL (397 MMbbl) OOIP (if present)
Surface area	24 km^2
Play type	Jurassic, asymmetric faulted anticline
Primary objective	Jurassic, lower Yarragadee Formation
Key strengths	Prospect closes on 2D seismic grid
Key weaknesses	Intra-Yarragadee Formation cross-fault seals
Proposed well location	Latitude 30°36'30"S Longitude 115°49'20"E Seismic line A89-711-R at SP 450
Seismic coverage	13 lines, 1.5 – 2 km-spaced seismic grid Vintage of seismic: 1989 and 1993

Summary

The Dandaragan Deep prospect is a large faulted anticline 80 km southwest of Jurien. Dandaragan 1 intersected a non-commercial show of oil at the top of the Yarragadee Formation, but did not penetrate the lower Yarragadee Formation reservoir–seal pairs to be targeted by Dandaragan Deep 1. Thus, the primary risk element is the potential for leakage across faults.

The Dandaragan Deep prospect has an estimated unrisked gas-in-place resource between 5.69 and 36.59 Gm^3 (201–1292 Bcf), with a mean value of 15.75 Gm^3 (556 Bcf). Unrisked OOIP resource, if present, is estimated at between 22.89 and 146.59 GL (144–922 MMbbl), with a mean value of 63.12 GL (397 MMbbl; Ausam Resources NL, 2000).

Nearby wells

Barberton 1, Cataby 1, Cypress Hill 1, Dandaragan 1, Walyering 1, 2, and 3, and Yallalie 1. Also see **Walyering accumulation** and **Walyering 4**.

Assessment of geological risk elements

• Trap: unproven cross-fault seals by intra-Yarragadee Formation shales	0.4
• Source: hydrocarbons recovered from nearby wells	0.8
• Migration and timing: adequate source, timing not assessed	0.5
• Reservoir: reasonable quality sandstone present	0.9
Probability of recovering hydrocarbons to the surface	1:7

Trap

The Dandaragan Deep prospect is a large, complexly faulted anticline at intra-Yarragadee Formation level that is reasonably well constrained by 2D seismic data (Fig. 54). The trap requires intraformational shale and siltstone to provide top and cross-fault seals within the mapped closure. Although there are no fields in which the Yarragadee Formation forms seals across significant faults, Erregulla 1 and Warro 1 and 2 show that shales within this formation have sealing potential. Dandaragan 1 tested the upper part of the Dandaragan Deep structure at the top of the Yarragadee Formation, directly below sealing shales of the Otorowiri Formation.

The Dandaragan Deep prospect sits within an upper Yarragadee Formation depocentre (Fig. 55). Shale intervals of lacustrine origin, if present within this part of the formation, should provide an adequate seal for the underlying section (Ausam Resources NL, 2000).

Source

In this area, hydrocarbons generated from the Cattamarra Coal Measures have been intersected in several wells. The

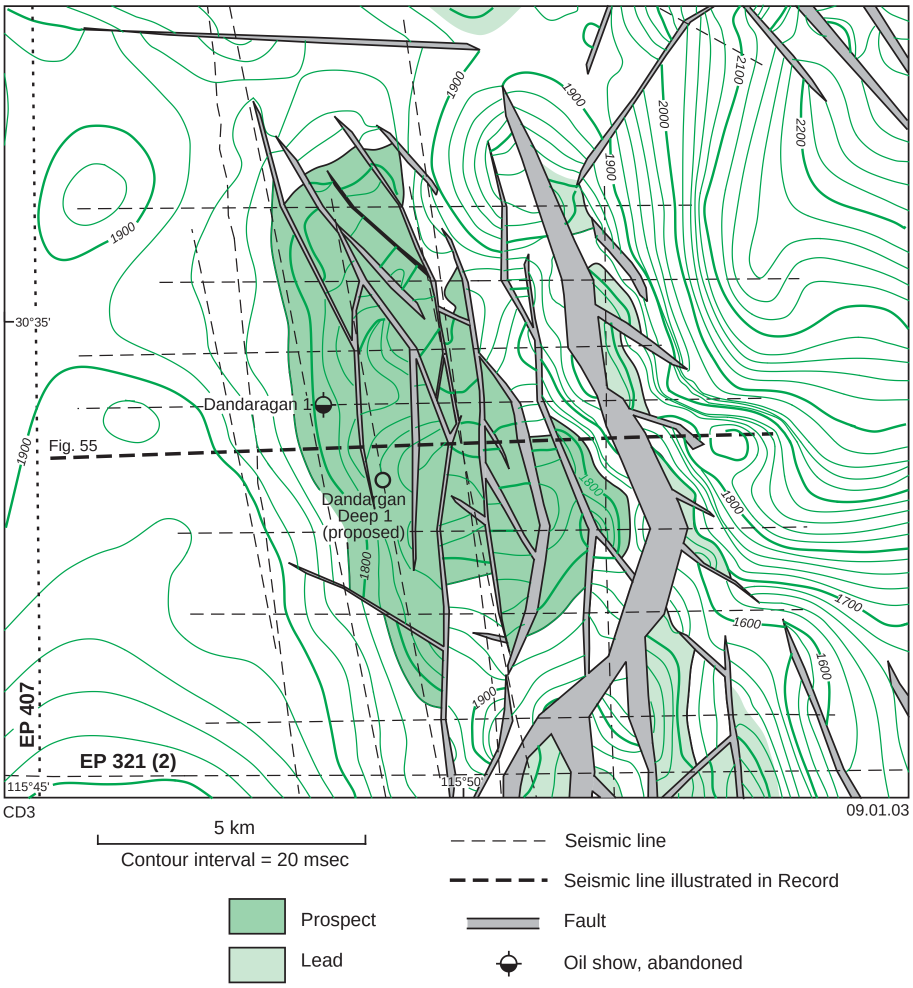


Figure 54. Two-way time contours to the intra-Yarragadee horizon, Dandaragan Deep prospect (Ausam Resources NL, 2000)

oil from Dandaragan 1 is from a dominantly terrestrial source, probably coaly intervals within the Cattamarra Coal Measures or lacustrine shale beds within the Yarragadee Formation, but is severely biodegraded. Maturity data show that in the Dandaragan Trough the Cattamarra Coal Measures are mature, whereas the lower part of the Yarragadee Formation is marginally mature.

Migration and timing

The presence of oil of terrestrial origin in Dandaragan 1 demonstrates hydrocarbon generation and migration has taken place within the Dandaragan area. Migration from the marine Kockatea Shale source pod to the southeast along fault planes is likely as well.

The Dandaragan Deep prospect and other similar structures within the area resulted from a major inversion within the Dandaragan Trough, immediately to the west of the prospect, associated with continental breakup during the Early Cretaceous, which in most areas coincided with the peak period of hydrocarbon expulsion.

Reservoir

Reservoir risk at Dandaragan Deep is low due to the relatively shallow depth of burial. The Yarragadee Formation contains fine- to coarse-grained feldspathic and quartzitic sandstone interbedded with lesser coal, shale, siltstone, and conglomerate. Porosity at the top of the Yarragadee Formation is 22% in Dandaragan 1, and therefore porosities in the range of 13–17% are expected (Ausam Resources NL, 2000).

EP 414

Permit EP 414 consists of three parts: EP 414 (1), EP 414 (2), and EP 414 (3); all three lie west of the Dandaragan Trough. There are two main prospects (Carnamah and Walyering) within EP 414.

Carnamah prospect

Hydrocarbon type	Oil
Permit	EP 414 (2)
Operator	Ausam Resources NL

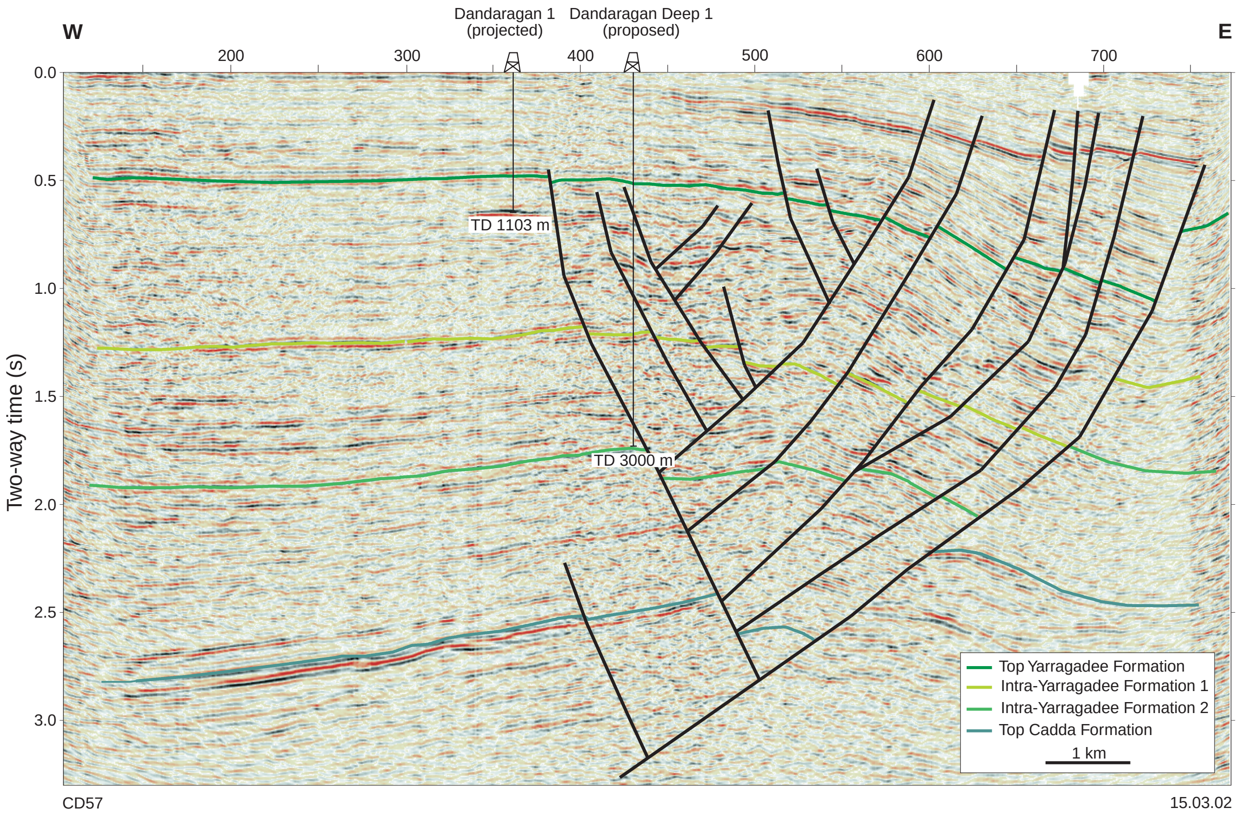


Figure 55. Seismic section A89-711-R showing the structure of the Dandaragan Deep prospect

Maturity	Low
Geological risk	1:6.2
Depth to objective	700 m
TD	Unknown
Volumetrics P_{50}	13.04 GL (82 MMbbl) recoverable reserves
Surface area	10.5 km^2
Play type	Faulted anticline
Primary objective	Yarragadee Formation and base Otorowiri Formation
Key strengths	Good reservoir and source rocks generating in the area
Key weaknesses	Biodegradation and potential failure of cross-fault seals
Proposed well location	Latitude 29°57'59.04"S Longitude 115°40'57.30"E Seismic line DR97-19-R near SP 675
Seismic coverage	5 lines cross the structure Vintage of seismic: 1972 and 1997

Summary

The Carnamah prospect is located 25 km north of Warro 1, 25 km east of Ocean Hill 1, and 65 km northeast of Jurien Bay. The trap is an anticline cut by northwesterly trending faults defined by five seismic lines (Fig. 56). The major objective is the upper Yarragadee Formation and sandstone at the base of the Otorowiri Formation. The major risk elements are risk of biodegradation and the potential for leak points across faults.

Nearby wells

Eganu 1, Ocean Hill 1, Warramia 1, and Warro 1.

Assessment of geological risk elements

• Trap: fault-bound anticline	0.5
• Source: proven Jurassic source in the area	0.8
• Migration and timing: has significant biodegradation occurred?	0.5
• Reservoir: sandstone in the Yarragadee Formation should have good porosity	0.8
Probability of recovering hydrocarbons to the surface	1:6.2

Trap

The objective of the Carnamah prospect is the base Otorowiri Formation withinin a wrench-related anticline of probable Early Cretaceous age on the downthrown block west of the Urella Fault (Fig. 57). The prospect is fault bound to the northeast and dip closed in the other directions, and is divided into two compartments by northwesterly trending faults (Fig. 56) that are predicted to seal (Ausam Resources NL, 2000). The top seal is the

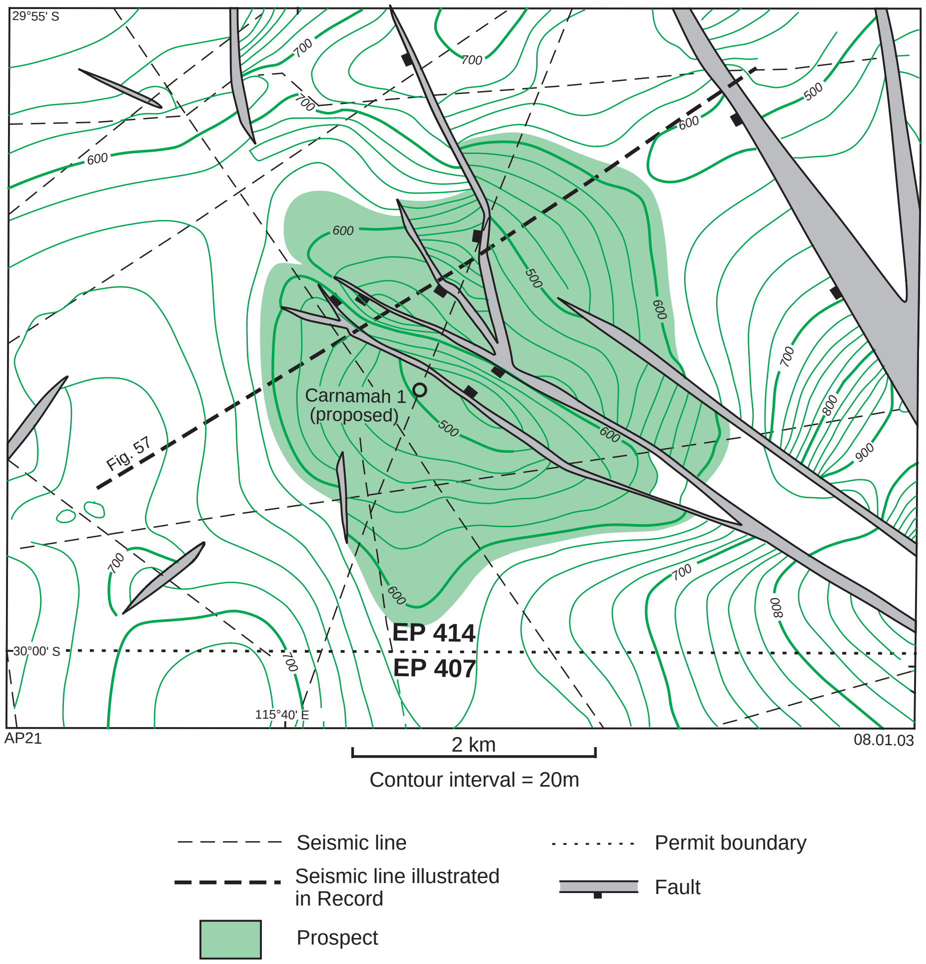


Figure 56. Depth contours to the top Yarragadee Formation, Carnamah prospect (after Premier Oil Australia Pty Ltd, 1998)

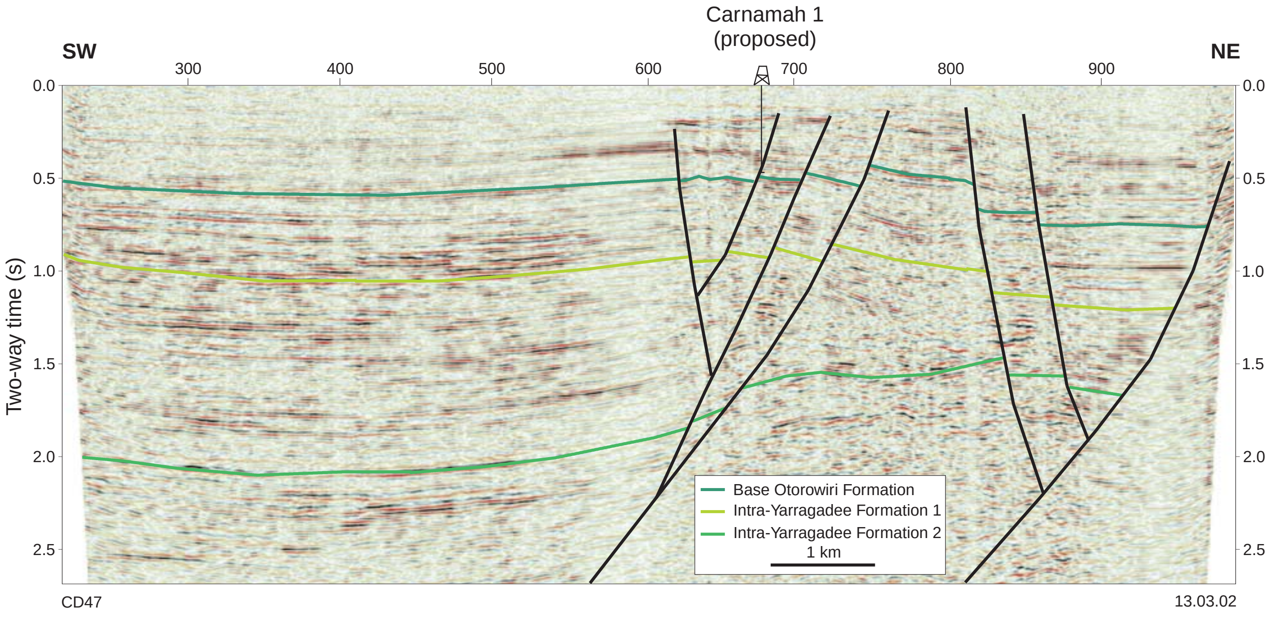


Figure 57. Seismic section DR97-19-R showing the structure of the Carnamah prospect. The depth to the objective is 700 m

Otorowiri Formation, which although thin, is a proven seal in the area. The volumetrics for Carnamah have been calculated from the southwestern portion of the structure only where fault seal is expected to be present. Therefore, seal risk is most significant for the western portion of the prospect.

Source

The Yarragadee Formation is an immature source rock in this area. However, the presence of oil shows in this formation in Ocean Hill 1 indicates production of some liquids in the region, most probably from the Cattamarra Coal Measures, although deeper sources cannot be ruled out.

Migration and timing

The biodegradation of oil in Dandaragan 1 shows that there is a preservation risk at shallow depths in this part of the basin. The Carnamah prospect is 20 km west of the outcrop edge of the Yarragadee Formation. Hydrodynamic flow in the formation to the east may have flushed and biodegraded hydrocarbons below the Otorowiri Formation (Fig. 58).

Reservoir

Good quality reservoir sandstone is predicted at the objective depth based on the nearby wells. The reservoir potential of the Yarragadee Formation is well illustrated by the heavy oil show in Dandaragan 1.

Fault terraces

L1

The eastern part of L1 lies on the Beharra Springs Terrace.

Nutsyia prospect

Hydrocarbon type	Gas
Permit	L1
Operator	Arc Energy NL
Maturity	Medium–high

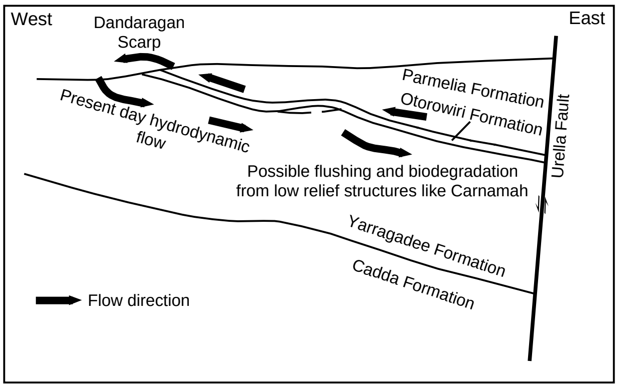


Figure 58. Predicted present day hydrodynamic flow below the Otorowiri Formation

Geological risk	1:15
Depth to objective	2600 m
TD	2780 m
Volumetrics P_{50}	0.83 Gm^3 (29.2 Bcf) OGIP
Surface area	4.6 km^2
Play type	Tilted fault block
Primary objective	Dongara Sandstone
Key strengths	Within area of known hydrocarbon generation
Key weaknesses	Structural definition and poor reservoir quality
Proposed well location	Latitude 29°21'21.07"S Longitude 115°05'59.02"E Seismic line P89-12L at SP 461
Seismic coverage	2D lines and edge of 3D survey, poor to fair seismic Vintage of seismic: Alpha lines, various ages

Summary

The Nutsyia prospect is 4 km southwest of the Mondarra gasfield, 680 m southwest of Mondarra 2, and 3 km north of Mount Adams 1. It is a poorly controlled, fault-bound high that has been partially tested by Mondarra 2, which has produced 0.05 Gm^3 (1.7 Bcf) gas from a thin zone within the Dongara Sandstone (Fig. 15). The primary risks are porosity degradation and the overall structural configuration due to poor seismic resolution at reservoir level. The area is covered by 2D lines of various vintages on a 1 km dip-line spacing, and partly by the 1998 Mondarra 3D Seismic Survey. The structure is poorly defined as the prospect lies on the edge of these surveys.

Nearby wells

Ejano 1, Mondarra 1, 2, 3, and 4, and Mount Adams 1.

Assessment of geological risk elements

• Trap: tilted fault block	0.4
• Source: close to known gasfields	0.9
• Migration and timing: relationship to preservation unknown	0.6
• Reservoir: Dongara Sandstone at this depth commonly has poor porosity	0.3
Probability of recovering hydrocarbons to the surface	1:15

Trap

The Nutsyia prospect is a northwesterly trending horst at top Dongara Sandstone level with dip closure to the northwest and southeast, but is fault bounded on the southwestern and northeastern sides (Fig. 59). Structurally, the prospect appears to be analogous to the Mondarra gasfield (Fig. 60). Therefore, trap age and fault style is inferrred to be similar to the Mondarra gasfield. The Kockatea Shale provides lateral and vertical seals. Faults bounding the horst show Permian growth, but the current structural configuration is largely due to Early Cretaceous structuring (Arc Energy NL, 1999).

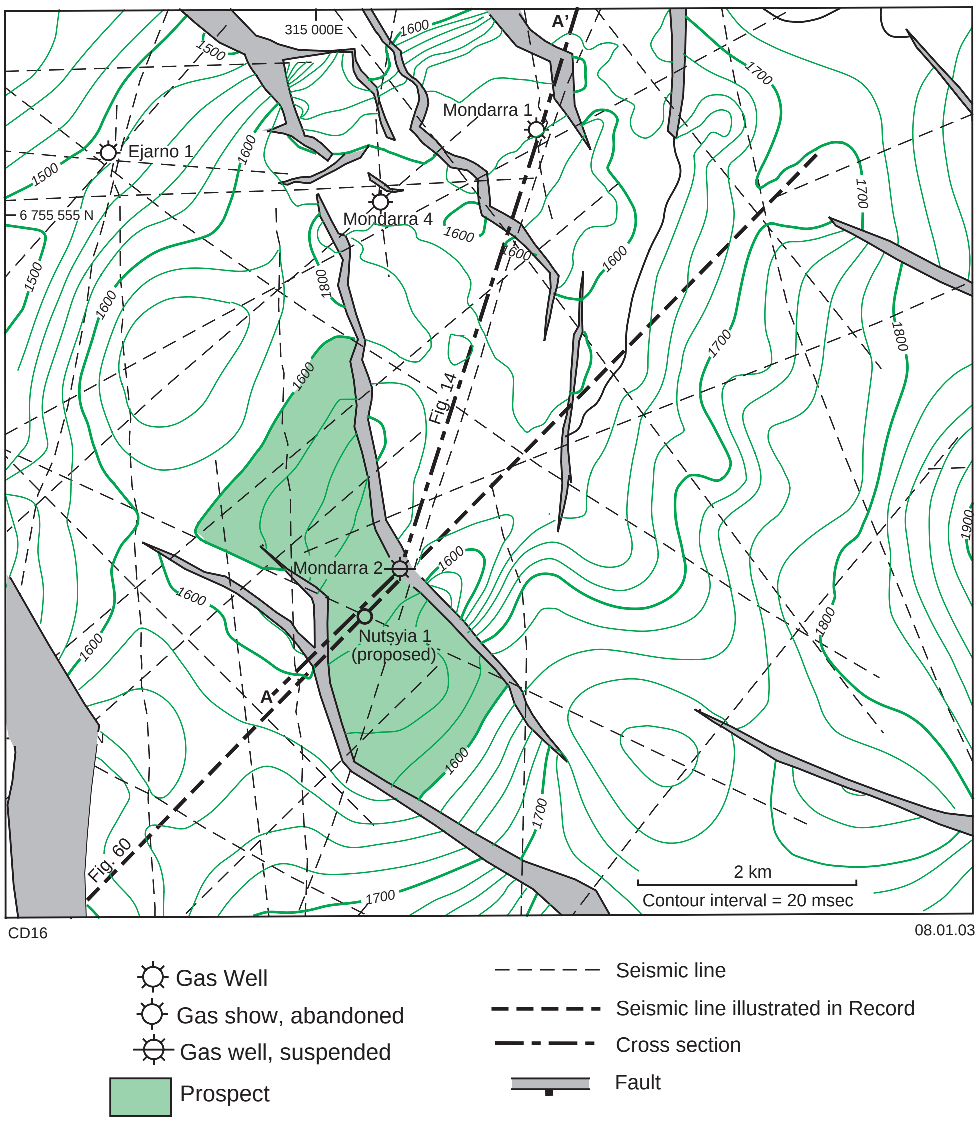


Figure 59. Two-way time contours of the top Dongara Sandstone, Nutsyia prospect (after Arc Energy NL, 1999)

Source

The Kockatea Shale is the main source rock for both oil and gas in this area. The gas may also be sourced from the Irwin River Coal Measures and the Carynginia Formation. Gas has been produced from the Mondarra gasfield and is present in Mount Adams 1.

Migration and timing

There are several fields in the area indicating favourable migration and timing of events. The prospect is on the migration pathway to the Dongara oil- and gasfield, and lies close to a mature source pod. Therefore, it should have received a similar hydrocarbon charge to the Mondarra gasfield. The timing of charge relative to porosity degradation is a significant risk for this prospect. The main objective, the Dongara Sandstone, is deeper than the porosity cut-off in Mondarra 1. Therefore, some form of porosity preservation was necessary to entrap hydrocarbons here. Preservation may be due to early hydrocarbon charge preventing formation of pore-filling minerals or by the precipitation of chlorite rims preventing the formation of quartz overgrowths. Consequently, the timing of these events compared to trap formation and burial is one of the primary risk elements.

Reservoir

In the nearby Mondarra gasfield the Dongara Sandstone has produced 0.62 Gm^3 (22 Bcf) of gas. From well data in that field, porosities in the reservoir range from 7.5 to 18% with an average of 15%. Porosity below the gas–water interface averages 6%. The porosity within the pay zone in Mondara 2 is 13–18%, compared to 6% on either side of that zone. The reservoir at Nutsyia is structurally higher than Mount Adams 1, but 500 m deeper than the Mondarra gasfield. The anomalous high porosity in Mount Adams 1 indicates that porosity can be preserved at these depths in this area. However, the majority of wells in this area indicate there are porosity problems at these depths.

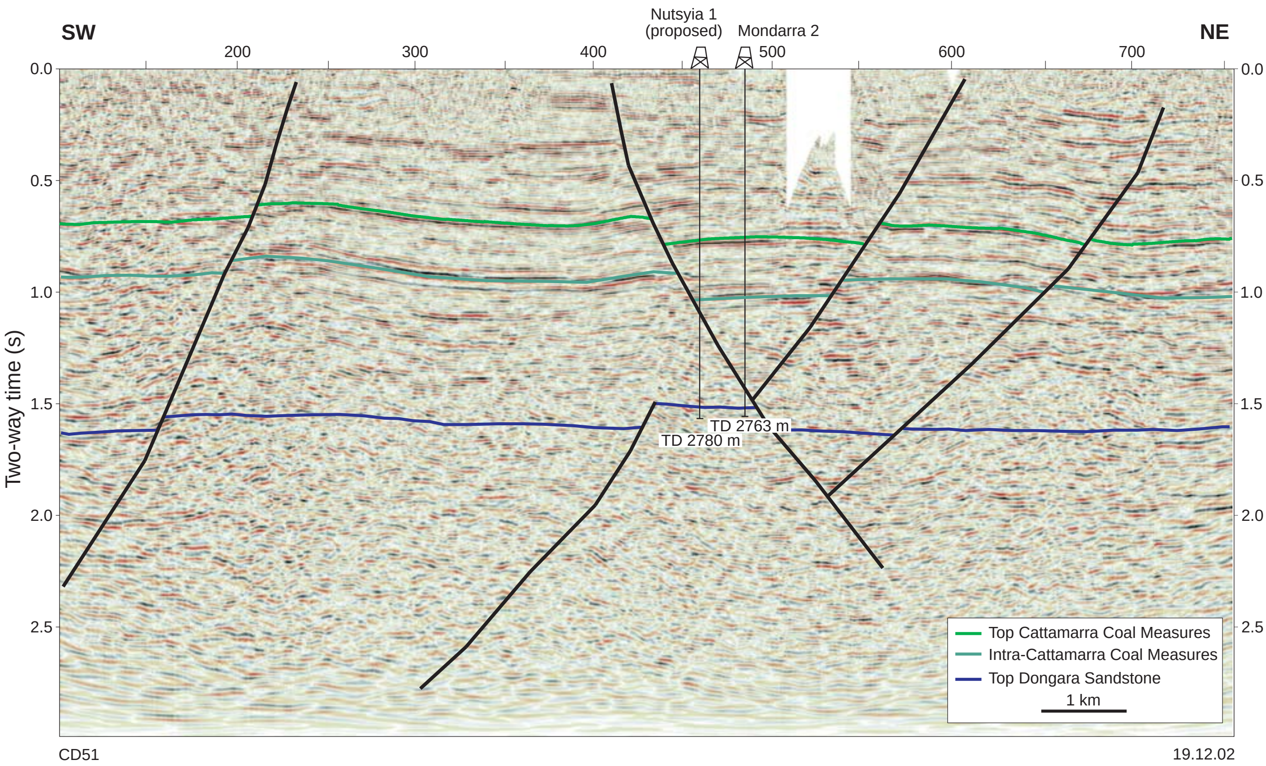


Figure 60. Seismic section P89-12L showing the structure of the Nutsyia prospect

If porosity preservation is facies dependent (Tupper et al., 1994), then the facies of the Dongara Sandstone must change between Mondarra 1 and Mount Adams 1, although such a change is not obvious on the logs.

Greenough and Bookara Shelfs

EP 111

EP 111 is the most northerly permit in the northern Perth Basin and lies about 6 km north of the Mount Horner oilfield, north of the easterly trending, down-to-the-south Bookara Fault. The permit has been divided into western and eastern survey areas. Northwesterly trending faults dominate the western survey area, whereas the eastern survey area is dominated by the easterly trending Bookara Fault and its orthogonal fault splay, the Heelans Fault. The sedimentary section in EP 111 thickens from 300 m in the northwest to greater than 3000 m in the southeast.

W-1 prospect

Hydrocarbon type	Oil
Permit	EP 111
Operator	Jervois Mining NL (surrendered in March 2002)
Maturity	Low
Geological risk	1:8.2
Depth to objective	375 m (to Cattamarra Coal Measures) 575 m (to Bookara Sandstone Member)
TD	610 m
Volumetrics P_{50}	0.45 GL (2.84 MMbbl) OOIP
Surface area	0.4 km^2
Play type	Faulted anticline
Objectives	Newmarracarra Limestone, Cattamarra Coal Measures, Bookara Sandstone Member
Key strengths	Reservoir
Key weaknesses	Migration from Dandaragan Trough
Proposed well location	Latitude 29°03'27.77"S Longitude 114°58'56.72"E Seismic line JM99-05 at SP 345
Seismic coverage	End of 2 seismic lines Vintage of seismic: 1986 and 1999

Summary

W-1 is 1 km north of Mount Hill 1 in the western survey area of EP 111 and lies within the Greenough Shelf. The structure is defined by the eastern ends of lines S86-04 and JM99-05 (Fig. 61). W-1 is associated with a tilted, northwesterly trending basement block and reverse fault (Shaw, 2000). Closure is provided by a normal fault to the west, by a reverse fault associated with easterly tilted basement to the east, and by a drape-related rollover to the north and south (Shaw, 2000). The W-1 prospect shows closure on all reservoir levels.

The volumetrics for the W-1 prospect are based on two independent pools: one within the Cattamarra Coal Measures level (good porosity penetrated in Connolly 1),

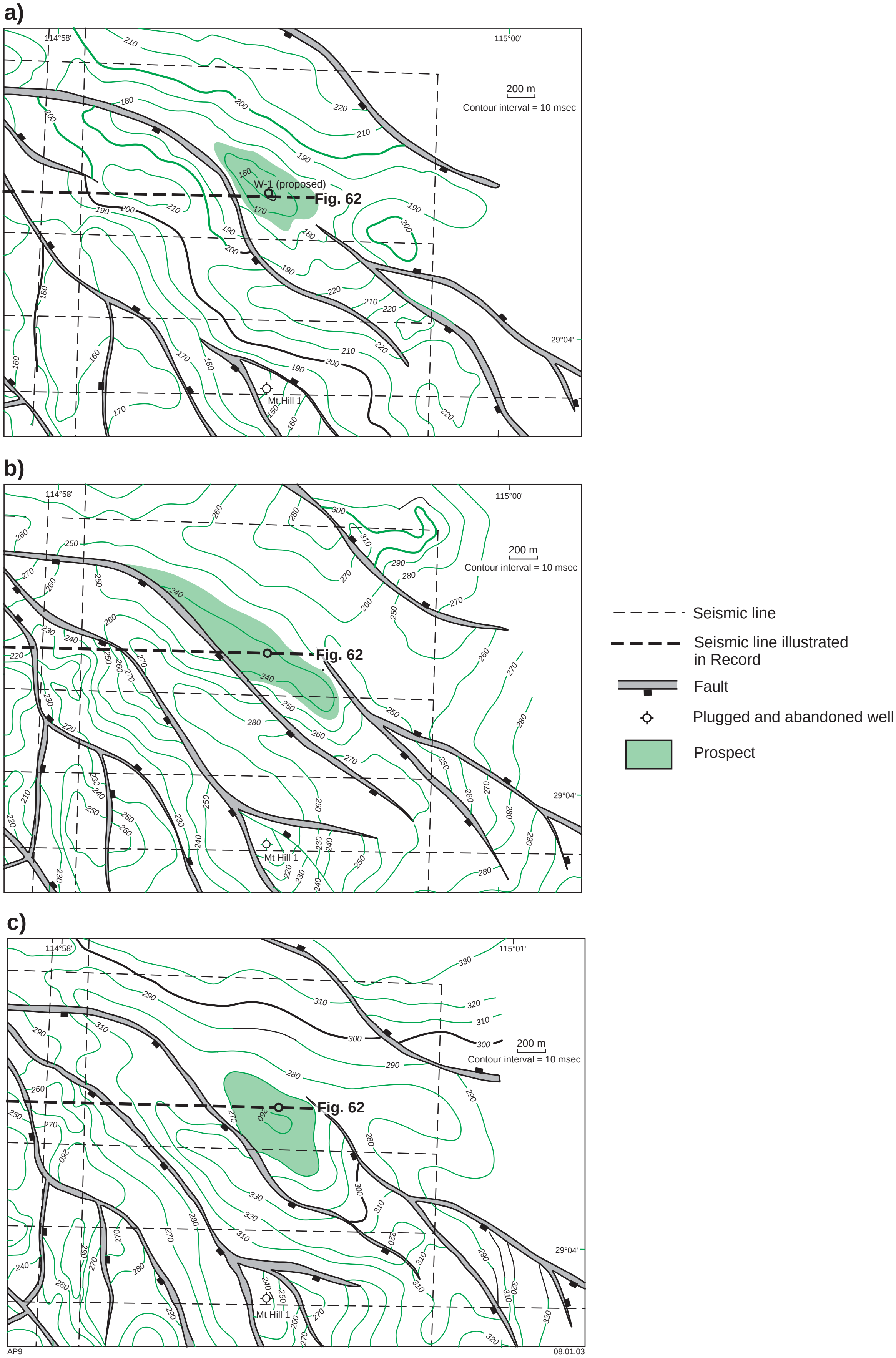


Figure 61. **Two-way time contours for the W-1 prospect: a) top Cadda Formation; b) intra-Cattamarra Coal Measures; c) top Bookara Sandstone (after Shaw, 2000)**

and the other from the Bookara Sandstone Member (good oil shows in Conder 1). Volumetrics for W-1 are calculated as 0.28 GL (1.74 MMbbl) OOIP for the Cattamarra Coal Measures, and 0.17 GL (1.10 MMbbl) OOIP for the Bookara Sandstone Member, giving a total of 0.45 GL (2.84 MMbbl) of OOIP.

Nearby wells

Mount Hill 1.

Assessment of geological risk elements

• Trap: poorly controlled	0.5
• Source: considerable distance from known source	0.7
• Migration and timing: migration through Bookara Fault unknown	0.5
• Reservoir: good reservoir expected at this depth	0.7
Probability of recovering hydrocarbons to the surface	1:8.2

Trap

The structure is constrained by the ends of two seismic lines. At all reservoir levels the trap is on the northern side of a northwesterly trending, down-to-the-southwest fault (Figs 61 and 62). Fault throw increases with depth from 8 msecs at the top Cadda Formation level, to 44 msecs at the Bookara Sandstone Member level. The fault does not continue to the top of the Yarragadee Formation. The majority of growth on this fault was during the deposition of the Cattamarra Coal Measures.

The closure at the top Cadda Formation level (190 msecs) potentially spills across the fault; however, the reservoir on the downthrown side of the fault appears to be closed, thereby increasing the independent closure at this level to 15 msecs (Fig. 61a). The seal depends on the presence of siltstone and claystone within the Yarragadee Formation. The Kockatea Shale provides the top seal. At the intra-Cattamarra Coal Measures horizon, closure is fault dependent (Fig. 61b). At Mount Horner, the Cattamarra Coal Measures have proven top and intraformational seals. The structure at the top Bookara Sandstone Member level is a four-way dip closure on the upthrown side of a down-to-the-southwest fault (Fig. 61c).

Source

The Kockatea Shale is the source for hydrocarbons in the Mount Horner oilfield and the most probable source for the prospects and leads north of the Bookara Fault in EP 111. In the southern portion of EP 111 the range of vitrinite reflectance values in the Kockatea Shale is 0.6 – 0.8% indicating a maturity corresponding to the early generation of oil (Shaw, 2000).

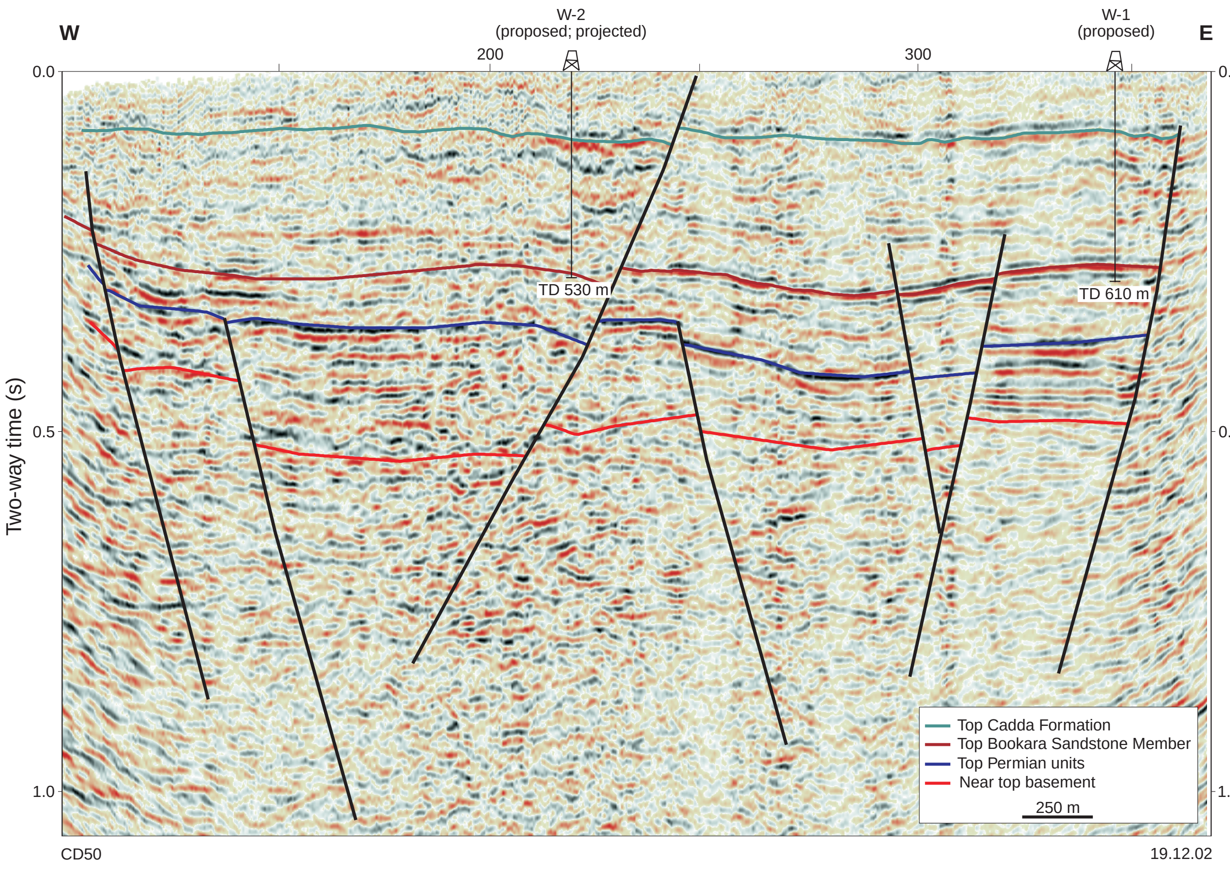


Figure 62. Seismic section JM99-05 showing the structure at the W-1 prospect

Migration and timing

To reach the W-1 prospect a long migration path is required from the source pod in the Dandaragan Trough across the easterly trending Allanooka and Bookara Faults, and the northerly trending Mountain Bridge – Mount Michael Faults. The Mount Horner oilfield, which is filled to spill point, was charged from the Dandaragan Trough demonstrating at least medium-range migration and that faults in this part of the basin did not prevent such migration. The Allanooka Fault appears to act as a barrier to migration to the east, but allowed migration in the Mount Horner area. The final migration route from the Mount Horner area to the W-1 prospect is through the Bookara Fault. The properties of the Bookara Fault are unknown, and consequently, the risk of hydrocarbon migration to leads in this area is greater than south of this fault.

Reservoir

All the reservoirs are shallow and have not undergone any significant burial and therefore, reservoir parameters are expected to be good. The porosity for the W-1 prospect is assumed to be 22% for the Cattamarra Coal Measures, based on Connolly 1, and 17.5% for the Bookara Sandstone Member, based on Conder 1.

W-2 prospect

Hydrocarbon type	Oil
Permit	EP 111
Operator	Jervois Mining NL (surrendered in March 2002)
Maturity	Low
Geological risk	1:10.2
Depth to objective	290 m (to Cattamarra Coal Measures) 495 m (to Bookara Sandstone Member)
TD	530 m
Volumetrics P_{50}	0.49 GL (3.10 MMbbl) OOIP
Surface area	0.4 km^2
Play type	Anticline
Objectives	Newmarracarra Limestone, Cattamarra Coal Measures, Bookara Sandstone Member
Key strengths	Reservoir
Key weaknesses	Long distance from source pod, poorly controlled
Proposed well location	Latitude 29°03'37.20"S Longitude 114°57'41.63"E Seismic line S86-04 at SP 2720
Seismic coverage	1 × 1.75 km grid of seismic in the area Vintage of seismic: 1986 (noisy and unreliable at shallow depths)

Summary

The W-2 prospect on the Greenough Shelf is 3 km northwest of Mount Hill 1, about 1.2 km west of W-1, and is in the western survey area of EP 111. The prospect is defined by one seismic line and bounded by two younger seismic lines. This prospect is located on a horst block on the downthrown, western side of a northwesterly trending fault. W-2 is in a similar position to W-1 and so has the same reservoir, source, migration, and timing risks.

The volumetrics for the W-2 prospect have been based on two independent pools: one within the Cattamarra Coal Measures level (good porosity penetrated in Connolly 1), and the other from the Bookara Sandstone Member (good oil shows in Conder 1). Volumetrics for W-2 are calculated as 0.28 GL (1.73 MMbbl) OOIP for the Cattamarra Coal Measures, and 0.22 GL (1.37 MMbbl) OOIP for the Bookara Sandstone Member, giving a total of 0.49 GL (3.10 MMbbl) of OOIP.

Nearby wells

Mount Hill 1.

Assessment of geological risk elements

• Trap: poorly controlled	0.4
• Source: considerable distance from known source	0.7
• Migration and timing: migration through Bookara Fault unknown	0.5
• Reservoir: good reservoir expected at this depth	0.7
Probability of recovering hydrocarbons to the surface	1:10.2

Trap

The W-2 prospect is interpreted as an elongated anticline with four-way dip closure at all levels on the western side of a northwesterly trending fault (Fig. 63). It is located on a northwesterly trending horst with conspicuous rollover, just to the west of a small graben on seismic line S86-04 (Fig. 64; Shaw, 2000). Drape and flexing provide easterly rollover, whereas a northerly rollover and structural closure across the prospect is indicated by the structurally lower positions of corresponding reflections on seismic lines JM99-05 and JM99-07.

The top seal for the Bookara Sandstone Member level is provided by the Kockatea Shale. Claystone beds within the Cattamarra Coal Measures are the likely top and intraformational seals. The Cadda Formation could also provide an effective seal to the underlying Cattamarra Coal Measures. Intraformational claystone and siltstone are necessary to seal the Cadda Formation level.

Source

The Kockatea Shale is the source for hydrocarbons in the Mount Horner oilfield and the most probable source for the prospects and leads north of the Bookara Fault in EP 111. In the southern portion of EP 111, vitrinite reflectance values in the Kockatea Shale are 0.6 – 0.8%, indicating a maturity corresponding to the early generation of oil (Shaw, 2000).

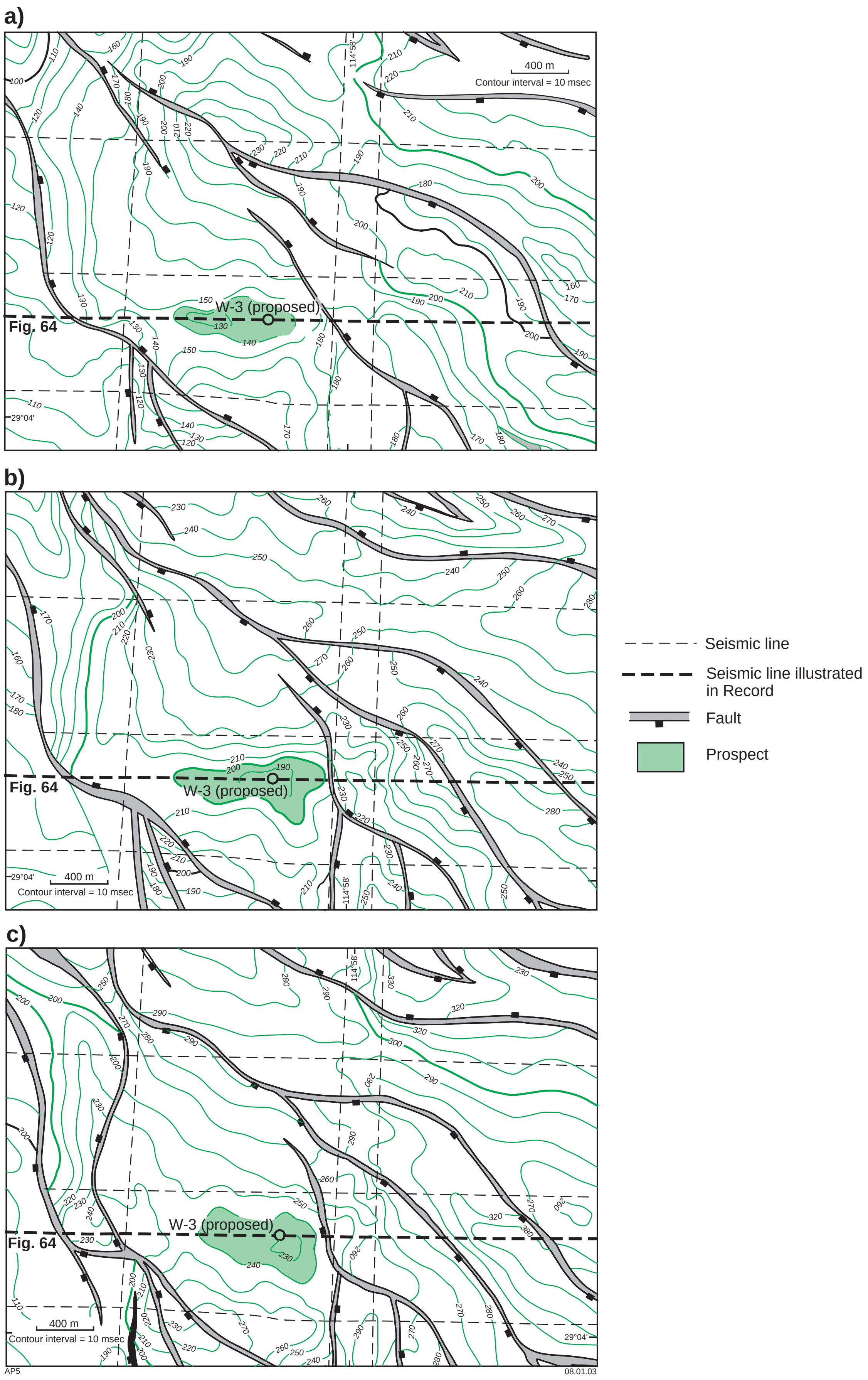


Figure 63. Two-way time contours for the W-2 prospect: a) top Cadda Formation; b) intra-Cattamarra Coal Measures; c) top Bookara Sandstone (after Shaw, 2000)

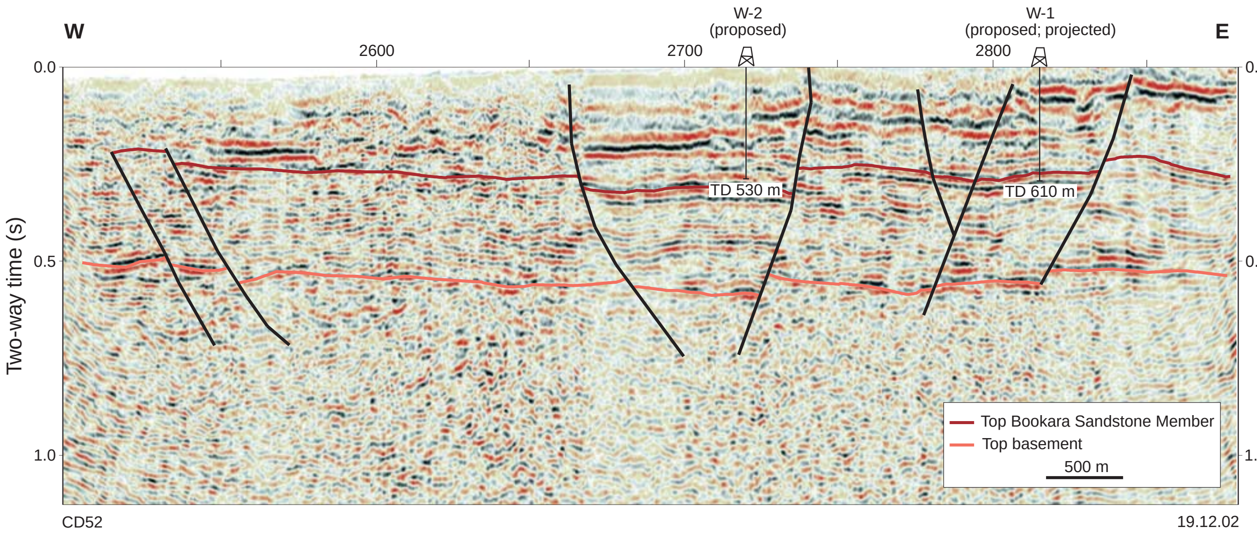


Figure 64. Seismic section S86-04 showing the structure at the W-2 prospect

Migration and timing

A long migration path from the Dandaragan Trough across the Bookara Fault is required in this area. Faults bounding the horst (upon which it is situated) extend beyond the survey area to the southeast, suggesting that they may link with basinal faults, thereby providing fault-related migration into the prospect.

Reservoir

Reservoir parameters are expected to be good as all the reservoirs are shallow and have not undergone significant burial. The porosity for the W-2 prospect is assumed to be 22% for the Cattamarra Coal Measures, based on Connolly 1, and 17.5% for the Bookara Sandstone Member, based on Conder 1.

W-3 prospect

Hydrocarbon type	Oil
Permit	EP 111
Operator	Jervois Mining NL (surrendered in March 2002)
Maturity	Low
Geological risk	1:12.8
Depth to objective	120 m (to Cattamarra Coal Measures) 260 m (to Bookara Sandstone Member)
TD	300 m
Volumetrics P_{50}	0.54 GL (3.42 MMbbl) OOIP
Surface area	0.5 km^2
Play type	Faulted anticline
Objectives	Newmarracarra Limestone, Cattamarra Coal Measures, Bookara Sandstone Member
Key strengths	Reservoir
Key weaknesses	Migration from Dandaragan Trough
Proposed well location	Latitude 29°02'23.98"S Longitude 114°56'31.79"E Seismic line S86-02 at SP 1620
Seismic coverage	1 × 1.75 km grid of seismic in the area Vintage of seismic: 1986 (noisy and unreliable at shallow depths)

Summary

The W-3 prospect lies on the Greenough Shelf within the western survey area of EP 111, 2 km northeast of Conder 1 and 1.5 km southwest of Connolly 1, at the western end of seismic line S86-02. The trap is dependent on a northwesterly trending, sinuous normal fault that is the continuation of the western fault of the horst block containing W-2 (Fig. 65).

The volumetrics for the W-3 prospect are based on two independent pools: one within the Cattamarra Coal Measures level (good porosity in Connolly 1), and the other from the Bookara Sandstone Member (good oil shows in Conder 1). Volumetrics for W-3 are calculated as 0.21 GL (1.30 MMbbl) OOIP for the Cattamarra Coal Measures, and 0.34 GL (2.12 MMbbl) OOIP for the Bookara Sandstone Member, giving a total of 0.54 GL (3.42 MMbbl) of OOIP.

Nearby wells

Conder 1 and Connolly 1.

Assessment of geological risk elements

- Trap: poorly controlled 0.4
- Source: considerable distance from known source 0.7

• Migration and timing: migration through Bookara Fault unknown	0.4
• Reservoir: good reservoir expected at this depth	0.7

Probability of recovering hydrocarbons to the surface	1:12.8

Trap

The W-3 prospect is a fault-dependent anticline at intra-Cadda Formation and top Bookara Sandstone Member levels (Figs 65a and c). At the intra-Cattamarra Coal Measures level the prospect is an elongate anticline dipping to the northwest and southeast (Fig. 65b). W-3 has virtually no fault independent closure at the Bookara Sandstone Member level (Fig. 66), compared to W-1 and W-2, which are independent of fault seal.

The Kockatea Shale provides the top seal for the Bookara Sandstone Member. The top and intraformational seals for the Cattamarra Coal Measures are claystone beds within the same formation. The Cadda Formation could also provide an effective seal to the Cattamarra Coal Measures. Intraformational seals are necessary for the Cadda Formation level.

Source

The Kockatea Shale is the source for hydrocarbons in the Mount Horner oilfield and the most likely source for prospects and leads north of the Bookara Fault in EP 111. In the southern portion of EP 111, vitrinite reflectance values in the Kockatea Shale have a range of 0.6 – 0.8%, indicating a maturity corresponding to the early generation of oil (Shaw, 2000).

Migration and timing

The fault system on which W-3 sits may have provided part of the migration path from the source pod at the base of the Kockatea Shale to the southeast. The migration pathway to W-3 is longer than to W-1 and W-2 and therefore less certain. As W-2 is on the southeastern part of the fault that formed the W-3 prospect, W-2 would be charged preferentially to W-3, thereby implying a somewhat lower prospectivity.

Reservoir

All the reservoirs are shallow and have not undergone any significant burial; therefore, reservoir parameters are expected to be favourable. The porosity for the W-3 prospect is assumed to be 22% for the Cattamarra Coal Measures, based on Connolly 1, and 17.5% for the Bookara Sandstone Member, based on Conder 1.

Tabletop lead

Hydrocarbon type	Oil
Permit	EP 111
Operator	Jervois Mining NL (surrendered in March 2002)
Maturity	Very low
Geological risk	1:19.8
Volumetrics P_{50}	1.31 GL (8.26 MMbbl) OOIP
Play type	Faulted anticline
Objectives	Newmarracarra Limestone, Cattamarra Coal Measures, Bookara Sandstone Member
Key strengths	Reservoir
Key weaknesses	Migration from the Dandaragan Trough
Seismic coverage	1 seismic line Vintage of seismic: 1994

Summary

The Tabletop lead on the Bookara Shelf is in the eastern survey area of EP 111 and falls on the edge of EP 111 and EP 368 where it is defined by one seismic line. There is a pronounced shallowing of the sedimentary section to the north, onto gneiss and granite basement (Northampton Complex). This could prove a risk for this lead, as there may be no structural mechanisms to provide dip closure. There is a possibility that stratigraphic traps are present as the sedimentary section pinches out onto the shallow basement; however, this play type is considered risky.

The volumetrics for the Tabletop lead are based on two independent pools within the Cattamarra Coal Measures equivalent to the ‘B sand’ and ‘F sand’ penetrated in Jay 1 and which produce in the Mount Horner oilfield. Fault dependent volumetrics at the ‘B sand’ level are calculated as 0.55 GL (3.48 MMbbl) OOIP and 0.76 GL (4.78 MMbbl) OOIP for the ‘F sand’, giving a total of 1.31 GL (8.26 MMbbl) of OOIP.

Nearby wells

Jay 1 and Rosslyn 1.

Assessment of geological risk elements

• Trap: fault-dependent structure	0.3
• Source: considerable distance from known source	0.6
• Migration and timing: migration through Bookara Fault unknown	0.4
• Reservoir: good reservoir expected at this depth	0.7

Probability of recovering hydrocarbons to the surface	1:19.8

Trap

At all mapped levels the Tabletop lead shows fault-related closure provided by the Heelans Fault to the northwest (Fig. 67). Faulting in the area is down to the south and there is an absence of structural mechanisms that could provide counter-regional dip closure (Shaw, 2000). Therefore, the faults in this area probably provide synthetic, rather than antithetic, trapping mechanisms. Similar synthetic fault traps are effective in the Mount Horner oilfield. Seal is provided by the Kockatea Shale.

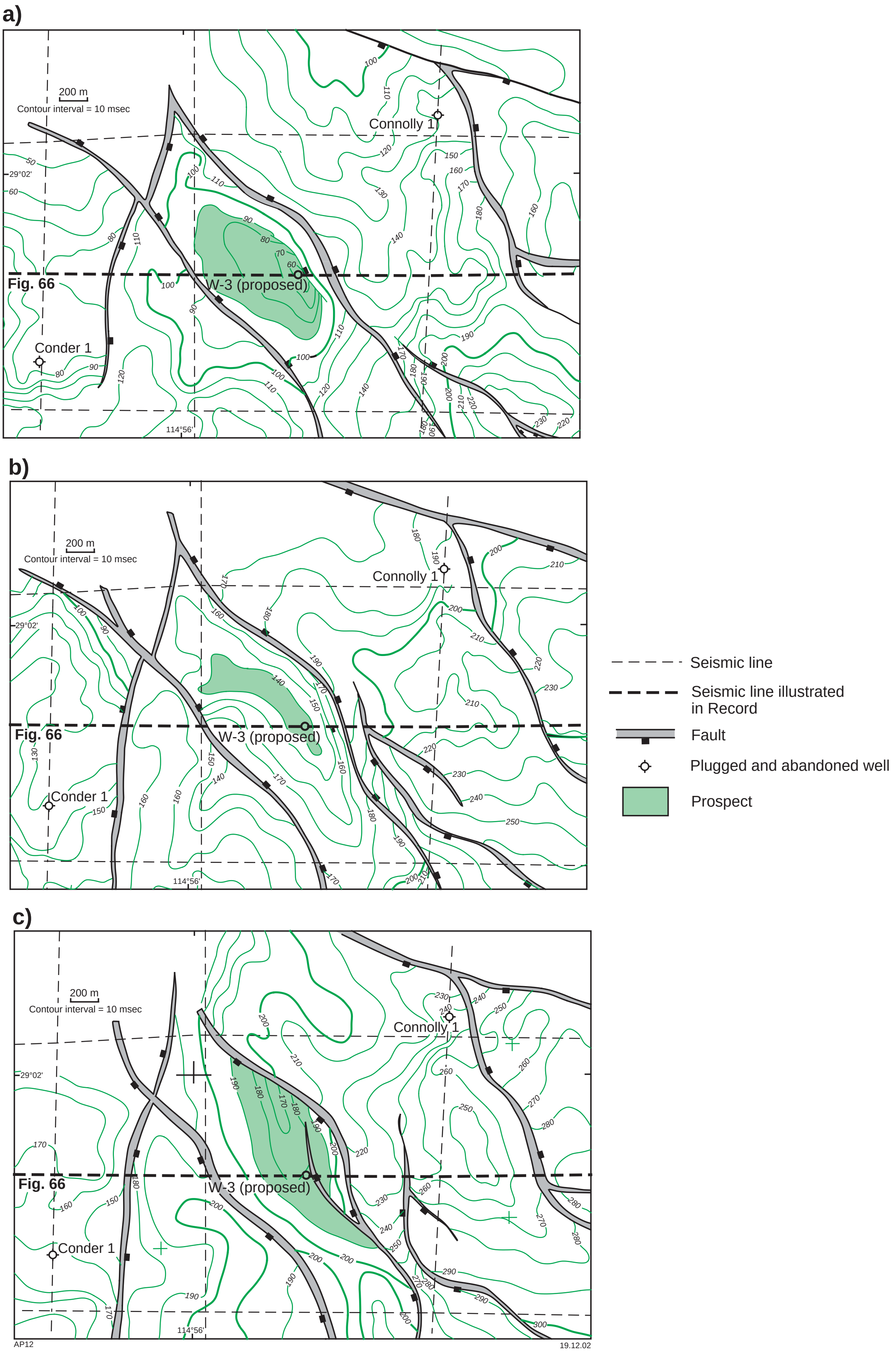


Figure 65. Two-way time contours for the W-3 prospect: a) top Cadda Formation; b) intra-Cattamarra Coal Measures; c) top Bookara Sandstone (after Shaw, 2000)

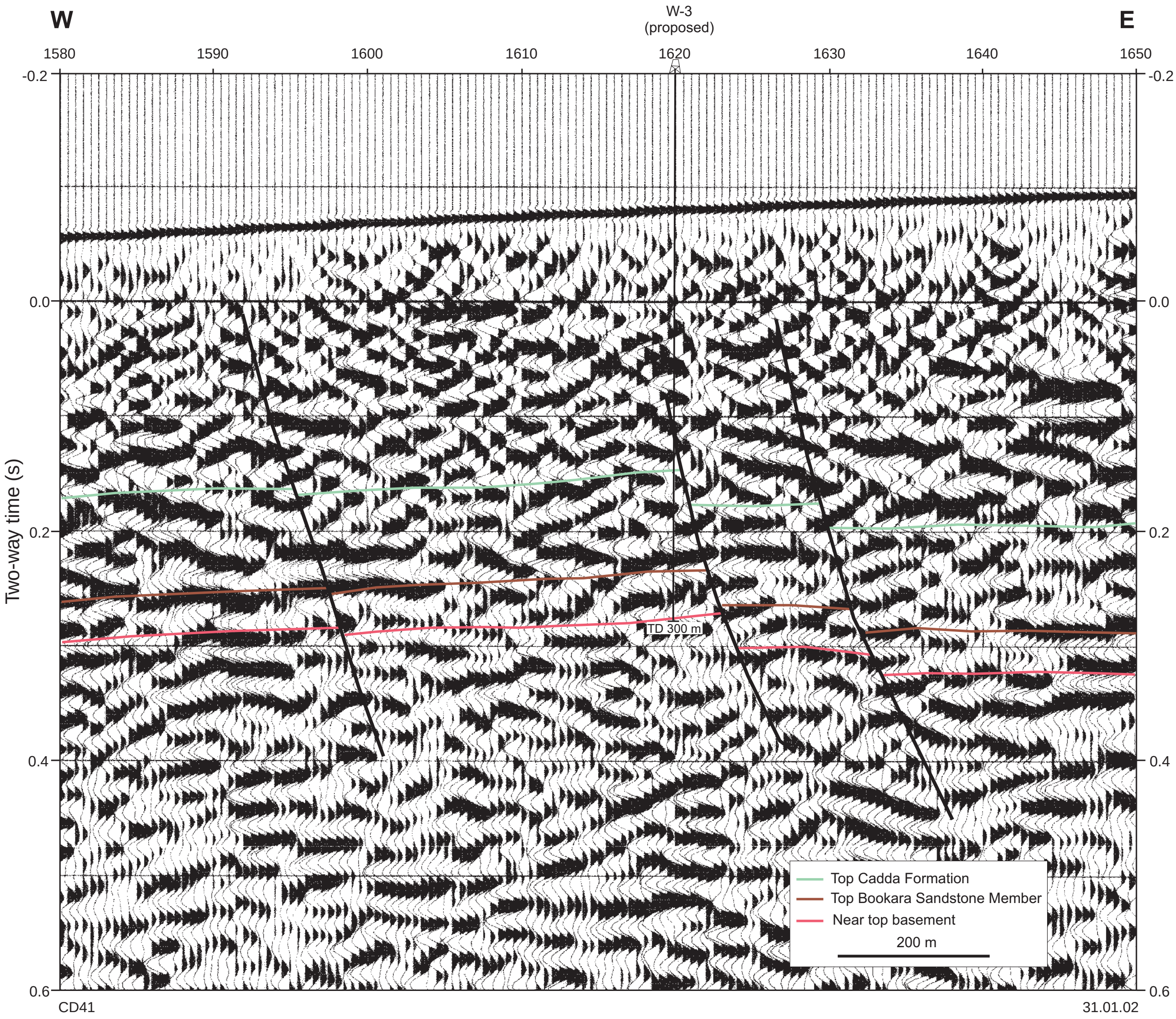


Figure 66. Seismic section S86-02 showing the structure at the W-3 prospect

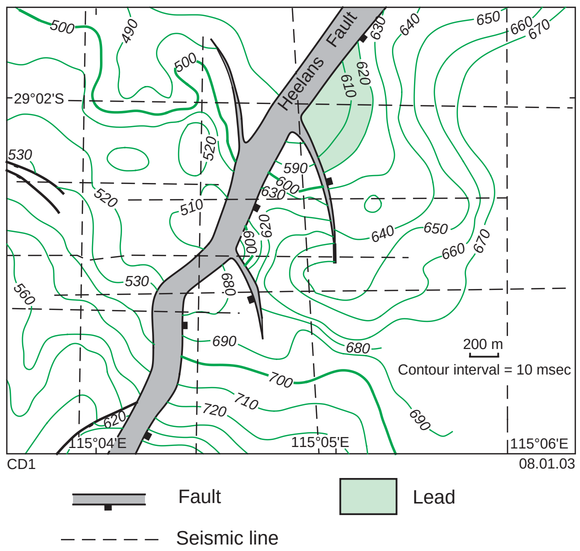


Figure 67. Two-way time contours of the top Bookara Sandstone, Tabletop lead (after Shaw, 2000)

Source

The Kockatea Shale in the northern part of the Dandaragan Trough is the source for the hydrocarbons in Mount Horner oilfield and the most probable source for the leads north of the Bookara Fault.

Migration and timing

A long migration path across the Mountain Bridge, Bookara, and Heelans Faults is required. The migration route from the Mount Horner oilfield to the Tabletop lead crosses the Bookara and Heelans Fault.

Reservoir

The reservoirs are fairly shallow and have not undergone any significant burial; therefore, reservoir parameters are expected to be good. The porosity is assumed to be 22% for the Tabletop lead, based on the 'B sands' and 'F sands' (typically 3–5 m thick) within the Cattamarra Coal Measures from the Mount Horner oilfield.

EP 394

Permit EP 394 is on the western-most edge of the northern Perth Basin and immediately north of the Dongara oil- and gasfield.

Wye prospect

Hydrocarbon type	Oil
Permit	EP 394
Operator	Ausam Resources NL (surrendered in 2002)
Maturity	Medium
Geological risk	1:10.2
Depth to objective	766 m
Volumetrics P_{50}	1.43 GL (9 MMbbl)
Play type	Faulted anticline
Primary objective	Bookara Sandstone Member
Key strengths	Proximity to Dongara and Mount Horner oilfields
Key weaknesses	Reservoir
Proposed well location	Not available
Seismic coverage	Covered by 1 km × 1 km grid Vintage of seismic: 1987, 1995, and 1997

Summary

The Wye prospect is located about 10 km west of the Mount Horner oilfield on the Greenough Shelf, updip from the Dongara oil- and gasfield. This prospect is an appraisal project by Ausam Resources NL of a gas discovery from Wye 1. The project involves drilling downdip of the gas accumulation, below the elevation of the defined lowest known intersection of gas in Wye 1, to test for the presence of an underlying oil leg (Ausam Resources NL, 2000). In the adjacent Dongara oil- and gasfield, this strategy has yielded around 11.32 Gm^3 (400 Bcf) of gas, leaving an underlying oil leg.

The success of the Wye project depends on the presence of an oil leg. If the gas in Wye 1 represents the cap to an oil-filled trap dependent on fault seal, then the reserves may be quite large. The presence of H_2S (a breakdown product from the biodegradation of oil) in gas from Wye 1 suggests an oil leg containing sulfurous crude oil (Ausam Resources NL, 2000).

Nearby wells

Allanooka 1 and 2, Horner West 1, and Wye 1.

Assessment of geological risk elements

- Trap: faulted, wedged anticlinal feature — 0.5
- Source: hydrocarbons recovered from nearby fields and wells — 0.7
- Migration and timing: proximity to Dongara oil- and gasfield and Mount Horner oilfield — 0.7
- Reservoir: although there is reasonable quality reservoir present within the area, it is thin at Wye 1 — 0.4

Probability of recovering hydrocarbons to the surface — 1:10.2

Trap

The prospect is located updip from the Dongara oil- and gasfield on a broad regional high. At all levels the Wye prospect is a rollover on the northeasterly trending Wye Fault with minor faulting on its flanks (Figs 68 and 69). At the Bookara Sandstone Member the prospect is wedged between conjugate fault sets (Fig. 68). The Kockatea Shale and Cadda Formation form the top seals within the prospect. Based on the regional framework of the Greenough Shelf, an alternative interpretation for the Wye prospect is that the horst block interpreted by Ausam Resources NL is part of a downthrown block (Fig. 70).

Source

As for the Mount Horner oilfield, 10 km to the west, hydrocarbons in the area are probably sourced from the basal part of the Kockatea Shale in the Dandaragan Trough.

Migration and timing

Oil shows in Conder 1 and Connolly 1 north of the Wye prospect imply it is located on an oil migration pathway.

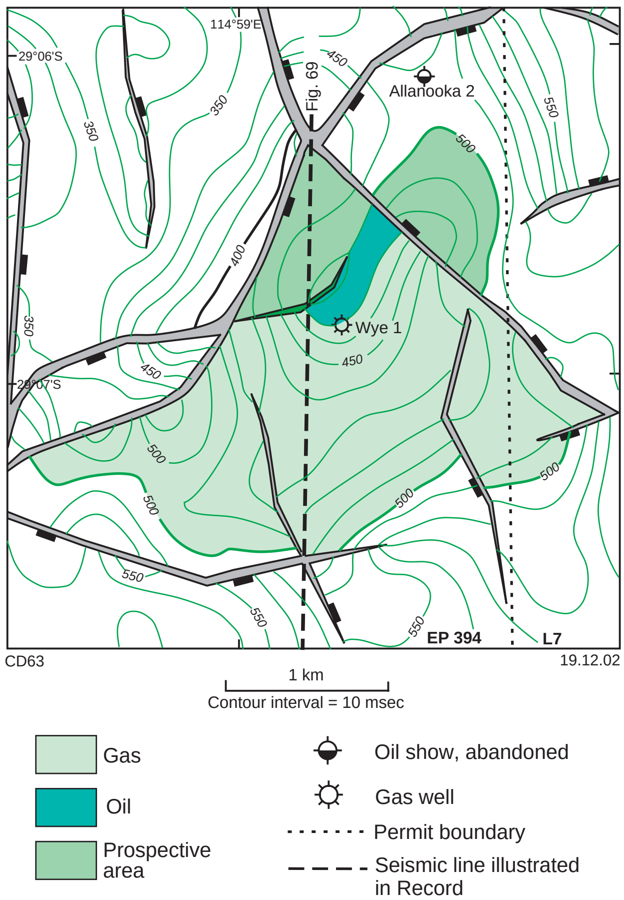


Figure 68. Two-way time contours of the base Kockatea Shale, Wye prospect (AusAm Resources NL, 2000)

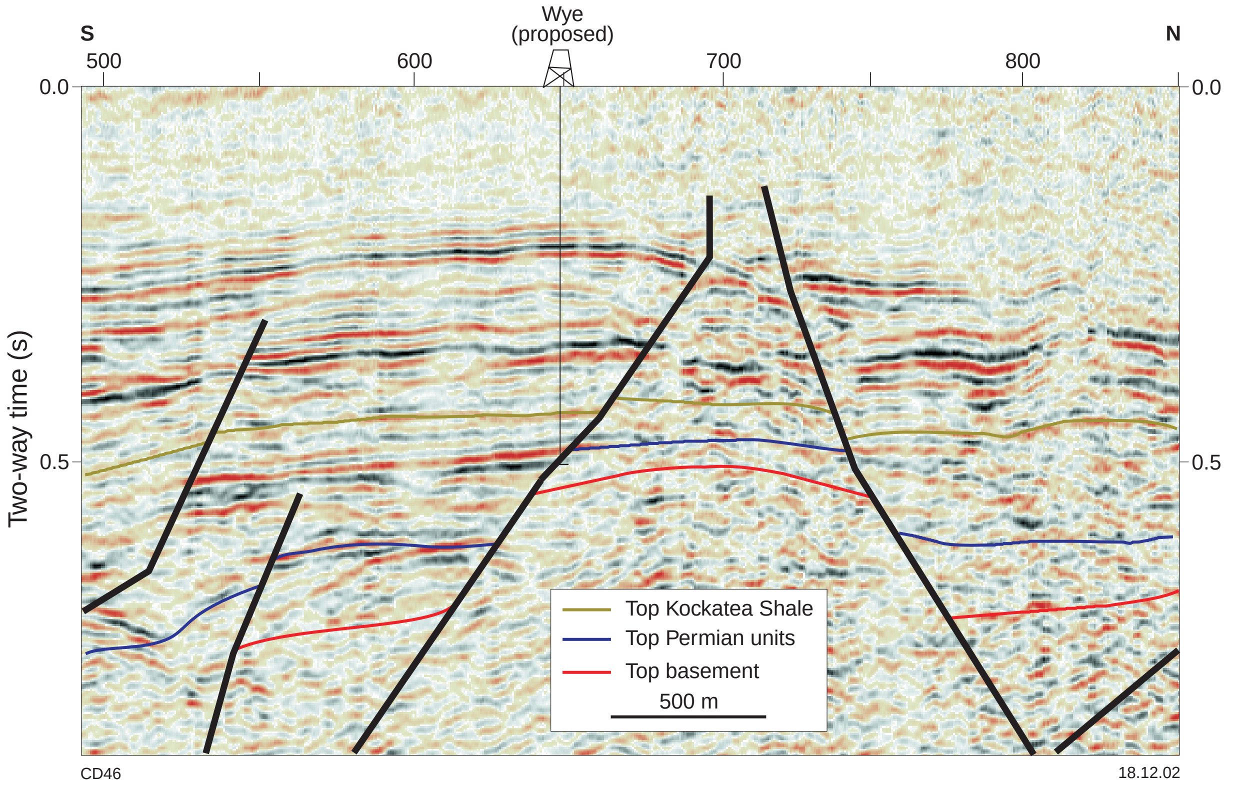


Figure 69. Seismic section DN95-106 showing the structure for the Wye prospect interpreted by AusAm Resources NL. The depth to the objective is 766 m

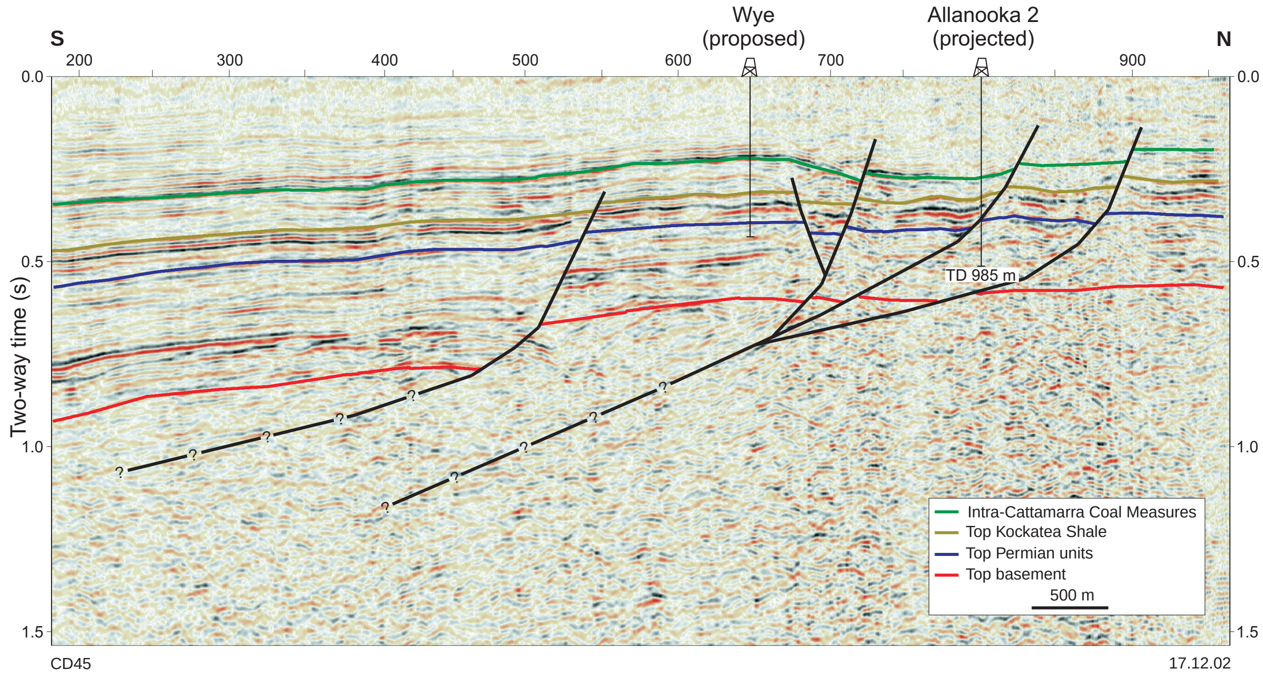


Figure 70. Seismic section DN95-106 showing the structure for the Wye prospect interpreted by GSWA. The depth to the objective is 766 m

Additional oil shows in Allanooka 1 suggest the prospect is well located to trap northward migrating hydrocarbons from the Dongara area to the south across the Allanooka Fault. There is some chance of biodegradation of oil at Wye due to the relatively shallow depth to reservoirs and fresh water in aquifers.

It is likely that during the Jurassic, oil migrated to Wye from the Mount Horner oilfield, which is filled to spill point, or from a breached Dongara Sandstone reservoir on the upthrown side of the Mount Horner Fault. The latter is considered to be the original supply of oil for the Mount Horner oilfield (Discovery Petroleum NL, 1996b). The gas probably migrated from the Dongara oil- and gasfield to the south, which is similarly filled to spill point.

Reservoir

Adjacent wells indicate good reservoir quality. Oil shows were noted in almost every porous sandstone from the top of the Cadda Formation to the Dongara Sandstone in Wye 1. Gas shows were noted in the lower section of the Kockatea Shale (Arranoo and Bookara Sandstone Members). The average porosity in Wye 1, based on wireline log data, was 11–15% for the Cattamarra Coal Measures and 13–18% from the thin sandstone in the basal part of the thin section of the Dongara Sandstone.

Re-appraisal of known accumulations

Tight gas accumulations

There are several accumulations of gas in tight or low permeability reservoirs in the northern Perth Basin. The primary risk for these accumulations requires engineering solutions such as modern fracture stimulation techniques, which may allow commercial flows. A better understanding of the interaction between clay minerals and drilling fluids has developed over the last few years. Many tight gas discoveries failed to produce at economic rates largely because of reservoir rocks being susceptible to permeability loss from the entry of drilling and hydraulic fracture fluids. Technology developed in North America has been applied successfully in the production of hydrocarbons from low permeability reservoirs (e.g. the Jonah field in the Green River Basin, Wyoming, USA). Some of the techniques used include: underbalanced drilling, which prevents damage to the reservoir by preventing invasion of drilling fluids into the rock matrix; horizontal drilling, which allows the drill hole to penetrate a greater volume of the reservoir, thereby promoting higher flow rates; hydraulic fracturing to enhance the flow capacity of the system; and production practices such as controlling production rates and drawdown levels to avoid severely damaging the reservoirs (Ausam Resources NL, 2000).

Ocean Hill prospect

Hydrocarbon type	Gas
Permit	EP 320
Operator	Origin Energy Developments Pty Ltd/Australian Worldwide Exploration Pty Ltd
Maturity	Tight gas accumulation
Geological risk	1:8.9
Depth to reservoir	3248 m
TD	3840 m
Volumetrics P_{50}	0.57 Gm^3 (20 Bcf)
Surface area	490 km^2
Play type	Anticline
Objectives	Cattamarra Coal Measures
Key strengths	Existing gas accumulation
Key weaknesses	Low porosity and permeability
Current well location	Latitude 29°56'12.78"S Longitude 115°23'47.02"E Seismic line B89-450 at SP 350
Seismic coverage	4 lines over the prospect; poorly defined Vintage of seismic: 1960, 1989, and 1990

Summary

Ocean Hill is located 18 km to the southwest of the Eneabba township and was drilled in 1991 by Arrow Petroleum within the northern part of the Coomallo Trough, on the western flank of the Dandaragan Trough. The structure is a highly faulted, northerly trending anticline.

Nearby wells

Ocean Hill 1.

Assessment of geological risk elements

• Trap: possible lack of lateral seal across faults	0.4
• Source: good gas shows were detected	0.7
• Migration and timing: very low permeability, but close to Dandaragan Trough	0.5
• Reservoir: reservoir quality sandstone is present	0.8
Probability of recovering hydrocarbons to the surface	1:8.9

Trap

The Ocean Hill prospect is a complexly faulted anticline, with four-way dip closure at the Jurassic level (Fig. 71). Faults that cut the Cadda Formation have not breached the seals, although they appear to have throws in excess of individual reservoir thicknesses. This suggests that the fault planes themselves may compartmentalize the structure (Sagasco Resources Ltd, 1991). Multiple-stacked gas reservoirs within the Cadda Formation and

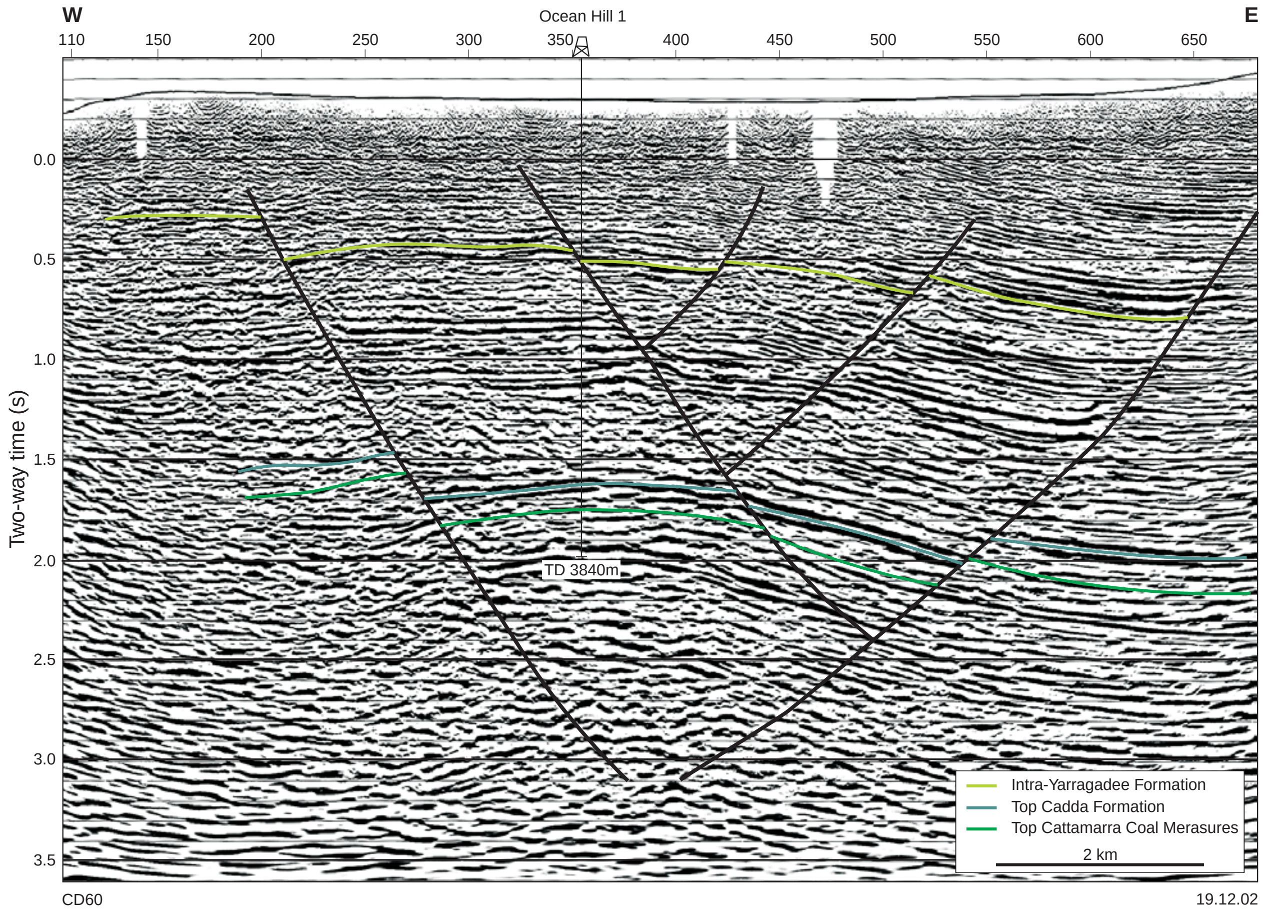


Figure 71. Seismic section B89-450 showing the structure of the Ocean Hill prospect

Cattamarra Coal Measures indicate that intraformational beds are the most effective seals. Therefore, the reservoir rocks are sealed vertically by the Cadda Formation and by intraformational shales.

Source

The Cattamarra Coal Measures are thought to be the source of hydrocarbons within Ocean Hill with a possible contribution from the Cadda Formation, although a deeper source is feasible. Maturity data indicate that the Cattamarra Coal Measures are within the oil-generative window at this location.

Migration and timing

Migration would have been from the Dandaragan Trough to the west. The Ocean Hill structure was probably formed during continental breakup. The concentration of gas in tight reservoirs in Ocean Hill 1 implies migration post-dated the structure.

Reservoir

Reservoir quality sandstone is present in the Cattamarra Coal Measures, but tends to be water-wet. Hydrocarbon shows were from tight sandstone. Very low permeabilities (between 0.06 and 0.18 mD) were noted and porosities from the sandstone units were estimated to be between 10 and 15%.

Warro prospect

Hydrocarbon type	Gas
Permit	EP 321/407
Operator	Ausam Resources NL
Maturity	Tight gas accumulation (medium–high)
Geological risk	1:7.7
Depth to Objective	3739 m
Volumetrics P_{50}	159 Gm^3 (5626 Bcf) OGIP
Surface area	68.8 km^2
Play type	Anticline with minor faulting at the crest
Primary objective	Lower Yarragadee Formation
Key strengths	Lead closes on 2D seismic grid
Key weaknesses	Yarragadee Formation, low porosity at this depth
Proposed well location	Not available
Seismic coverage	About 8 lines, 1.5 – 3.0 km, consisting of 4 dip and 4 strike lines Vintage of seismic: 1976 and 1991

Summary

The Warro prospect is located 65 km southwest of the Woodada gasfield and about 32 km east of the DBNGP and Parmelia gas pipelines. The prospect sits on the boundary between EP 321 and EP 407, on the eastern side of the Dandaragan Trough. At Warro, gas is trapped in tight sandstone within a relatively simple, four-way dip-closed anticline with an unrisked OGIP resource estimated between 90 and 168 Gm^3 (3166–5934 Bcf), with a mean value of 124 Gm^3 (4365 Bcf; Ausam Resources NL, 2000). Warro 1, drilled in 1977 by WAPET, intersected gas shows over a 350 m interval, but commercial flow rates were not achieved in this or the two follow-up wells. Thus, the primary risk element is the potential for porosity degradation at the reservoir depth. Only a minor amount of gas was produced on test, but poor drilling and fracturing processes are thought to have contributed to the low test rates.

Ausam Resources NL's appraisal program aims to rectify the problem of tight gas by using proven technologies and strategies for the evaluation of these reservoirs. Ausam Resources NL (2000) suggested that the drilling fluid used was incompatible with the reservoir and the propping agent was of insufficient strength to maintain fracture closure pressure. The program will include two new wells and re-entering Warro 2 via a sidetrack to perforate specific zones. The new wells and the sidetrack will be drilled using the underbalanced drilling technique until commercial flow rates are thought to be sustainable, and if this does not work, hydraulically fracturing may be attempted (Ausam Resources NL, 2000).

Nearby wells

Warramia 1, and Warro 1 and 2.

Assessment of geological risk elements

• Trap: nature of trap uncertain	0.6
• Source: demonstrated accumulation	0.9
• Migration and timing: moderate gas show in Warro 1	0.8
• Reservoir: uncertain reservoir quality	0.3
Probability of recovering hydrocarbons to the surface	1:7.7

Trap

Warro is a large, north-northwesterly trending anticline with four-way dip closure at top Yarragadee Formation level (Fig. 72). Minor faulting is present in the south-western corner, central area, and northern corner of the prospect (Fig. 73). Intraformational seals within the Yarragadee Formation are evident. Lateral seal across faults could prove to be high risk.

Source

The source for the Warro prospect may have been generated by the Yarragadee Formation downdip from the drilled section (Crostella, 1995) or from deeper horizons.

Migration and timing

Fluids most probably migrated out of the Dandaragan Trough into this area. The Warro structure is younger than the Yarragadee Formation and probably resulted from the Early Cretaceous breakup of the continent.

Reservoir

The Yarragadee Formation has low porosities and low permeabilities within the Warro prospect. Three favourable reservoir zones have been identified: zone A (3739–3844 m) with an estimated porosity of 6.2%; zone B (3867–3965 m) with an estimated porosity of 8.2%; and zone C (3990–4258 m) with an estimated porosity of 8.5%.

Post-mortems of recent exploration wells

Arradale 1

Arradale 1 was drilled in November 2001 by Australian Worldwide Exploration Ltd within the Allanooka Terrace, about 22 km east of the Mount Horner oilfield on EP 368 (Fig. 11), and was plugged and abandoned.

Stratigraphy

Arradale 1 was spudded in the Yarradagee Formation. The Dongara Sandstone was intersected at 2076 m, about 124 m higher than predicted. It was drilled to a total depth of 2245 m. Further details on the stratigraphy are not available at this stage.

Trap

Arradale 1 was interpeted to be the largest, undrilled prospect in the oil-prone part of the northern Perth Basin (Australian Worldwide Exploration Ltd, 2001a). The well tested a downthrown fault trap on the western side of the north-northwesterly trending Wicherina Fault, which has over 1000 m of throw at the base of the Triassic level (base Kockatea Shale; Figs 74 and 75). It also lies on the northern side of the Allanooka Fault and is overlain by a Jurassic rollover (Fig. 76).

Reservoir and seal

Good quality (water-wet) reservoir was intersected in Arradale 1. The top seal in the area is provided by the Kockatea Shale and basal Woodada Formation, and is estimated to be 120–200 m thick. Lateral seal is provided by the Holmwood Shale, which is more than 500 m thick in the nearby Depot Hill 1.

Hydrocarbons

No significant hydrocarbon shows were detected; however, minor oil shows were noted in the Woodada Formation from 1906 to 1032 m and 2064 to 2076 m.

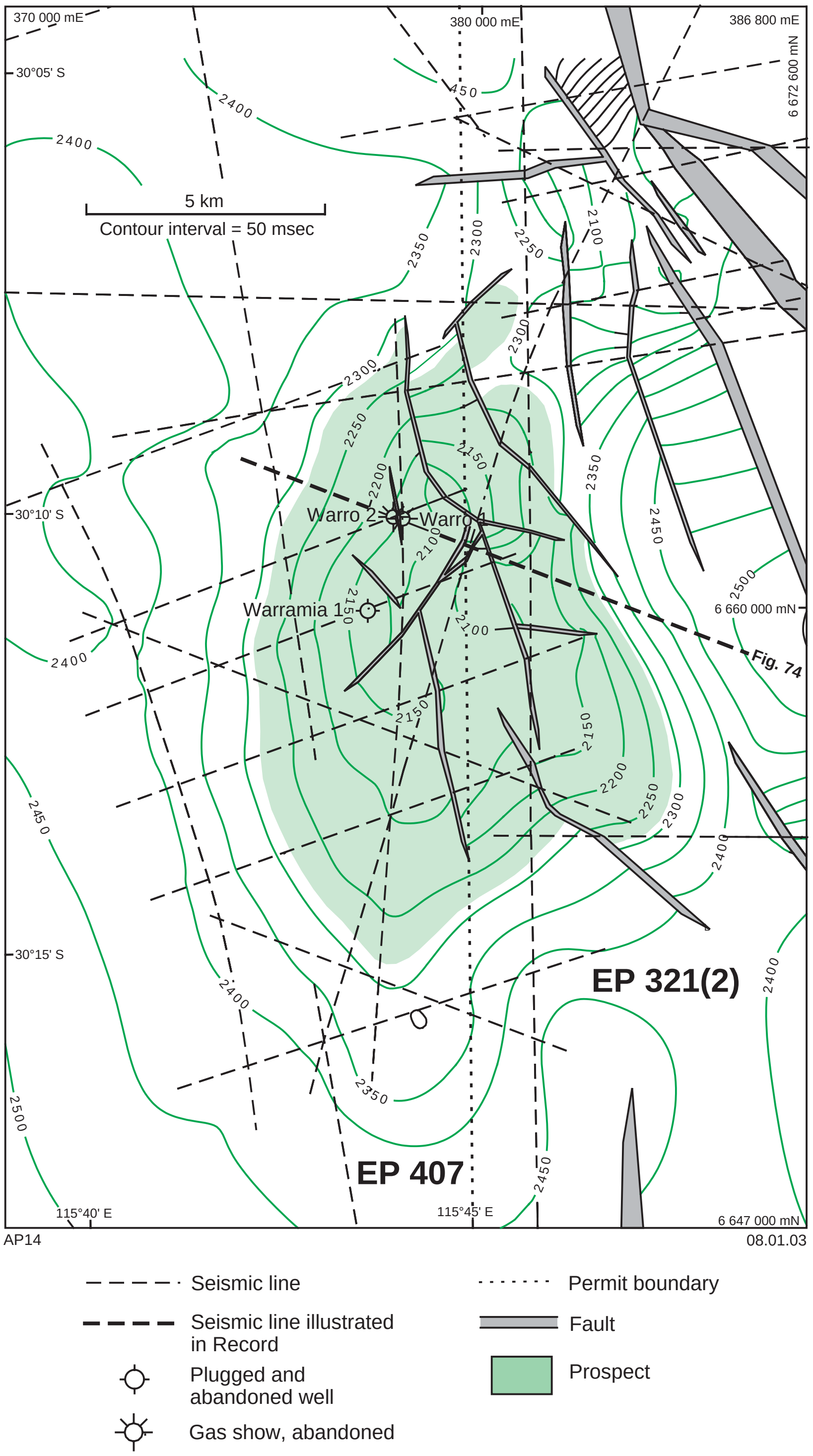


Figure 72. Two-way time contours of the lower Yarragadee Formation, Warro prospect (after AusAm Resources NL, 2000)

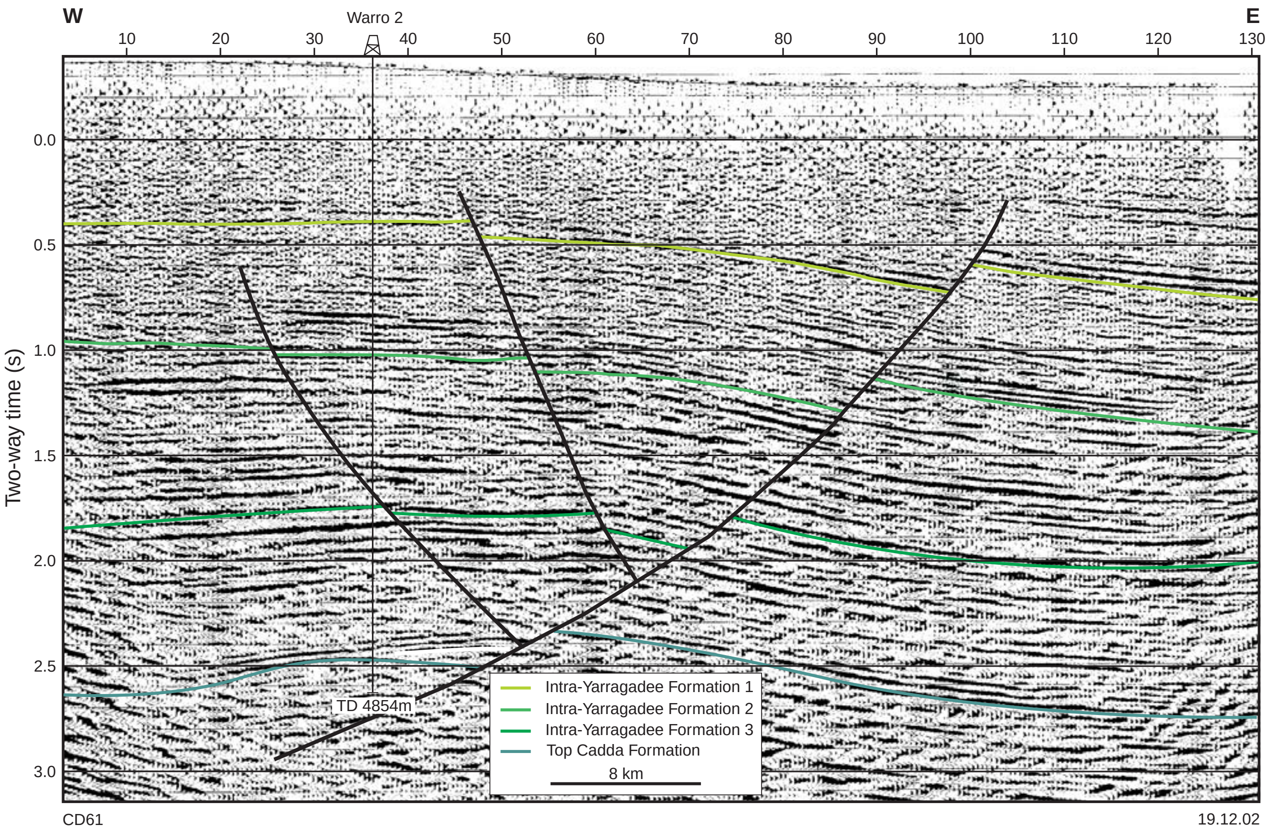


Figure 73. Seismic section P76-3L showing the structure of the Warro prospect

Source rock

The source rock is likely to be the Kockatea Shale south of the Allanooka Fault. The source pod in the Dandaragan Trough is responsible for producing the hydrocarbons that has charged the Dongara, Yardarino, and Mount Horner fields, and most likely sourced this prospect. Maturation data indicate that the Kockatea Shale was mature for oil generation in the Late Jurassic to Early Cretaceous in the Dandaragan Trough, and is currently within the oil generation window in the southern part of EP 368.

Reasons for failure

Potential reservoirs, a seal, and hydrocarbons (Lockyer 1, Mount Horner, North Erregulla 1, and Wayvanerry 1) are present in the area, but migration proved to be a major risk element. At top Dongara Sandstone the trap was dependent on fault-plane seal through fault smearing. Therefore, it is likely that there was a breach in this seal. As at Wayvanerry 1, there is also the possibility that Arradale 1 is in a migration shadow associated with the Allanooka Fault. Insufficent data are available to further evaluate the reason for failure.

Beharra Springs South 1

Beharra Springs South 1 was drilled in September 2001 by Origin Energy Developments Pty Ltd, 4.5 km south of the Beharra Springs gasfield and about 36 km south-southeast of Dongara. The prospect was identified from the results of a 3D seismic survey.

Stratigraphy

Beharra Springs South 1 was spudded in the Yarradagee Formation. The primary objective, the Dongara Sandstone, was intersected at 3375 m. Beharra Springs South 1 was drilled to a total depth of 3471 m. Further details on the stratigraphy are not available at this stage.

Trap

Beharra Springs South 1 has fault dependent closure (Fig. 77). It is located on the upthrown side of the Beharra Springs Fault and is in a similar structural position to the Beharra Springs gasfield. The northern closure is bound by the easterly trending fault that bounds the southern extent of the Beharra Springs gasfield. The throw of the fault is reduced in the eastern end of the prospect.

Reservoir and seal

Analysis of Beharra Springs South 1 showed the Dongara Sandstone was water-saturated. Fault seal to the east is provided by the Woodada Formation and potentially a tight interval at the base of the Lesueur Sandstone.

Hydrocarbons

No hydrocarbon shows were noted in the Dongara Sandstone. The well was plugged back to a depth of 3302 m to test a zone in the Kockatea Shale that recorded hydrocarbon shows during drilling (Origin Energy Developments Pty Ltd, 2001b). A DST over the interval

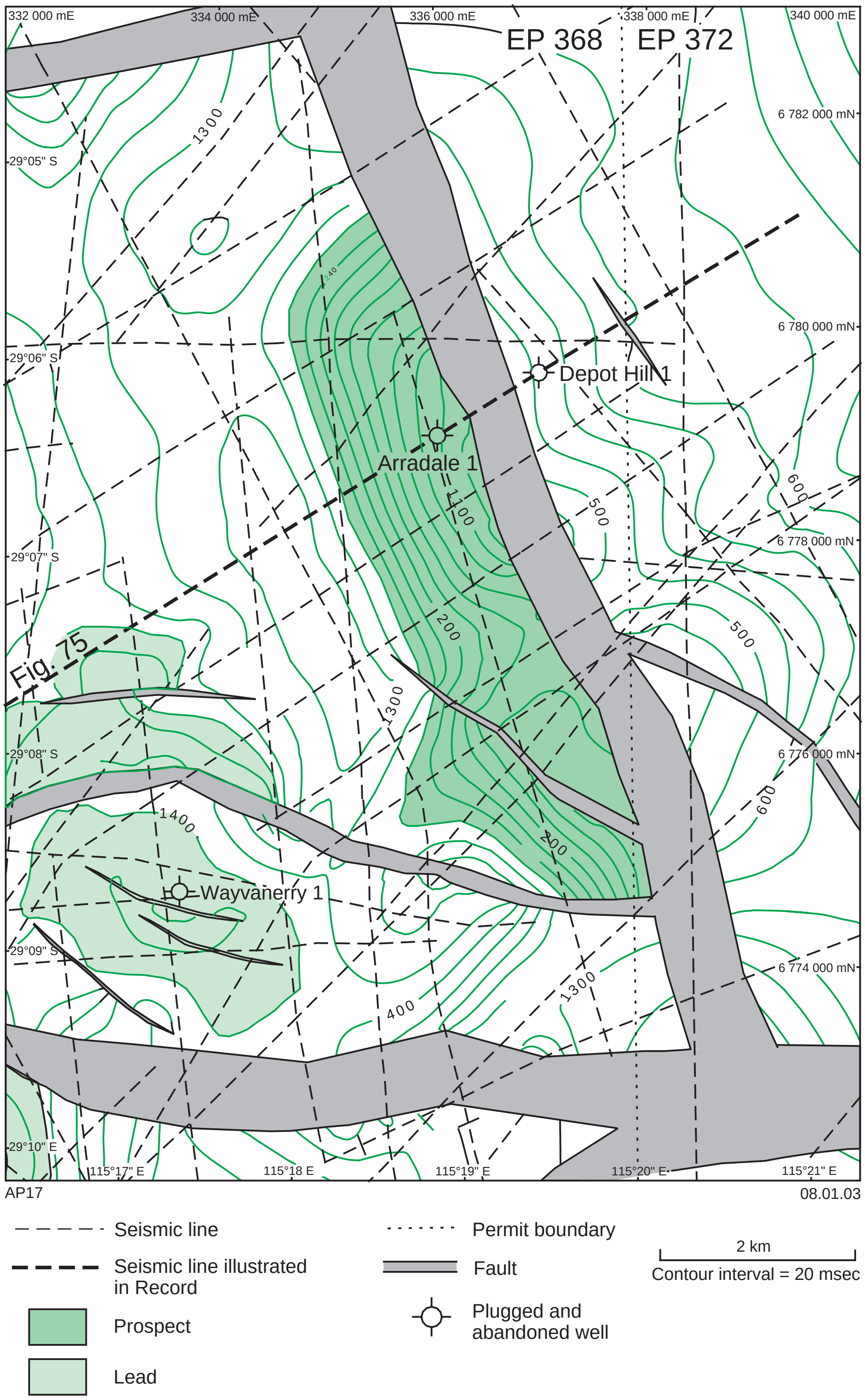


Figure 74. Two-way time contours of the basal Triassic horizon, Arradale 1 (after Australian Worldwide Exploration Ltd, 2001, written comm.)

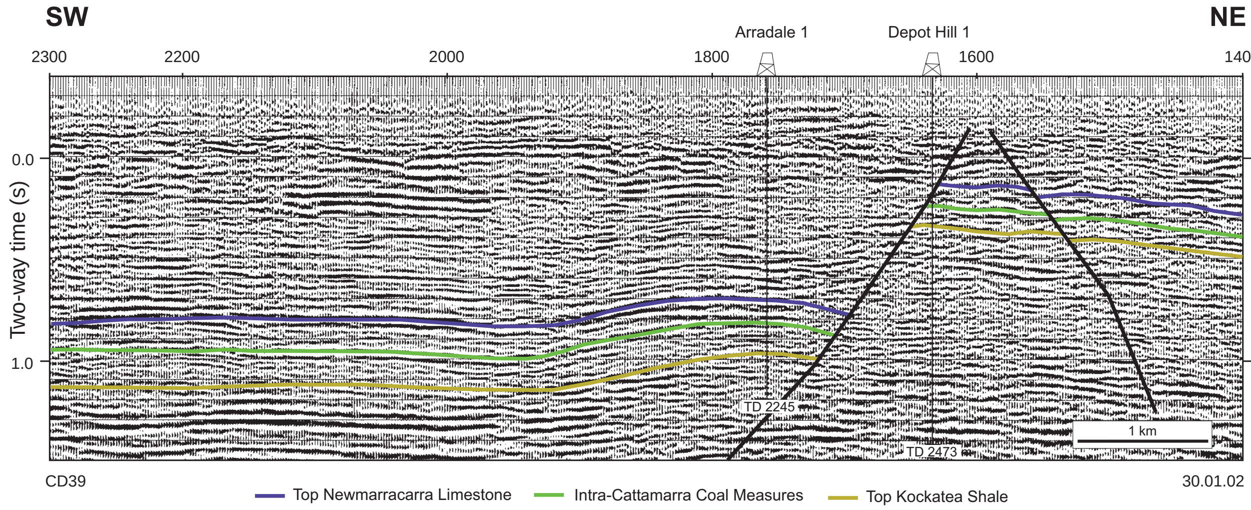


Figure 75. Seismic section BS82-05 showing the structure of Arradale 1

3249–3302 m yielded 1228 m^3 of water cushion, 79.5 L (0.5 bbl) of oil–mud emulsion, and 159 L (1 bbl) of rat-hole mud, with a total calculated flow of about 318 L (2 bbl) oil in a two-hour flow period (Origin Energy Developments Pty Ltd, 2001c). The oil emulsion samples were 25.5° API, whereas cleaner oil samples in the tool chamber were 53.3° API. Oil recovery from the Kockatea Shale in Beharra Springs South 1 is insufficient to justify economic completion. However, it does encourage further exploration along the Beharra Springs structure.

Source rock

The dominant source for gas in the area is the Irwin River Coal Measures, with the Kockatea Shale acting as a secondary source. Maturation data indicate that the Kockatea Shale is currently mature for oil generation (since the Late Jurassic) and the Irwin River Coal Measures are currently mature for gas generation (since the Middle Jurassic) in the Beharra Springs region.

Reasons for failure

The presence of the nearby Beharra Springs gasfield and the oil show in Beharra Springs South 1 imply that the gas source, migration, and timing in the area are adequate. At present, insufficent data are available to evaluate the reason for failure; however, lack of adequate seal across the Beharra Springs Fault appears likely.

Walyering 4

The Walyering accumulation was discovered in 1971 by WAPET and is located on the southern part of the Coomallo Trough, on the western side of the Dandaragan Trough. It is a complexly faulted anticline that sits in an area dominated by northerly trending faults (Figs 78 and 79). Walyering 4 was drilled in December 2001 by Ausam Resources NL using underbalanced muds and is 150 m east and updip of Walyering 1.

Stratigraphy

Walyering 4 was spudded in the Yarradagee Formation. The ‘A sands’ of the Cattamarra Coal Measures was intersected from 3210 to 3270 m, about 40 m higher than Walyering 1, and the ‘B sands’ at 3350 m, which was the bottom of the hole (Pancontinental Oil and Gas NL, 2001; 2002). Further details on the stratigraphy are not available at this stage.

Trap

The Walyering structure is a northerly trending, complexly faulted anticline at the Cattamarra Coal Measures level (Fig. 79). The structure is controlled by a major northerly trending, down-to-the-east fault that developed during the Late Jurassic (Fig. 78). Antithetic and synthetic faulting has compartmentalized the structure into a number of blocks.

Reservoir and seal

The Cattamarra Coal Measures are sealed both vertically and laterally across faults by the intraformational claystone, siltstone, and coals of the same formation. The Cattamarra Coal Measures also form the reservoir within this area. The Cattamarra Coal Measures in Walyering 4 were water-wet.

Hydrocarbons

No significant hydrocarbons were recorded from the log analysis, but high gas readings and fluorescence were noted within the Cattamarra Coal Measures and from numerous intervals from 2777 to 3270 m (Pancontinental Oil and Gas NL, 2001).

Source rock

The Cattamarra Coal Measures are the most likely source for the gas and condensate in the Walyering accumulation.

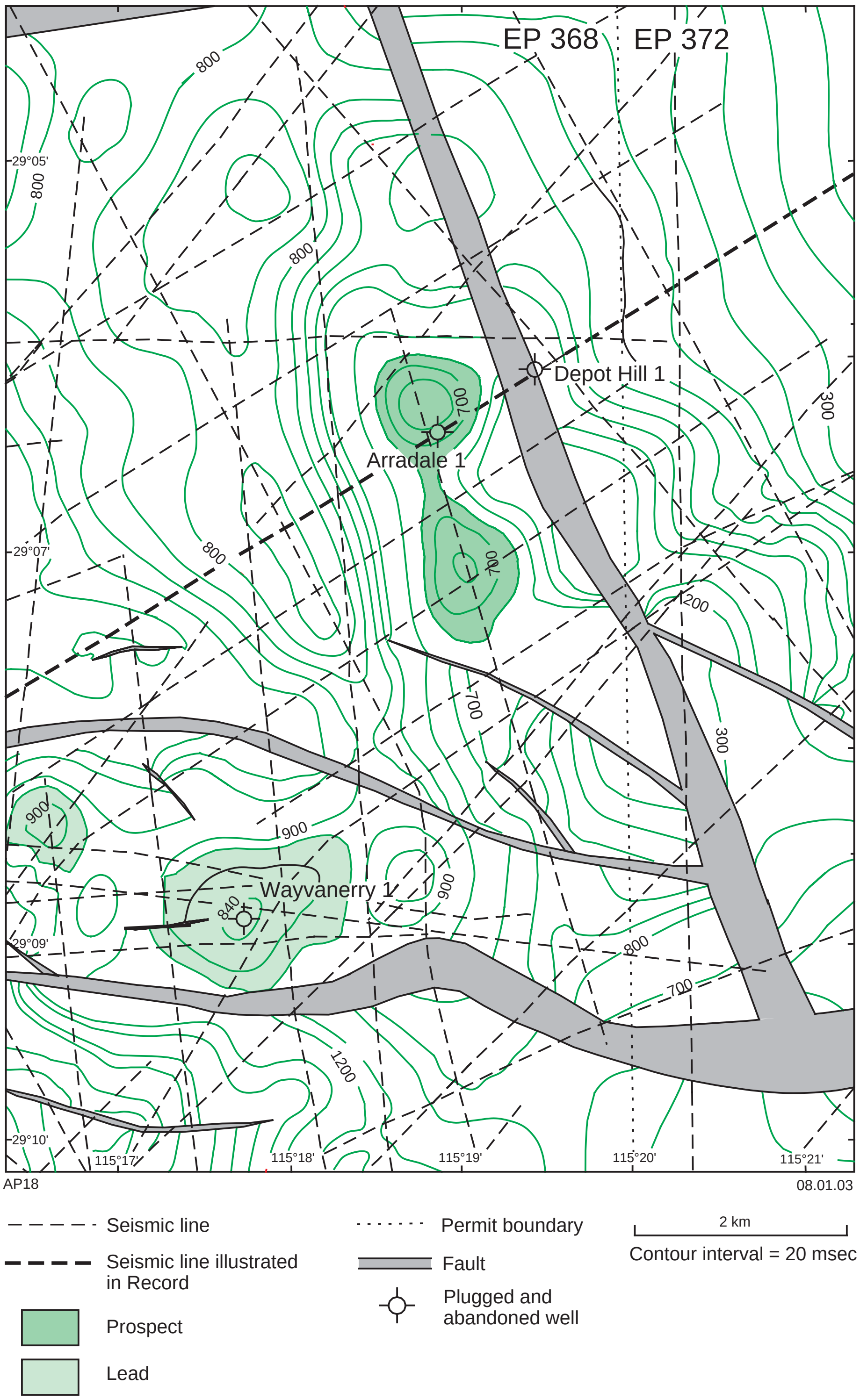


Figure 76. Two-way time contours of the Newmarracarra Limestone, Arradale 1 (after Australian Worldwide Exploration Ltd, 2001, written comm.)

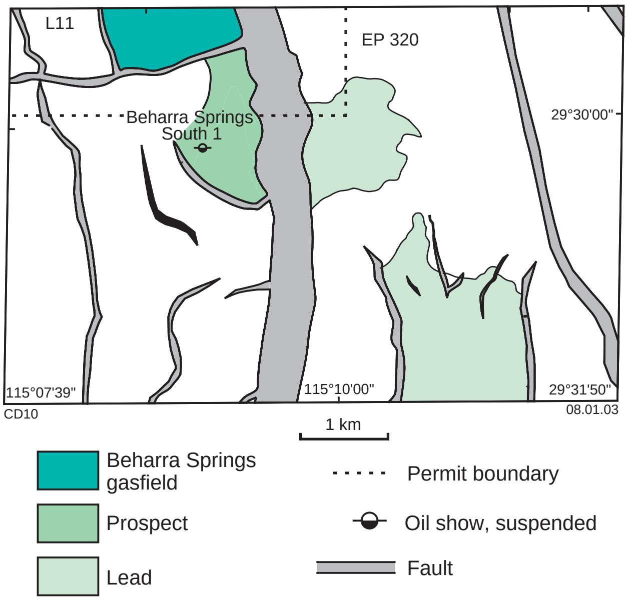


Figure 77. Two-way time contours of the Dongara Sandstone, Beharra Springs South 1 (after Origin Energy Resources Ltd, 2001)

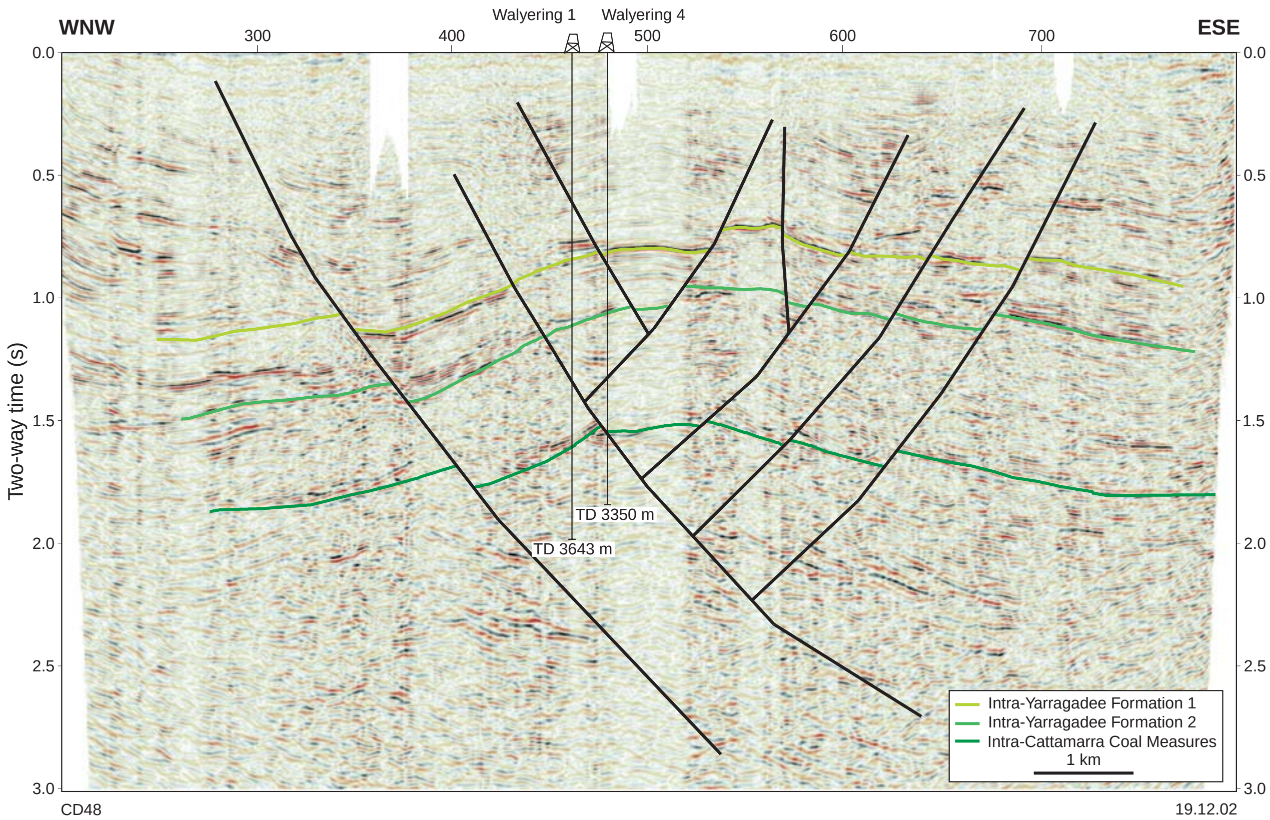


Figure 78. Seismic section DR97-21 showing the structure of the Walyering accumulation

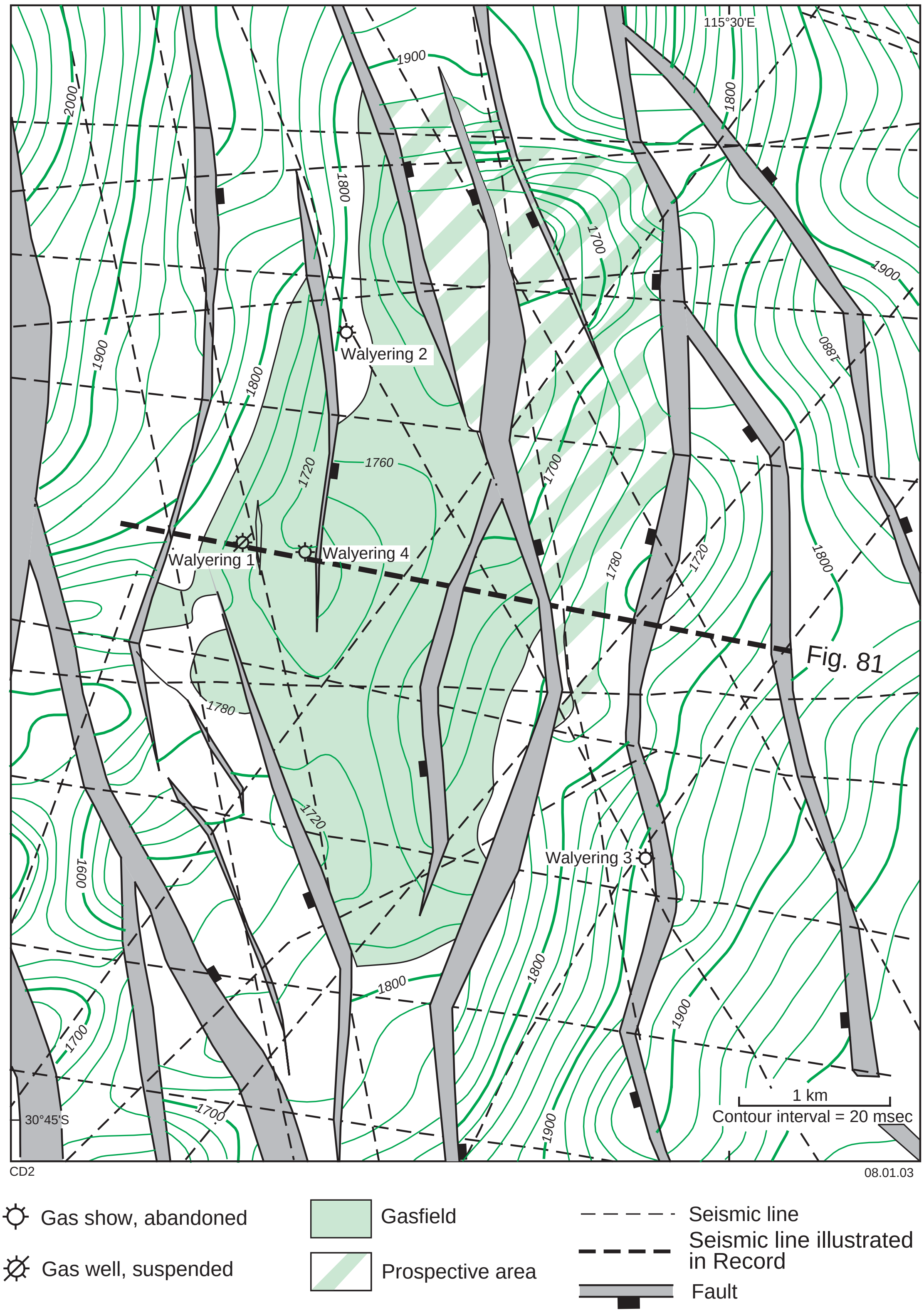


Figure 79. Two-way time contours of the Cattamarra Coal Measures for the Walyering accumulation and its possible extension (after AusAm Resources NL, 2000)

Other possibilities include the Irwin River Coal Measures and the Carynginia Formation. Maturation data suggest that the Cattamarra Coal Measures were mature for oil generation in the Dandaragan Trough during the Late Cretaceous to Early Cainozoic.

The source pod for the Walyering accumulation is within the Dandaragan Trough to the west. During the Early Cretaceous there was reactivation on the northerly trending faults within the Perth Basin due to wrenching. This resulted in the development of the Walyering structure. The gas, and possibly oil, migrated into this structure, filling individual sandstone reservoirs.

Reasons for failure

The Walyering wells probably did not test a valid trap (Crostella, 1995) and the same reasons probably apply to Walyering 4. The Cattamarra Coal Measures in this well are not hydrocarbon bearing. At present insufficent data are available to evaluate the reason for failure.

Acknowledgements

We would like to thank Origin Energy Developments Pty Ltd, Roc Oil Company Ltd, Empire Oil Company Ltd, Australian Worldwide Exploration Ltd, and Arc Energy NL for their comments on this Record.

References

ARC ENERGY NL, 1999, Nutsyia 1 — combined detailed drilling programme and environmental management plan: Western Australia Geological Survey, Statutory petroleum exploration report, S8601 R1 A8 (unpublished).

ARC ENERGY NL, 2002a, Quarterly report for the quarter ending 31 March 2002: Report to the Australian Stock Exchange, 30 April 2002, 10p.

ARC ENERGY NL, 2002b, New onshore gas discovery; appraisal of Hovea: Report to the Australian Strock Exchange, 15 July 2002, 2p.

AUSAM RESOURCES NL, 2000, Prospectus: Report to the Australian Stock Exchange, 1 June 2000, 117p.

AUSTRALIAN WORLDWIDE EXPLORATION LTD, 2001a, AWE farms-out exploration commitments: Report to the Australian Stock Exchange, 4 July 2001, 2p.

AUSTRALIAN WORLDWIDE EXPLORATION LTD, 2001b, AWE discovers gas in Perth Basin: Report to the Australian Stock Exchange, 13 August 2001, 2p.

AUSTRALIAN WORLDWIDE EXPLORATION LTD, 2001c, AWE in outstanding gas flow from Beharra Springs North 1 well: Report to the Australian Stock Exchange, 10 December 2001, 2p.

AUSTRALIAN WORLDWIDE EXPLORATION LTD, 2002a, Quarterly report, March 2002: Report to the Australian Stock Exchange, 6 May 2002, 7p.

AUSTRALIAN WORLDWIDE EXPLORATION LTD, 2002b, AWE's Jingemia 1 oil discovery completed for production testing: Report to the Australian Stock Exchange, 12 November 2002, 2p.

BACKHOUSE, J., 1991, Permian palynostratigraphy of the Collie Basin, Western Australia: Review of Palaeobotany and Palynology, v. 67, p. 237–314.

BJØRKUM, P. A., OELKERS, E. H., NADEAU, P. H., WALDERHAUG, O., and MURPHY, W. M., 1998, Porosity prediction in quartzose sandstones as a function of time, temperature, depth, stylolite frequency, and hydrocarbon saturation: American Association of Petroleum Geologists Bulletin, v. 82, no. 4, p. 637–648.

BOREHAM, C. J., HOPE, J. M., and HARTUNG-KAGI, B., 2001b, Understanding source, distribution and preservation of Australian natural gas: a geochemical perspective: APPEA Journal, v. 41, p. 523–547.

BOREHAM, C. J., HOPE, J. M., HARTUNG-KAGI, B., and VAN AARSSEN, B. J. K., 2001a, More sources for gas and oil in Perth Basin: Study highlights potential for multiple petroleum systems: Australian Geological Survey Organisation, Research Newsletter, December 2000, p. 5–9.

CADMAN, S. J., PAIN, L., and VUCKOVIC, V., 1994, Perth Basin, Western Australia: Bureau of Resource Sciences, Australian Petroleum Accumulations Report 10, 103p.

CROSTELLA, A., 1995, An evaluation of the hydrocarbon potential of the onshore northern Perth Basin, Western Australia: Western Australia Geological Survey, Report 43, 67p.

CROSTELLA, A., 2001, Geology and petroleum potential of the Abrolhos Sub-basin, Western Australia: Western Australia Geological Survey, Report 75, 57p.

CROSTELLA, A., and BACKHOUSE, J., 2000, Geology and petroleum exploration of the central and southern Perth Basin, Western Australia: Western Australia Geological Survey, Report 57, 85p.

DENTITH, M. C., BEVAN, A. W. R., BACKHOUSE, J., FEATHERSTONE, W. E., and KOEBERL, C., 1999, Yallalie: a buried structure of possible impact origin in the Perth Basin, Western Australia: Geology Magazine, v. 136, p. 619–632.

DISCOVERY PETROLEUM NL, 1996a, Northern Perth Basin EP23 (part 2) — hydrocarbon potential: Western Australia Geological Survey, Statutory petroleum exploration report, S6023R 4 A5 V2 (unpublished).

DISCOVERY PETROLEUM NL, 1996b, Wye no. 1, well completion report: Western Australia Geological Survey, Statutory petroleum exploration report, S20337 A3 (unpublished).

ELLIS, G. K., and BRUCE, R. H., 1998, Dongara oil and gas field, Perth Basin, *in* The Sedimentary Basins of Western Australia 2 *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia; Sedimentary Basins of Western Australia Symposium, Perth, W.A., 1998, Proceedings, p. 625–636.

EMPIRE OIL AND GAS NL, 1997, Prospectus: Report to the Australian Stock Exchange, 1 October 1997, 104p.

EMPIRE OIL AND GAS NL, 2001, Quarterly report 30th June 2001: Report to the Australian Stock Exchange, 31 July 2001, 15p.

EMPIRE OIL COMPANY LTD, 1999, EP 389 annual report year 5, 19 July 1998 to 18 July 1999: Western Australia Geological Survey, Statutory petroleum exploration report, S6389 A16 (unpublished).

EMPIRE OIL COMPANY LTD, 2000, EP 389 annual report year 5, 19 July 1999 to 18 July 2000: Western Australia Geological Survey, Statutory petroleum exploration report, S6389 A21 (unpublished).

GRADSTEIN, F. M., AGTERBERG, F. P., OGG, J. G., HARDENBOOL, J., VAN VEEN, P., THIERRY, J., and HUANG, Z., 1994, A Mesozoic time scale: Journal of Geophysical Research, v. 99, n. B12, p. 24051–24074.

HALL, P. B., 1989, The future prospectivity of the Perth Basin: APEA Journal, v. 29, p. 440–449.

HALL, P. B., and KNEALE, R. L., 1992, Perth Basin rejuvenated: APEA Journal, v. 32, p. 33–43.

HARRIS, L. B., 1994, Structural and tectonic synthesis for the Perth Basin, Western Australia: Journal of Petroleum Geology, v. 17, p. 129–156.

HARRIS, L. B., HIGGINS, R. I., DENTITH, M. C., and MIDDLETON, M. F., 1994, Analogue modelling of transtensional faulting applied to the structure of the Perth Basin, Western Australia, *in* The Sedimentary Basins of Western Australia *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia; Sedimentary Basins of Western Australia Symposium, Perth, W.A., 1994, Proceedings, p. 801–809.

HELBY, R., MORGAN, R., and PATRIDGE, A. D., 1987, A palynological zonation of the Australian Mesozoic, *in* Australian Mesozoic palynology *edited by* P. A. JELL: Association of Australasian Palaeontologists, Memoir 4, p. 1–94.

HOCKING, R. M., MORY, A. J., and WILLIAMS, I. R., 1994, An atlas of Neoproterozoic and Phanerozoic basins of Western Australia, *in* The Sedimentary Basins of Western Australia *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia; Sedimentary Basins of Western Australia Symposium, Perth, W.A., 1994, Proceedings, p. 21–43.

JONES, D. K., 1976, Perth Basin, *in* Economic geology of Australia and Papua New Guinea, Volume — 3. Petroleum *edited by* R. B. LESLIE, M. J. EVANS, and C. L. KNIGHT: Australasian Institute of Mining and Metallurgy, Monograph 7, p. 108–126.

LE BLANC SMITH, G., and MORY, A. J., 1995, Geology and Permian coal resources of the Irwin Terrace, Western Australia: Geological Survey of Western Australia, Report 44, 60p.

LONGLEY, I. M., BRADSHAW, M. T., and HEBBERGER, J., 2001, Chapter 15 — Australian petroleum provinces of the twenty-first century, *in* Petroleum provinces of the twenty-first century *edited by* M. W. DOWNEY, J. C. THREET, and W. A. MORGAN: AAPG Memoir, v. 74, p. 287–317.

MAGOON, L. B., and DOW, W. G., 1994, (editors), The petroleum system — from source to trap: American Association of Petroleum Geologists Memoir, v. 60, 655p.

MORY, A. J., and IASKY, R. P., 1996, Stratigraphy and structure of the onshore northern Perth Basin, Western Australia: Western Australia Geological Survey, Report 46, 102p.

MORY, A. J., IASKY, R. P., and SHEVCHENKO, S., 1998, The Coolcalalaya Sub-basin: a forgotten frontier between the Perth and Carnarvon Basins, WA, *in* The Sedimentary Basins of Western Australia *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia; Sedimentary Basins of Western Australia Symposium, Perth, W.A., 1994, Proceedings, p. 613–622.

ORIGIN ENERGY DEVELOPMENTS PTY LTD, 2001a, Beharra Springs North 1 — new gas pool discovery in the onshore Perth Basin, Western Australia: Report to the Australian Stock Exchange, 13 August 2001, 1p.

ORIGIN ENERGY DEVELOPMENTS PTY LTD, 2001b, Beharra Springs South 1 progress report, onshore Perth Basin, Western Australia: Report to the Australian Stock Exchange, 20 September 2001, 1p.

ORIGIN ENERGY DEVELOPMENTS PTY LTD, 2001c, Beharra Springs South 1 progress report, onshore Perth Basin, Australia: Report to the Australian Stock Exchange, 24 September 2001, 1p.

ORIGIN ENERGY DEVELOPMENTS PTY LTD, 2001d, Hovea 1 progress report, onshore Perth Basin, Australia: Report to the Australian Stock Exchange, 15 October 2001, 1p.

ORIGIN ENERGY RESOURCES LTD, 2000, EP 413 annual report for permit year 1, 26 August 1999 – 25 August 2000: Western Australia Geological Survey, Statutory petroleum exploration report, S6413 R1 A1 (unpublished).

ORIGIN ENERGY RESOURCES LTD, 2001, EP 320 annual report for permit year 4, 17 March 2000 – 16 March 2001: Western Australia Geological Survey, Statutory petroleum exploration report, S6320 R2 A8 (unpublished).

OWAD-JONES, D. L., and ELLIS, G. K., 2000, Western Australia atlas of petroleum fields, onshore Perth Basin: Petroleum Division, Department of Minerals and Energy, v. 1, 114p.

PANCONTINENTAL OIL AND GAS NL, 2001, Walyering 4 update and Australian drilling status report: Report to the Australian Stock Exchange, 12 December 2001, 3p.

PANCONTINENTAL OIL AND GAS NL, 2002, Quarterly activities report March 2002: Report to the Australian Stock Exchange, 30 April 2002, 12p.

PHILIPS, S. E., and CATHRO, D. L., 1991, Petrology Report, Perth Basin; SAGASCO Resources Ltd: Western Australia Geological Survey, Statutory petroleum exploration report, S30766 A2 (unpublished).

PREMIER OIL AUSTRALIA PTY LTD, 1998, EP 100 (R3) Perth Basin, Western Australia, annual report year ended 3 March 1998, permit year 5: Western Australia Geological Survey, Statutory petroleum exploration report, S6100 R3 A9 (unpublished).

RASMUSSEN, B., and GLOVER, J. E., 1996, Fluid evolution interpreted from diagenetic assemblages and salinity data in Permo–Triassic sandstone, northern Perth Basin, Western Australia: Journal of Sedimentary Research, v. 66, no. 3, p. 492–500.

RASMUSSEN, B., GLOVER, J. E., and ALEXANDER, R., 1989, Hydrocarbon rims on monazite in Permian–Triassic arenites, northern Perth Basin, Western Australia: pointers to the former presence of oil: Geology, v. 17, p. 115–118.

ROC OIL COMPANY LTD, 2001, Cliff Head 1, offshore Perth Basin, Western Australia: Report to the Australian Stock Exchange, 31 December 2001, 1p.

ROC OIL COMPANY LTD, 2002, Cliff Head oilfield: update and future plans: Report to the Australian Stock Exchange, 16 January 2002, 7p.

ROC OIL (WA) PTY LTD, 2000a, WA-286-P: Application for approval to drill an offshore well, Cliff Head 1: Western Australia Geological Survey, Statutory petroleum exploration report, S5286 A3 (unpublished).

ROC OIL (WA) PTY LTD, 2000b, WA-286-P: Cliff Head 1 prospect file, abridged version (economics omitted): Western Australia Geological Survey, Statutory petroleum exploration report, S5286 A7 (unpublished).

ROC OIL (WA) PTY LTD, 2002, Cliff Head 2 drilling update: Report to the Australian Stock Exchange, 3 January 2002, 1p.

SAGASCO RESOURCES LTD, 1991, Ocean Hill 1, well completion report, EP 320, Perth Basin: Western Australia Geological Survey, Statutory petroleum exploration report, S20066 A2 (umpublished).

SALEM, A. M., MORAD, S., MATO, L. F., and AL-AASM, I. S., 2000, Diagenesis and reservoir-quality evolution of fluvial sandstones during progressive burial and uplift: evidence from the Upper Jurassic Boipeda Member, Recôncavo Basin, Northern Brazil: American Association of Petroleum Geologists Bulletin, v. 84, p. 1015–1040.

SHAW, R. D., 2000, Jago Seismic Survey: interpretation report, EP 111, north Perth Basin; Jervois Mining NL: Western Australia Geological Survey, Statutory petroleum exploration report, S10411 A3 (unpublished).

SONG, T., and CAWOOD, P. A., 2000a, Structural styles in the Perth Basin associated with the Mesozoic break-up of Greater India and Australia: Tectonophysics, v. 317, p. 55–72.

SONG, T., and CAWOOD, P. A., 2000b, Multistage deformation of linked fault systems in extensional regions: an example from the northern Perth Basin, Western Australia: Australian Journal of Earth Sciences, v. 46, p. 897–903.

SUMMONS, R. E., BOREHAM, C. J., FOSTER, C. B., MURRAY, A. P., and GORTER, J. D., 1995, Chemostratigraphy and the composition of oils in the Perth Basin, Western Australia: APEA Journal, v. 35, p. 613–632.

THOMAS, B. M., 1979, Geochemical analysis of hydrocarbon occurrences in the northern Perth Basin, Australia: American Association of Petroleum Geologists Bulletin, v. 63, p. 1092–1107.

THOMAS, B. M., 1982, Land plant source rocks for oil and their significance in Australian sedimentary basins: APEA Journal, v. 22, p. 164–178.

THOMAS, B. M., 1984, Hydrocarbons, source rocks and maturity trends in the northern Perth Basin, Australia, *in* Petroleum geochemistry and basin evolution *edited by* G. DEMAISON and R. J. MURRIS: American Association of Petroleum Geologists Memoir, v. 35, p. 341–403.

THOMAS, B. M., and BROWN, S. A., 1983, Hydrocarbon generation in the northern Perth Basin: APEA Journal, v. 23, p. 64–74.

TYLER, I. M., and HOCKING, R. M., 2002, A revision of the tectonic units of Western Australia: Western Australia Geological Survey, Annual Review 2000–01, p. 33–44.

TUPPER, N. P., PHILLIPS, S. E., and WILLIAMS, B. P. J., 1994, Advances in the understanding of Upper Permian reservoir distribution and quality, north Perth Basin, *in* The Sedimentary Basins of Western Australia *edited by* P. G. PURCELL and R. R. PURCELL: Petroleum Exploration Society of Australia; Sedimentary Basins of Western Australia Symposium, Perth, W.A., 1994, Proceedings, p. 823–837.

VOYAGER ENERGY LTD, 2001, Cliff Head 1 update: Report to the Australian Stock Exchange, 31 December 2001, 1p.

WARRIS, B. J., 1988, The geology of the Mount Horner oilfield, Perth Basin, Western Australia: APEA Journal, v. 28, p. 88–99.

WEST AUSTRALIAN PETROLEUM PTY LTD, 1996, L1 and L2 exploration review: Western Australia Geological Survey, Statutory petroleum exploration report, S8601 A6 (unpublished).

YOUNG, G. C., and LAURIE, J. R., (editors), 1996, An Australian Phanerozoic timescale: Oxford University Press, Melbourne, 279p.

Appendix 1

Abbreviations

AHD	Australian height datum
AMSL	Australian mean sea level
API	Standard method of measuring density of liquid hydrocarbons by the American Petroleum Institute
AVO	Amplitude versus offset
B	Billion (10^9)
Bcf	Billion cubic feet
bbl	American barrel (= 158.9873 L)
cf	Cubic feet (= 0.02832 m^3)
cp	Centipoise
DST	Drillstem test
G	Giga (10^9)
KB	Kelly bushing
kL	Kilolitre (= 6.28981 bbl)
m^3	Cubic metres (= 35.3147 cubic feet)
MD	The linear distance of a well measured along its drilled projection
MM	Million
mRT	Metres below rotary table
mD	Millidarcies
msec	Milliseconds
OGIP	Original gas-in-place
OOIP	Original oil-in-place
P_{50}	Median probability reserves
ϕ	Porosity
SP	Shotpoint
SS	Sub-sea-level datum
T	Trillion (10^{12})
TVD	True vertical depth
TWT	Two-way time

PERMIT/LICENCES
State Petroleum Act 1967

EP	Exploration permit
L	Production licence

State Petroleum (Submerged Lands) Act 1982

TP/	Territorial sea exploration permit

Commonwealth Petroleum (Submerged Lands) Act 1967

WA-	Exploration permit

Appendix 2

List of northern Perth Basin permits, operators, and contact details as of December 2002

Permits	*Operator*	*Address*	*Web address*
L1 L2	Arc Energy NL	Level 1, 46 Ord Street West Perth, W.A. 6005	http://www.arcenergy.com.au/
EP 321 EP 407 EP 414	Ausam Resources NL	PO Box 1133 West Perth, W.A. 6872	http://www.ausam-resources.com.au/
EP 23 EP 368 TP/15	Australian Worldwide Exploration Pty Ltd	PO Box 733 North Sydney, N.S.W. 2059	http://www.awexp.com.au/home_content.html
EP 389	Empire Oil and Gas NL	9 O'Beirne Street Claremont, W.A. 6010	http://www.empireoil.com.au/
EP 320 EP 413 L11	Origin Energy Developments Pty Ltd	34 Colin Street West Perth, W.A. 6005	http://www.originenergy.com.au/
WA-286-P	Roc Oil Company Ltd	Level 16, 100 William Street Sydney, N.S.W. 2011	http://www.rocoil.com.au/

Appendix 3

Surveys conducted for petroleum exploration in the northern Perth Basin to January 2002

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Onshore								
Aeromagnetic S. of the Perth Basin	Bureau of Mineral Resources	1957	PE-27-H	Aeromagnetic	–	35 405.6	–	152
Allanooka S.S.	Discovery Petroleum NL	1993	EP 23 (R4) EP 368 L7	2D reflection	D93	131.7	16	10147
Alpha 1 Geochemical S.	Exploration Geophysics	1978	EP 100	Geochemical	–	–	9	1430
Arramall Geochemical S.	Barrack House Group	1988	EP 320	Geochemical	–	140.0	–	3308
Arrowsmith 1985 Airborne Spectrometer S.	Metramar Minerals Ltd	1985	EP 96 (R1)	Spectrometer	–	–	–	3175
Arrowsmith Detail S.S.	West Australian Petroleum Pty Ltd	1970	EP 21	2D reflection	A70	31.0	4	1169
Arrowsmith Geochemical S.	Barrack House Group	1986	EP 320	Geochemical	–	100.0	–	3065
Athamo S.S. and Gravity S.	French Petroleum Co. (Australia) Pty Ltd	1966	PE-228-H	2D reflection Gravity	A66 –	578.0 627.0	33 –	270 270
Augusta–Moora Gravity S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	Gravity	–	–	–	54 V1
Barberton S.S.	West Australian Petroleum Pty Ltd	1972	EP 24	2D reflection	P73	59.0	6	810
Barragoon Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1971	EP 21 EP 23 EP 24 EP 25	2D reflection	BR71	666.3	19	622
Beagle 1993 S.S.	Sagasco Resources Ltd	1993	EP 100 (R3) EP 320 L4	2D reflection	SB93	108.1	12	10146
Beagle Refraction S.S.	West Australian Petroleum Pty Ltd	1960	PE-27-H	2D refraction	B60	169.2	6	635 V1
Beharra East Uphole S.	Sagasco Resources Ltd	1995	EP 320 (R1)	Velocity	–	–	–	10242 V2
Beharra Springs S.S.	Barrack House Group	1987	EP 320 EP 100 (R1)	2D reflection	B87	177.0	19	3122

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Beharra Springs 3D S.S.	Boral Energy Resources Ltd	1999	L11 EP 320 (R2) EP 413 L1 (R1)	3D reflection	BS99	212.4	138	10415
Bonniefield Detail S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	BD66	83.0	7	282
Bonniefield Gravity S.	Lassoc Pty Ltd	1984	EP 201	Gravity	–	–	–	2615
Bonniefield Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1965	PE-27-H LP 111-H LP 126-H1	2D reflection	BR65	10.0	2	16 V
Bookara Aeromagnetic S.	Balmoral Resources NL	1984	EP 201	Aeromagnetic	–	800.0	–	2735
Bookara Detail S.S.	West Australian Petroleum Pty Ltd	1965	PE-27-H LP 111-H LP 126-H	2D reflection	B65	44.2	21	217
Bookara Shelf S.S.	Mesa Australia Ltd	1982	EP 23 (R2)	2D reflection	BS82	279.0	14	2007
Boolaroo S.S.	Discovery Petroleum NL	1995	EP 100 (R3) EP 320 (R1)	2D reflection	DB95	54.2	3	10240
Brand S.S.	Xlx NL	1979	EP 96	2D reflection	B79	63.0	7	1573
Bullsbrook North 2000 2D S.S.	Empire Oil Company (WA) Ltd	2000	EP 389	2D reflection	99BBN	33.0	4	10432
Bullsbrook South 1998 S.S.	Empire Oil Company (WA) Ltd	1998	EP 389	2D reflection	E97	12.0	1	10388
Burma S.S.	Pancontinental Petroleum Pty Ltd	1982	EP 111	2D reflection	P82	168.0	20	1948
Cadda Detail S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D reflection	CD62	292.0	2	74 V1
Cattamarra S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D reflection	C62	292.0	2	74 V2
Central Perth Basin Gravity S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	Gravity	–	2 534.0	–	54 V2
Cockleshell S.S.	West Australian Petroleum Pty Ltd	1960	PE-27-H	2D reflection 2D refraction	C60 C60	29.0 62.5	6 5	635 V2 635 V2
Conder Geochemical S.	Doral Resources NL	1988	EP 111 (R1) EP 201 (R1)	Geochemical	–	90.0	–	3265

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Conder S87 S.S.	Strata Oil NL	1987	EP 111 (R1) EP 201 (R1)	2D reflection	S87	12.0	4	3145
Coolcalalaya Gravity and Magnetic S.	Sunningdale Oils Pty Ltd	1973	EP 48 EP 69	Gravity/Magnetic	–	2 027.0	–	819
Coolimba 1998 S.S.	Phoenix Energy Pty Ltd	1998	L4 L5	2D reflection	PC98	82.2	5	10394
Coomallo S.S.	West Australian Petroleum Pty Ltd	1972	EP 21 EP 24	2D reflection	P72	146.0	7	690
Coomallo II S.S.	West Australian Petroleum Pty Ltd	1973	EP 21	2D reflection	P73	35.0	3	835
Coomallo Detail S.S.	Barrack Energy Ltd	1990	EP 320	2D reflection	B89	118.4	10	3987
Coomallo Hill S.S.	Barrack Energy Ltd	1989	EP 320 EP 100 (R2)	2D reflection	B89	76.1	4	10001
Coorow 1982 S.S.	Hudbay Oil (Australia) Ltd	1982	EP 100	2D reflection	HP82	292.0	14	2078
Correy S.S.	Barrack Energy Management Pty Ltd	1989	EP 320	2D reflection	B89	80.0	5	3849
Cypress Hill S.S.	Ampol Exploration Ltd	1988	EP 321 EP 100 (R1)	2D reflection	A88	274.0	27	3324
Cypress Hill Test S.S.	Ampol Exploration Ltd	1989	EP 321	2D reflection	–	10.0	1	3499
Dalaroo S.S.	Ampol Exploration Ltd	1993	EP 321 (R1)	2D reflection	A93	56.0	6	10148
Dalaroo West Gravity and Magnetic S.	Agnew Clough Ltd	1989	EP 278 (R1) EP 321	Gravity	–	50.9	–	3286
Dandaragan 1981 S.S.	Mesa Australia Ltd	1981	EP 100 EP 24 (R2)	2D reflection	D81	117.0	10	1867
Dandaragan S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	D66	287.0	14	276
Dandaragan Area Magnetic S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	Magnetic	–	26.0	2	321
Dandaragan East Flank Detail S.S.	West Australian Petroleum Pty Ltd	1972	EP 23 EP 24	2D reflection	P72	372.0	15	684
Dandaragan West S.S.	West Australian Petroleum Pty Ltd	1970	EP 24	2D reflection	DW70	48.0	2	542

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Dee S.S.	Premier Oil Australia Pty Ltd	1999	EP 414	2D reflection	PD99	135.4	13	10410
Dempster S.S.	Barrack Energy Ltd	1989	EP 100 (R2) EP 320	2D reflection	B89	85.0	8	3485
Depot S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	D66	69.0	4	284 V2
Depot Hill S.S.	West Australian Petroleum Pty Ltd	1967	PE-27-H	2D reflection	DH67	116.0	1	284 V1
Depot Hill Detail S.S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	2D reflection	DH63	53.1	4	52 V1
Dongara 1967 Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1967	PE-27-H	2D reflection	D67	95.4	14	344 V1
Dongara 2 S.S.	West Australian Petroleum Pty Ltd	1978	L1 L2	2D reflection	P78	48.0	6	1471
Dongara 3 S.S.	West Australian Petroleum Pty Ltd	1989	L1 L2	2D reflection	P89	171.8	15	3540
Dongara Aeromagnetic S.	West Australian Petroleum Pty Ltd	1992	L1 L2	Aeromagnetic	–	3427.0	–	10153
Dongara Detail S.S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	2D reflection	D63	71.9	19	52 V2
Dongara Experimental S.S.	West Australian Petroleum Pty Ltd	1988	L1 L2	2D reflection	P88	22.0	3	3306
Dongara Experimental 2 S.S.	West Australian Petroleum Pty Ltd	1989	L2	2D reflection	P89	6.9	1	3500
Dongara–Mullewa Gravity S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	Gravity	–	–	–	59
Dongara North 3D (483) S.S.	West Australian Petroleum Pty Ltd	1994	L1 (R1) L2 (R1)	3D reflection	Q	469.8	637	10201
Dongara Reconnaissance 1963 S.S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	2D reflection 2D refraction	D63 –	285.0 373.0	19 –	52 V3 52 V3
Dongara Regional Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	2D reflection	D63	62.6	5	53
Dongara South West Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1970	EP 21 EP 23	2D reflection	DSW70	122.0	6	645 V2
Duggan S.S.	Barrack Energy Ltd	1989	EP 323 EP100 (R2)	2D reflection Geochemical	BD89 –	145.6 30.0	8 –	3507 3507

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Eganu Gravity S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	Gravity	–	16.0	–	73
Eganu S.S.	West Australian Petroleum Pty Ltd	1964	PE-27-H	2D reflection 2D refraction	E64 E64	189.9 82.1	8 –	159 159
Ejarno Detail S.S.	West Australian Petroleum Pty Ltd	1965	PE-27-H LP 111-H LP 126-H	2D reflection	ED65	38.2	12	216 V1
Ejarno Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1965	PE-27-H LP 111-H LP 126-H	2D reflection	ER65	100.7	13	216 V2
Eneabba S.S.	West Australian Petroleum Pty Ltd	1960	EP 21	2D reflection 2D refraction	E60 E60	173.7 67.7	18 –	676 676
Eneabba 1984 S.S.	Strata Oil NL	1984	EP 100 (R1) EP 174	2D reflection	S84	180.0	15	2441
EP 111 Geochemical S.	Strata Oil NL	1985	EP 111 (R1) EP 201 EP 96 (R1)	Geochemical	–	–	–	2835
EP 23 Experimental 1986 S.S.	Western Mining Corporation Ltd	1986	EP 23 (R3)	2D reflection	X86	20.0	1	2928
EP 389 Line E97-34 S.S.	Empire Oil Company (WA) Ltd	1998	EP 389	2D reflection	E97	49.8	1	10384
Erangy Spring S.S.	Western Mining Corporation Ltd	1984	EP 23 (R2)	2D reflection	ES84	94.0	9	2550
Eridon Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D reflection	E62	282.0	13	58
Erregulla 1966 S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	E66	60.0	5	291 V2
Erregulla 1967 S.S.	West Australian Petroleum Pty Ltd	1967	PE-27-H	2D reflection	E67	26.6	2	284 V3
Erregulla 2 Detail S.S.	West Australian Petroleum Pty Ltd	1970	EP 23	2D reflection	E70	50.0	5	1345
Erregulla 3 S.S.	West Australian Petroleum Pty Ltd	1974	EP 21 EP 23	2D reflection	P74	92.0	9	980 V1
Erregulla 4 Uphole Velocity S.	West Australian Petroleum Pty Ltd	1978	EP 23 (R1)	Velocity	–	–	–	1479
Erregulla Extension 1 S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	EE66	66.0	3	291 V1

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Erregulla West S.S.	Barrack Energy Ltd	1989	EP 23 (R3) EP 320	2D reflection	B89	51.0	6	3910
Eurangoa S.S.	Barrack Energy Ltd	1990	L7	2D reflection	B90	34.3	4	10002
Gairdner Airborne Spectrometer S.	Barrack Energy Ltd	1988	EP 100 (R2)	Geochemical	–	800.0	–	3334
Georgina S.S.	Barrack Energy Ltd	1989	L7 EP 233 L2	2D reflection	B89	67.2	7	3893
Georgina Experimental S.S.	Barrack Energy Ltd	1989	L7	2D reflection	B89	11.5	2	3971
Gingin S.S.	West Australian Petroleum Pty Ltd	1955	PE-27-H	2D reflection	G55	84.0	5	457 V2
Gingin Aeromagnetic and Radiometric S.	Empire Oil Company (WA) Ltd	1997	EP 389 EP 321 (R1)	Aeromagnetic	–	12 432.8	–	10296
Gingin Anticline North S.S.	Bureau of Mineral Resources	1955	PE-27-H	2D reflection	GAN55	32.0	3	3003
Gingin Brook 2000 2D S.S.	Empire Oil Company (WA) Ltd	2000	EP 389	2D reflection	99GGB	30.3	3	10414
Gingin Bullsbrook D1 Detail S.S.	West Australian Petroleum Pty Ltd	1972	EP 24 EP 25	2D reflection	P72	406.0	25	683
Gingin Detail S.S.	West Australian Petroleum Pty Ltd	1964	PE-27-H	2D reflection	GD64	319.0	18	83 V1
Gingin North 1998 S.S.	Empire Oil Company (WA) Ltd	1998	EP 389	2D reflection	E97	14.1	1	10387
Gingin Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1956	PE-27-H	2D reflection	GR56	84.0	2	83 V2
Gingin Reflection S.S.	Bureau of Mineral Resources	1955	PE-27-H	2D reflection	BMR55	45.1	1	3008
Gingin West 1999 S.S.	Empire Oil Company (WA) Ltd	1999	EP 389	2D reflection	GGW	48.2	6	10413
Goondaring S.S.	Western Mining Corporation Ltd	1988	EP 23 (R3)	2D reflection	88	59.6	7	3289
Goonderoo S.S.	Agnew Clough Ltd	1985	EP 278	2D reflection	AC85	17.0	1	2603
Goonderoo 1986 Gravity S.	Agnew Clough Ltd	1986	EP 278 EP 321	Gravity	A89G	–	3	2962
Goonderoo 1989 Gravity S.	Ampol Exploration Ltd	1989	EP 321	Gravity	–	23.0	–	3545

Appendix 3 (continued)

Survey name	Company	Year	Tenement	Survey type	Line prefix	Total kilometres	No. of lines	S number
Goonderoo 1989 S.S.	Ampol Exploration Ltd	1989	EP 321 EP 100 (R2)	2D reflection	A89	201.8	15	3466
Goonderoo 1989 (Phase 2) S.S.	Ampol Exploration Ltd	1989	EP 321	2D reflection	–	52.0	–	3529
Goonderoo Airborne Geochemical S.	Agnew Clough Ltd	1984	EP 278	Geochemical	–	–	–	2664
Goonderoo Geochemical S.	Agnew Clough Ltd	1983	EP 278	Geochemical	–	–	–	2318
Goonderoo West Ground Magnetic S.	Agnew Clough Ltd	1983	EP 278	Magnetic	–	28.5	–	2295
Grange S.S.	West Australian Petroleum Pty Ltd	1970	EP 23	2D reflection	G70	122.0	3	645 V1
Gravity S. of the Perth Basin	Bureau of Resource Sciences	1951	PE-27-H	Gravity	–	–	–	3001
Green Head Refraction S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D refraction	GH62	174.0	11	57
Grey S.S.	Hughes and Hughes Oil and Gas	1979	EP 100	2D reflection	G79	152.0	19	1496
Hakea S.S.	Arc Energy NL	1999	L1 (R1) L2 (R1)	2D reflection	A99	82.1	11	10416
Heaton S.S.	West Australian Petroleum Pty Ltd	1968	PE-27-H	2D reflection	H68	29.0	3	1416 V1
Heaton Experimental S.S.	Mesa Australia Ltd	1981	EP 23 (R2)	2D reflection	HE81	12.0	2	1759
Heelans S.S.	Victoria International Petroleum NL	1990	EP 111 (R2) EP 23 (R3) L7	2D reflection	SV90	56.4	8	3967
Hibbertia 3D S.S.	Origin Energy Developments Pty Ltd	2002	L1	3D reflection	–	255.0	–	10477
Hill River Aeromagnetic S.	West Australian Petroleum Pty Ltd	1955	PE-27-H	Aeromagnetic	–	–	2	712 V1
Hill River Detail S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D reflection 2D refraction	HRD62 HRD62	238.7 7.2	20 3	60 60
Hill River (1955) S.S.	West Australian Petroleum Pty Ltd	1955	PE-27-H	2D reflection	HR55	26.0	4	712 V2
Hunt Gully Detail S.S.	West Australian Petroleum Pty Ltd	1965	PE-27-H LP 111-H LP 126-H	2D reflection	HG65	104.6	10	179
Hunt Gully Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1965	PE-27-H LP-111-H LP-126-H	2D reflection	HG65	173.1	15	216 V3

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Irwin Detail S.S.	West Australian Petroleum Pty Ltd	1964	PE-27-H	2D reflection	ID64	43.0	3	155
Irwin River Airborne Geochemical S.	Western Mining Corporation Ltd	1988	EP 23 (R3)	Geochemical	–	–	–	3335
Irwin River S.S.	Mesa Australia Ltd	1981	EP 105 L1	2D reflection	81-R	100.0	12	1833
Jago S.S.	Jervois Mining NL	1999	EP 111 (R3)	2D reflection	JM99	29.3	7	10411
Karinga Geochemical S.	Barrack House Group	1987	EP 323 EP 100 (R1)	Geochemical	–	60.0	–	3228
Khan S.S.	Boral Energy Resources Ltd	1995	EP 100 (R3) EP 320 (R1)	2D reflection	SK95	198.1	13	10242 V1
Koojan West S.S.	Agnew Clough Ltd	1986	EP 321	2D reflection	AC86	12.0	2	2995
Lake Indoon S.S.	Hughes and Hughes Oil and Gas	1981	EP 100	2D reflection	LI81	157.0	14	1735
Lancelin S.S.	West Australian Petroleum Pty Ltd	1967	PE-27-H	2D reflection	L67	24.0	2	376
Lancelin 3 S.S.	West Australian Petroleum Pty Ltd	1973	EP 24	2D reflection	P73	122.0	7	841 V1
Lancelin Experimental S.S.	West Australian Petroleum Pty Ltd	1970	PE-27-H	2D reflection	LE70	39.0	2	579
Logue 1994 S.S.	Consolidated Gas Pty Ltd	1994	L4 L5 EP 100 (R3)	2D reflection	CG94L	136.0	16	10210
Logue Infill 1995 S.S.	Consolidated Gas Pty Ltd	1995	L4 L5	2D reflection	CG95	37.7	9	10272
Lovegrove S.S.	Sagasco Resources Ltd	1993	EP 320 (R1) EP 100 (R3)	2D reflection	SL93	109.6	13	10145
Mingenew S.S.	Discovery Petroleum NL	1994	EP 23 (R4) EP 368 EP 372 L7	2D reflection	D94	371.8	45	10206
Mondarra S.S.	West Australian Petroleum Pty Ltd	1968	PE-27-H	2D reflection	M68	144.9	11	1416 V2
Mondarra 2 S.S.	West Australian Petroleum Pty Ltd	1974	L1	2D reflection	P74	12.0	1	980 V2

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Mondarra 3 S.S.	West Australian Petroleum Pty Ltd	1982	L1	2D reflection	P82	13.1	2	2011
Mondarra Gas Storage 3D S.S.	CMS Gas Transmission of Australia	1998	L1 (R1)	3D reflection	MDR, Q	178.7	480	10370
Mooladarra Land S.S. and Gravity S.	West Australian Petroleum Pty Ltd	1975	EP 21 EP 23	2D reflection	P75	112.0	9	1113
Mooladarra 2 Land S.S.	West Australian Petroleum Pty Ltd	1976	EP 21 (R1) EP 23 (R1)	2D reflection	P76	23.0	2	1181
Mooratara S.S.	Carnarvon Petroleum NL	1993	EP 201 (R2) L2	2D reflection	93	14.6	3	10167
Mooriary S.S.	Western Mining Corporation Ltd	1987	EP 23 (R3)	2D reflection	87	54.2	4	3114
Mooriary (Phase 2) S.S.	Western Mining Corporation Ltd	1987	EP 23 (R3)	2D reflection	87	42.0	4	3138
Mount Adam Detail S.S.	Layton Geophysics International	1980	EP 105	2D reflection	80	59.0	10	1474
Mount Adams S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	MA66	121.0	10	263 V1
Mount Hill 1985 S.S.	Strata Oil NL	1986	EP 111 (R1)	2D reflection	S86	74.7	11	2768
Mount Hill 1986 S.S.	Lassoc Pty Ltd	1986	EP 201 (R1) EP 111 (R1)	2D reflection	86	51.5	10	2925
Mount Hill 80 S.S.	Pancontinental Petroleum Pty Ltd	1980	EP 111 EP 23	2D reflection	80	11.7	1	1713
Mount Horner Airborne Spectrometer S.	Metramar Minerals Ltd	1985	EP 96 (R1)	Radiometric	–	–	–	2889
Mount Horner Ground Geochemical S.	Metramar Minerals Ltd	1985	EP 96 (R1)	Geochemical	–	–	11	2911
Mullering S.S.	West Australian Petroleum Pty Ltd	1973	EP 24	2D reflection	P73	74.0	4	841 V2
Mullering 2 S.S.	West Australian Petroleum Pty Ltd	1975	EP 24	2D reflection	P75	38.0	3	983
Mungarra 1980 S.S.	Pancontinental Petroleum Pty Ltd	1981	EP 111 EP 23 (R2)	2D reflection	P80	384.0	19	1738
Mungarra Detail S.S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	2D reflection	M63	77.8	6	52 V4
Mungenooka S.S.	Boral Energy Resources Ltd	1997	EP 320 (R2) L11	2D reflection	BPM97	178.3	15	10328

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Namban (Lancelin) S.S.	West Australian Petroleum Pty Ltd	1969	PE-27-H	2D reflection	N69	69.0	2	478
Narkarino S.S.	Premier Oil Australia Pty Ltd	1995	EP 394	2D reflection	DN95	66.5	7	10262
Nhargo S.S.	Lassoc Pty Ltd	1984	EP 201 EP 96 (R1)	2D reflection	84	29.8	6	2706
Nine Mile Experimental S.S.	Lassoc Pty Ltd	1984	EP 201	2D reflection	–	5.0	1	2573
Nine Mile S.S.	Lassoc Pty Ltd	1984	EP 201	2D reflection	84	31.0	5	2602
North Perth A.L.F.	BP	1989	SI1/1988-89	S	–	6 593.0	–	3862 V2
North Perth Basin Detail Gravity S.	West Australian Petroleum Pty Ltd	1965	PE-228-H PE-27-H	Gravity	–	–	–	286
Northampton Gravity S.	West Australian Petroleum Pty Ltd	1955	PE-27-H	Gravity	–	–	–	931
Northern Perth Basin Digital Reflection S.	West Australian Petroleum Pty Ltd	1965	PE-27-H LP-111-H LP-126-H	2D reflection	–	87.0	15	16 V2
Ocean Hill S.S.	Barrack Energy Ltd	1988	EP 320	2D reflection	B88	90.6	5	3444
P81 S.S.	Australian Aquitaine Petroleum Pty Ltd	1981	EP 174 EP 100	2D reflection	P81	272.0	19	740
Pacific S.S.	Pacific Basin Exploration Pty Ltd	1981	EP 96	2D reflection	S81	140.0	9	1845
Parmelia S.S.	Arc Energy NL	1998	L1 (R1) L2 (R1)	2D reflection	A98	310.5	30	10363
Peron S.S.	West Australian Petroleum Pty Ltd	1961	PE-27-H	2D reflection	P61	11.3	2	651
Perth Basin Gravity S.	Bureau of Mineral Resources	1952	PE-27-H	Gravity	–	–	–	3001
Perth Basin Gravity S.	West Australian Petroleum Pty Ltd	1956	PE-27-H	Gravity	C	–	2	416
Poodooloo S.S.	French Petroleum Co. (Australia) Pty Ltd	1965	PE-228-H	2D reflection	P65	75.4	7	222
Rakrani S.S.	Lassoc Pty Ltd	1989	EP 201 (R1)	2D reflection	LP89	40.2	8	3530
Red Gully S.S.	Empire Oil Company (WA) Ltd	1998	EP 389	2D reflection	E97	151.4	14	10386

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Ruth S.S.	Discovery Petroleum NL	1997	EP 368 EP 372 EP 394	2D reflection	DR97	301.1	23	10326
Sangaree Gravity S.	Ampol Exploration Ltd	1990	EP 321 EP 100	Gravity	–	20.0	–	10013
Skipper S.S.	Barrack Energy Ltd	1990	EP 23 (R3) EP 320	2D reflection	B90	78.0	4	10005
Strawberry Bridge 1988 Geochemical S.	Western Mining Corporation Ltd	1988	EP 233 EP 320	Geochemical	–	132.0	–	3415
Strawberry Hill S.S.	West Australian Petroleum Pty Ltd	1994	L1 (R1) L2 (R1)	2D reflection	P93	135.5	10	10188
Tabletop S.S.	Barrack Energy Ltd	1989	L7 L2	2D reflection	B89	50.7	8	3326
Tabletop 1994 S.S. and Extension S.	Victoria International Petroleum NL	1994	EP 111 (R2)	2D reflection	VP94	24.5	7	10209
Tangletoe/Gingin Brook S.S.	Empire Oil Company (WA) Ltd	1998	EP 389	2D reflection	E97/GGB97	156.9	11	10385
Terling Gravity S. and Extension S.	CRA Exploration Pty Ltd	1982	EP 181 EP 278	Gravity	–	150.0	–	2204 V1
Terling Gravity S. and Extension S.	CRA Exploration Pty Ltd	1983	EP 181	Gravity	–	50.0	–	2204 V2
Tomkins S.S.	Barrack Energy Ltd	1989	EP 320 L1	2D reflection	B89	77.5	7	3790
Ularino 2D S.S.	Origin Energy Developments Pty Ltd	2001	EP 413	2D reflection	–	60.0	–	10478
Wakeford S.S.	Lassoc Pty Ltd	1987	EP 201 (R1) EP 111 (R1) EP 96 (R2)	2D reflection	87	77.0	12	3124
Walcott S.S.	Western Mining Corporation Ltd	1989	EP 23 (R3) EP 320 L2	2D reflection	89	130.0	10	3523
Walyering S.S.	West Australian Petroleum Pty Ltd	1967	PE-27-H	2D reflection	W67	136.9	7	340
Walyering Detail S.S.	West Australian Petroleum Pty Ltd	1970	EP 24	2D reflection	WD70	35.0	3	595

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Walyering West Detail S.S.	West Australian Petroleum Pty Ltd	1971	EP 24	2D reflection	WWD71	130.0	8	661
Warradong Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D reflection	W62	55.1	3	61
Warradong S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	W66	71.0	5	263 V3
Warradong 2 S.S.	West Australian Petroleum Pty Ltd	1973	EP 21 EP 23 L1	2D reflection	P73	47.0	4	845
Warramia S.S.	Ampolex Ltd	1991	EP 351 EP 100 (R2) EP 321	2D reflection	A91	89.0	8	10053
Wedge Island Reconnaissance S.S.	West Australian Petroleum Pty Ltd	1966	PE-27-H	2D reflection	W66	198.0	8	290
White Point S.S.	West Australian Petroleum Pty Ltd	1967	PE-27-H	2D reflection	WP67	59.4	6	344 V4
White Point Detail S.S.	West Australian Petroleum Pty Ltd	1968	PE-27-H	2D reflection	WP68	25.2	3	344 V3
White Point East S.S.	West Australian Petroleum Pty Ltd	1972	L1	2D reflection	P72	24.0	3	777
Wicherina Detail S.S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	2D reflection	W63	130.9	6	52 V5
Winchester 2 S.S.	West Australian Petroleum Pty Ltd	1976	EP 24 (R1)	2D reflection	P76	42.0	4	1180
Winchester Land S.S. and Gravity S.	West Australian Petroleum Pty Ltd	1975	EP 24	2D reflection	P75	42.1	3	1114
Wondado Spring Airborne Spectrometer S.	Balmoral Resources NL	1985	EP 201	Radiometric	–	–	–	2893
Woodada Reconnaissance S.S. and Gravity S.	French Petroleum Co. (Australia) Pty Ltd	1965	PE-228-H	2D reflection	W65	211.0	12	171
Woolka S.S.	Barrack Energy Ltd	1990	EP 323 EP 100 (R2)	2D reflection	SB89	224.8	5	10000
Woolmulla Detail S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D reflection	WD62	72.0	2	48
Woolmulla South Detail S.S.	West Australian Petroleum Pty Ltd	1962	PE-27-H	2D reflection	WS62	163.0	6	74 V3
Woolmulla South S.S.	Barrack Energy Ltd	1989	EP 100 (R2)	2D reflection	BW89	85.9	6	3524
Wye Springs S.S.	Barrack House Group	1987	EP 96 (R2)	2D reflection	B87	20.0	4	3123
Yallalie Aeromagnetic S.	Ampol Exploration Ltd	1989	EP 321 EP 100 (R2)	Aeromagnetic	–	220.0	11	S3464
Yandanooka S.S.	Sagasco Resources Ltd	1992	EP 320 EP 100 (R1) L1	2D reflection	S92	262.7	21	S10091

Appendix 3 (continued)

Survey name	*Company*	*Year*	*Tenement*	*Survey type*	*Line prefix*	*Total kilometres*	*No. of lines*	*S number*
Yardanogo S.S.	Barrack Energy Management Pty Ltd	1989	EP 320 EP 100 (R2) EP 23 (R3)	2D reflection	B88	212.0	18	S3456
Yardanogo North S.S.	Barrack Energy Ltd	1990	EP 320 EP 100	2D reflection	B90	44.0	5	S10006
Yardarino Detail S.S.	West Australian Petroleum Pty Ltd	1963	PE-27-H	2D reflection	Y63	285.0	18	S52 V6
Yardarino 2 S.S.	West Australian Petroleum Pty Ltd	1975	L2 EP 23	2D reflection	P75	16.0	2	S980 V3
Offshore								
AGSO S. 57, North Perth Basin M.S.S.	Australian Geological Survey Organisation	1986	–	2D reflection	057	–	19	–
Dongara 1967 M.S.S.	West Australian Petroleum Pty Ltd	1967	PE-225-H PE-27-H	2D reflection 2D refraction	D67 D67	661.0 24.0	12 –	17 17
Dongara 1968 M.S.S.	West Australian Petroleum Pty Ltd	1968	PE-225-H PE-27-H	2D reflection	D68	1110.0	21	410 V2
Dongara Offshore M.S.S.	Diamond Shamrock Oil Co. (Australia)	1982	WA-162-P WA-115-P WA-165-P	2D reflection	DS82	870.6	37	2046
Green Head M.S.S.	Geometals Oil Exploration Pty Ltd	1980	WA-115-P	2D reflection	GH80	301.0	27	1718
Lancelin (SW) M.S.S.	West Australian Petroleum Pty Ltd	1972	WA-14-P	2D reflection	L72	209.7	14	788 V1
Perth Basin Aeromagnetic S.	Enterprise Oil Exploration Ltd	1992	WA-230-P WA-231-P	Aeromagnetic	–	28 213.0	–	10141
Perth Basin M.S.S.	West Australian Petroleum Pty Ltd	1971	WA-13-P	2D reflection WA-14-P WA-20-P	PB71	778.0	41	611 V3
TP/15 Michelle 2D M.S.S.	Premier Oil Australia Pty Ltd	1999	TP/15	2D reflection	PM99	159.1	–	10425
WA-286-P Michelle 2D M.S.S.	Premier Oil Australia Pty Ltd	1999	WA-286-P	2D reflection	PM99	413.4	42	10426
Wedge Island M.S.S.	West Australian Petroleum Pty Ltd	1969	WA-14-P	2D reflection	WI69	379.0	6	520 V2

NOTES: A.L.F.: airborne laser fluorosensor
S. number: Western Australia Geological Survey statutory petroleum exploration report number
M.S.S.: marine seismic survey
S.S.: seismic survey
S.: survey

Appendix 4

Wells drilled for petroleum exploration in the northern Perth Basin

Well name	*S no.*	*Type*	*Latitude (S)*	*Longitude (E)*	*Kelly bushing elevation (m AHD)*	*Total depth (m)*	*Bottomed in*	*Year*	*Company*	*Status 1*	*Status 2*	*Gas show*	*Oil show*
Abbarwardoo 1	50	STR	28°35’14"	115°09’40"	221	600	Lower Permian	1962	WAPET	Dry	P&A	Nil	Nil
Allanooka 1	188	NFW	29°08’33"	115°00’52"	51	1 187	Lower Permian	1965	WAPET	Dry	P&A	Poor	Poor
Allanooka 2	191	NFW	29°06’00"	115°00’13"	70	1 006	Precambrian	1965	WAPET	Dry	P&A	Nil	Nil
Arradale 1	20750	NFW	29°06’28"	115°18’47"	276	2 245	Lower Permian	2001	AWE	Dry	P&A	Nil	Nil
Arramall 1	3442	NFW	29°35’23"	115°05’50"	37	2 250	Precambrian	1989	Barrack House	Dry	P&A	Poor	Poor
Arranoo 1	20206	NFW	29°08’19"	115°04’44"	161	1 750	Lower Permian	1994	Discovery	Dry	P&A	Nil	Good
Arranoo South 1	20274	NFW	29°09’19"	115°05’07"	150	1 782	Lower Permian	1995	Discovery	Dry	P&A	Poor	Poor
Arrowsmith 1	203	NFW	29°36’39"	115°07’07"	56	3 446	Precambrian	1965	French	Gas	P&A	Excellent	Nil
Badaminna 1	337	NFW	31°20’27"	115°40’07"	41	2 438	Lower Jurassic	1967	WAPET	Dry	P&A	Nil	Nil
Barberton 1	20030	NFW	30°49’05"	115°58’25"	222	3 414	Lower Triassic	1990	Ampolex	Dry	P&A	Nil	Nil
Barragoon 1	987	NFW	31°21’36"	115°35’15"	40	2 335	Upper Jurassic	1974	WAPET	Dry	P&A	Nil	Nil
Beekeeper 1	1964	NFW	29°42’46"	115°11’12"	53	3 012	Lower Permian	1982	Aquitaine	Dry	P&A	Poor	Poor
Beharra 1	333	NFW	29°29’06"	115°00’50"	27	2 056	Precambrian	1966	French	Dry	P&A	Nil	Nil
Beharra 2	336	NFW	29°30’56"	115°01’15"	33	1 925	Lower Permian	1967	French	Dry	P&A	Nil	Nil
Beharra Springs 1	20009	NFW	29°27’51"	115°08’28"	49	3 700	Lower Permian	1990	Arrow	Gas	Well	Producer	Poor
Beharra Springs 2	20061	EXT	29°28’41"	115°08’42"	57	3 493	Lower Permian	1991	Arrow	Gas	Well	Producer	Poor
Beharra Springs 3	20092	EXT	29°27’20"	115°08’27"	51	3 505	Lower Permian	1992	Sagasco	Gas	Susp	Excellent	Poor
Beharra Springs North 1	20721	NFW	29°26’03"	115°08’27"	60	3 450	Permian	2001	Origin	Gas	Susp	Excellent	Nil
Beharra Springs South 1	20730	NFW	29°30’13"	115°09’00"	55	3 471	Permian	2001	Origin	Dry	P&A	Fair	Good
BMR 10 Dongara	3048 A1	STR	29°49’38"	114°58’30"	6	1 192	Lower Permian	1959	BMR	Dry	P&A	Nil	Nil
BMR 10A Dongara	3048 A2	STR	29°49’36"	114°58’30"	8	1 482	Precambrian	1960	BMR	Dry	P&A	Nil	Nil
Bonniefield 1	2689	NFW	29°10’13"	114°54’52"	21	1 012	Precambrian	1985	Balmoral	Dry	P&A	Poor	Nil
Bookara 1	205	STR	28°59’01"	114°46’23"	21	282	Precambrian	1965	WAPET	Dry	P&A	Nil	Nil
Bookara 2	384	STR	29°09’59"	114°54’41"	11	760	Lower Triassic	1967	WAPET	Dry	P&A	Nil	Nil
Bookara 3	385	STR	29°06’27"	114°53’25"	33	538	Precambrian	1967	WAPET	Dry	P&A	Nil	Nil
Bootine 1	1781	NFW	31°10’35"	115°49’37"	173	4 306	Lower Jurassic	1981	Mesa	Gas	P&A	Excellent	Nil
Bullsbrook 1	771	NFW	31°28’36"	115°50’33"	91	4 257	Lower Jurassic	1972	WAPET	Dry	P&A	Poor	Nil
Cadda 1	226	NFW	30°20’11"	115°12’53"	82	2 795	Precambrian	1965	French	Dry	P&A	Poor	Nil
Casuarinas 1	1966	NFW	28°55’32"	115°09’12"	244	1 478	Lower Permian	1981	Jervois	Dry	P&A	Nil	Nil
Cataby 1	20220	NFW	30°41’11"	115°20’01"	65	2 298	Lower Jurassic	1994	Discovery	Dry	P&A	Fair	Good
Central Yardarino 1	20314	NFW	29°11’57"	115°03’05"	56	2 500	Lower Permian	1995	WAPET	Dry	P&A	Poor	Poor
Cliff Head 1	20757	NFW	29°27’53"	114°52’11"	25	1 499	Lower Permian	2002	Roc Oil	Oil	Susp	Fair	Good
Cliff Head 2	20759	EXT	29°27’53"	114°52’11"	25	2 020	Lower Permian	2002	Roc Oil	Oil	Susp	Fair	Good
Coomallo 1	953	NFW	30°14’51"	115°25’03"	258	3 520	Lower Jurassic	1974	WAPET	Dry	P&A	Nil	Nil
Conder 1	3351	NFW	29°02’39"	114°55’27"	29	253	Precambrian	1988	Doral	Dry	P&A	Nil	Fair
Connolly 1	3355	NFW	29°02’12"	114°57’11"	112	478	Precambrian	1988	Doral	Dry	P&A	Nil	Poor
Cypress Hill 1	3361	NFW	30°27’47"	115°48’47"	215	990	Upper Jurassic	1988	Ampolex	Dry	Waterbore	Nil	Nil
Dandaragan 1	20307	NFW	30°35’47"	115°48’32"	270	1 103	Upper Jurassic	1995	Discovery	Dry	Susp	Poor	Good
Denison 1	1307	NFW	29°13’28"	114°57’22"	35	2 300	Lower Permian	1977	WAPET	Dry	P&A	Nil	Nil
Depot Hill 1	2346	NFW	29°06’02"	115°19’35"	270	2 473	Lower Permian	1983	Mesa	Dry	P&A	Nil	Nil
Diamond Soak 1	2474	NFW	28°54’54"	115°16’06"	272	1 722	Lower Permian	1983	Pancontinental	Dry	P&A	Nil	Nil

Appendix 4 (continued)

Well name	*S no.*	*Type*	*Latitude (S)*	*Longitude (E)*	*Kelly bushing elevation (m AHD)*	*Total depth (m)*	*Bottomed in*	*Year*	*Company*	*Status 1*	*Status 2*	*Gas show*	*Oil show*
Dongara 1	303	NFW	29°15'08"	114°59'26"	49	2 161	Lower Permian	1966	WAPET	Gas	Well	Producer	Nil
Dongara 2	307	EXT	29°14'54"	114°58'41"	27	1 745	Lower Permian	1966	WAPET	Gas	Shut in	Producer	Nil
Dongara 3	319	EXT	29°15'28"	115°00'11"	31	1 775	Lower Permian	1966	WAPET	Gas	Well	Producer	Nil
Dongara 4	347	EXT	29°13'46"	114°59'01"	65	1 818	Lower Permian	1967	WAPET	Gas	Shut in	Producer	Nil
Dongara 5	386	EXT	29°11'14"	114°59'06"	32	1 808	Lower Permian	1967	WAPET	Dry	P&A	Nil	Nil
Dongara 6	395	EXT	29°11'41"	114°56'28"	29	1 559	Precambrian	1967	WAPET	Dry	P&A	Nil	Nil
Dongara 7	401	EXT	29°18'34"	115°01'48"	46	2 164	Lower Permian	1968	WAPET	Dry	P&A	Nil	Nil
Dongara 8	465	EXT	29°15'05"	115°01'26"	53	1 899	Lower Permian	1969	WAPET	Oil	Shut in	Nil	Excellent
Dongara 9	466	EXT	29°13'27"	115°00'13"	86	1 910	Lower Permian	1969	WAPET	Gas	Well	Producer	Nil
Dongara 10	485	EXT	29°14'24"	115°00'15"	73	2 042	Lower Permian	1969	WAPET	Gas & oil	Susp	Producer	Good
Dongara 11	490	EXT	29°15'59"	115°00'37"	67	1 835	Lower Permian	1969	WAPET	Gas	Susp	Producer	Nil
Dongara 12	496	EXT	29°14'17"	115°01'22"	29	2 013	Lower Permian	1969	WAPET	Gas	Well	Producer	Fair
Dongara 13	499	EXT	29°12'46"	115°00'08"	88	2 033	Lower Permian	1969	WAPET	Dry	P&A	Nil	Poor
Dongara 14	506	EXT	29°13'26"	115°01'09"	77	1 918	Lower Permian	1969	WAPET	Oil	Susp	Nil	Producer
Dongara 15	501	EXT	29°16'29"	115°01'07"	66	1 939	Lower Permian	1969	WAPET	Gas	Shut in	Producer	Nil
Dongara 16	524	EXT	29°16'10"	114°59'39"	30	1 924	Lower Permian	1969	WAPET	Gas	P&A	Producer	Nil
Dongara 17	529	EXT	29°17'06"	115°01'45"	83	1 949	Lower Permian	1969	WAPET	Oil	Shut in	Nil	Producer
Dongara 18	535	EXT	29°16'29"	115°02'06"	105	1 920	Lower Permian	1970	WAPET	Gas	Well	Producer	Nil
Dongara 19	538	EXT	29°16'00"	115°02'48"	114	2 179	Lower Permian	1970	WAPET	Oil	Susp	Nil	Producer
Dongara 20	1005	DEV	29°15'59"	115°01'23"	81	1 939	Lower Permian	1974	WAPET	Gas & oil	Well	Producer	Producer
Dongara 21 ST	1591	DEV	29°14'01"	115°00'48"	90	1 889	Lower Permian	1980	WAPET	Gas	Shut in	Producer	Good
Dongara 22	1607	DEV	29°14'20"	114°58'49"	36	1 800	Lower Permian	1980	WAPET	Dry	P&A	Nil	Nil
Dongara 23	1753	DEV	29°15'40"	115°00'25"	27	1 765	Lower Permian	1981	WAPET	Gas	Well	Producer	Nil
Dongara 24	1799	DEV	29°14'09"	115°01'06"	30	1 808	Lower Permian	1981	WAPET	Gas & oil	Well	Producer	Good
Dongara 25	1823	DEV	29°14'31"	115°01'34"	56	1 830	Lower Permian	1981	WAPET	Gas	Well	Producer	Fair
Dongara 26	20006	DEV	29°14'45"	114°58'20"	23	1 830	Lower Permian	1990	WAPET	Dry	P&A	Nil	Nil
Dongara 27	20007	DEV	29°12'02"	115°01'24"	38	1 730	Lower Permian	1990	WAPET	Dry	P&A	Fair	Fair
Dongara 28	20312	DEV	29°14'37"	115°00'55"	34	1 850	Lower Permian	1995	WAPET	Gas	Well	Excellent	Poor
Dongara 29	20603	DEV	29°15'10"	115°01'28"	64	1 850	Lower Permian	2000	Arc Energy	Dry	P&A	Fair	Good
Dongara 30	20610	DEV	29°15'10"	115°01'28"	64	2 030	Lower Permian	2000	Arc Energy	Gas & oil	Susp	Good	Good
Donkey Creek 1	320	NFW	29°37'31"	115°17'30"	111	3 853	Lower Triassic	1966	French	Dry	P&A	Nil	Nil
East Heaton 1	2736	NFW	29°06'48"	115°15'04"	259	2 520	Lower Permian	1985	WMC	Dry	P&A	Nil	Nil
East Lake Logue 1	2287	NFW	29°49'59"	115°09'17"	54	2 430	Lower Permian	1983	Hudbay	Gas	Susp	Producer	Nil
East Lake Logue 2	20138	DEV	29°49'55"	115°09'22"	46	2 303	Lower Permian	1992	Consolidated	Gas	Well	Producer	Poor
Eganu 1	35	STR	29°59'09"	115°49'42"	237	600	Middle Jurassic	1963	WAPET	Dry	P&A	Nil	Nil
Ejarno 1	1803	NFW	29°18'50"	115°04'38"	80	2 868	Lower Permian	1981	WAPET	Dry	P&A	Good	Nil
Eleven Mile 1	3366	NFW	29°04'35"	114°53'02"	37	322	Precambrian	1988	Lassoc	Dry	P&A	Nil	Nil
Eneabba 1	34	NFW	29°34'10"	115°20'01"	127	4 179	Lower Triassic	1961	WAPET	Gas	P&A	Good	Poor
Erregulla 1	293	NFW	29°22'34"	115°23'56"	237	4 244	Lower Permian	1966	WAPET	Oil	Susp	Fair	Excellent
Erregulla 2	1584	EXT	29°22'27"	115°23'56"	248	3 577	Middle Triassic	1980	Mesa	Dry	P&A	Poor	Poor
Eurangoa 1	219	NFW	29°07'34"	115°08'21"	254	2 277	Lower Permian	1965	WAPET	Dry	P&A	Fair	Poor
Gairdner 1	20040	NFW	30°04'13"	115°08'50"	182	2 172	Lower Permian	1990	Arrow	Dry	P&A	Nil	Poor
Georgina 1	1830	NFW	29°08'36"	115°04'30"	146	1 831	Lower Permian	1981	Xlx	Dry	P&A	Poor	Poor
Gingin 1	181	NFW	31°08'35"	115°49'38"	203	4 544	Middle Jurassic	1965	WAPET	Gas	P&A	Producer	Nil
Gingin 2	225	EXT	31°10'20"	115°50'39"	266	4 482	Middle Jurassic	1966	WAPET	Gas	Susp	Excellent	Nil

Appendix 4 (continued)

Well name	*S no.*	*Type*	*Latitude (S)*	*Longitude (E)*	*Kelly bushing elevation (m AHD)*	*Total depth (m)*	*Bottomed in*	*Year*	*Company*	*Status 1*	*Status 2*	*Gas show*	*Oil show*
Gingin 3	20521	EXT	31°09’09"	115°49’59"	9	4 200	Middle Jurassic	1998	Empire	Dry	Susp	Poor	Poor
Goonderoo Corehole 1	2262V 1	NFW	30°30’41"	116°02’11"	236	28	Precambrian	1982	Agnew Clough	Dry	Susp	Nil	Poor
Goonderoo Corehole 1A	2262V 2	NFW	30°30’41"	116°02’11"	237	25	Precambrian	1982	Agnew Clough	Dry	Susp	Nil	Poor
Green Head 1	M7391	Coal	30°06’00"	115°05’04"	62	685	Lower Permian	1974	Amax	Dry	Abd	Poor	Nil
Green Head 2	M7391	Coal	30°08’20"	115°00’00"	2	328	Lower Triassic	1974	Amax	Dry	Abd	Nil	Nil
Green Head 3	M7391	Coal	30°00’00"	115°04’02"	54	690	Lower Permian	1974	Amax	Dry	Abd	Nil	Nil
Greenough 1	2279	NFW	28°51’10"	114°39’24"	13	445	Lower Triassic	1983	Balmoral	Dry	P&A	Nil	Nil
Hakia 1	20599	NFW	29°12’57"	115°05’46"	61	2 763	Lower Permian	1999	Arc Energy	Dry	P&A	Good	Nil
Hampton Arms 1	20275	STR	28°58’06"	114°44’39"	18	451	Lower Permian	1995	Victoria	Dry	P&A	Nil	Nil
Heaton 1	702	NFW	29°07’14"	115°12’50"	190	2 438	Lower Permian	1972	Abrolhos	Dry	P&A	Nil	Nil
Hill River 1	15 A1	STR	30°16’04"	115°18’45"	112	579	Lower Jurassic	1962	WAPET	Dry	P&A	Nil	Nil
Hill River 2	15 A2	STR	30°11’04"	115°14’07"	190	494	Lower Jurassic	1962	WAPET	Dry	P&A	Nil	Nil
Hill River 2A	15 A5	STR	30°11’16"	115°14’07"	184	116	Lower Jurassic	1962	WAPET	Dry	Abd	Nil	Nil
Hill River 3	15 A3	STR	30°00’36"	115°11’20"	126	264	Upper Triassic	1962	WAPET	Dry	P&A	Nil	Nil
Hill River 4	15 A4	STR	30°23’28"	115°13’56"	94	308	Upper Triassic	1962	WAPET	Dry	P&A	Nil	Nil
Hill River 4/1	15 A7	STR	30°21’43"	115°12’20"	68	155	Lower Jurassic	1962	WAPET	Dry	P&A	Nil	Nil
Hill River 4/2	15 A7	STR	30°21’39"	115°12’41"	72	155	Upper Triassic	1962	WAPET	Dry	P&A	Nil	Nil
Hill River 4/3	15 A7	STR	30°22’41"	115°13’10"	74	155	Upper Triassic	1962	WAPET	Dry	P&A	Nil	Nil
Hill River 4/4	15 A7	STR	30°22’36"	115°13’41"	87	155	Upper Triassic	1962	WAPET	Dry	P&A	Nil	Nil
Horner West 1	3133	NFW	29°08’12"	115°02’34"	98	1 451	Lower Permian	1987	Barrack	Dry	P&A	Nil	Nil
Hovea 1	20738	NFW	29°19’05"	115°02’30"	69	2 134	Permian	2001	Arc Energy	Oil	Susp	Good	Excellent
Hunt Gully 1	3330	NFW	29°05’50"	115°09’13"	242	1 983	Lower Permian	1988	Barrack Energy	Dry	P&A	Nil	Poor
Huntswell 1	20256	NFW	29°07’00"	115°07’53"	250	1 903	Lower Permian	1994	Discovery	Dry	P&A	Fair	Fair
Illyarrie 1	20590	NFW	29°13’47"	115°02’48"	50	2 608	Lower Permian	1999	Arc Energy	Dry	P&A	Fair	Fair
Indoon 1	2253	NFW	29°52’57"	115°09’09"	43	2 257	Lower Permian	1982	Hudbay	Gas	Susp	Producer	Nil
Jay 1	20187	NFW	29°04’40"	115°03’28"	134	1 295	Lower Jurassic	1993	Victoria	Dry	P&A	Nil	Fair
Jurien 1	40	NFW	29°40’24"	115°35’06"	12	1 026	Precambrian	1962	WAPET	Dry	P&A	Poor	Poor
Leander Reef 1	2 499	NFW	29°26’18"	114°44’16"	8	3 234	Lower Permian	1984	Diamond	Dry	P&A	Poor	Poor
Lockyer 1	20456	NFW	29°11’05"	115°15’45"	142	3 327	Upper Permian	1998	Premier	Dry	P&A	Good	Poor
Mondarra 1	445	NFW	29°18’01"	115°07’05"	83	3 063	Lower Permian	1968	WAPET	Gas	Well	Producer	Poor
Mondarra 2	451	EXT	29°21’05"	115°06’17"	31	2 854	Lower Permian	1969	WAPET	Gas	Susp	Producer	Nil
Mondarra 3	464	EXT	29°17’32"	115°06’51"	103	2 987	Lower Permian	1969	WAPET	Oil	P&A	Poor	Good
Mondarra 4	491	EXT	29°19’09"	115°06’10"	49	2 895	Upper Permian	1969	WAPET	Dry	P&A	Poor	Nil
Mooratara 1	20207	NFW	29°12’46"	114°54’37"	8	1 630	Lower Permian	1994	Royal	Dry	P&A	Nil	Nil
Mount Horner 1	195	NFW	29°07’42"	115°05’11"	200	2 252	Lower Permian	1965	WAPET	Oil	Shut in	Nil	Producer
Mount Horner 2	204	EXT	29°08’45"	115°04’40"	155	2 056	Lower Permian	1965	WAPET	Dry	P&A	Nil	Poor
Mount Horner 3	1707	EXT	29°07’42"	115°05’11"	198	1 558	Lower Permian	1980	Xlx	Oil	Susp	Nil	Producer
Mount Horner 4	1730	EXT	29°07’45"	115°05’29"	219	1 816	Lower Permian	1981	Xlx	Dry	Susp	Poor	Poor
Mount Horner 4A	3272	DEV	29°07’42"	115°05’30"	211	1 265	Lower Jurassic	1988	Barrack House	Oil	Susp	Nil	Producer
Mount Horner 5	1793	EXT	29°07’32"	115°05’22"	216	1 819	Lower Permian	1981	Xlx	Oil	Susp	Poor	Good
Mount Horner 5A	3279	DEV	29°07’32"	115°05’25"	217	1 280	Lower Jurassic	1988	Barrack House	Oil	Susp	Nil	Producer
Mount Horner 6	2476	DEV	29°08’08"	115°05’30"	205	1 850	Lower Permian	1983	Barrack House	Dry	P&A	Nil	Poor
Mount Horner 7	3132	EXT	29°07’24"	115°05’34"	217	1 848	Lower Permian	1987	Barrack House	Oil	Susp	Nil	Excellent
Mount Horner 8	3312	DEV	29°07’56"	115°05’35"	201	1 306	Lower Jurassic	1988	Barrack House	Oil	Susp	Nil	Producer
Mount Horner 9	3302	EXT	29°07’37"	115°05’40"	216	1 310	Lower Jurassic	1988	Barrack House	Oil	Susp	Nil	Producer

Appendix 4 (continued)

Well name	*S no.*	*Type*	*Latitude (S)*	*Longitude (E)*	*Kelly bushing elevation (m AHD)*	*Total depth (m)*	*Bottomed in*	*Year*	*Company*	*Status 1*	*Status 2*	*Gas show*	*Oil show*
Mount Horner 10	3377	DEV	29°07'52"	115°05'52"	217	1 451	Lower Jurassic	1989	Arrow	Oil	Well	Nil	Producer
Mount Horner 11	3715	DEV	29°08'45"	115°06'37"	181	1 408	Lower Jurassic	1989	Arrow	Dry	P&A	Nil	Poor
Mount Horner 12	20134	DEV	29°07'19"	115°05'04"	191	1 805	Lower Jurassic	1992	Arrow	Oil	Susp	Nil	Producer
Mount Horner 13	20153	DEV	29°07'05"	115°05'54"	179	1 676	Lower Permian	1993	Discovery	Oil	Well	Poor	Producer
Mount Horner 14	20194	DEV	29°07'22"	115°05'19"	202	1 803	Lower Permian	1993	Discovery	Oil	Well	Fair	Producer
Mountain Bridge 1	20156	NFW	29°36'00"	115°06'55"	46	3 416	Lower Permian	1993	Sagasco	Dry	P&A	Good	Poor
Mount Adams 1	288	NFW	29°24'21"	115°10'05"	91	3 791	Lower Permian	1966	WAPET	Dry	P&A	Fair	Poor
Mount Hill 1	193	STR	29°04'05"	114°59'07"	117	565	Lower Triassic	1964	WAPET	Dry	P&A	Poor	Nil
Mungenooka 1	20509	NFW	29°23'28"	115°12'49"	158	3 842	Lower Triassic	1998	Boral	Gas	P&A	Good	Fair
Mullering 1	20119	NFW	30°41'22"	115°19'35"	61	1 666	Lower Jurassic	1992	Arrow	Dry	P&A	Poor	Nil
Mungarra 1	174	STR	28°51'02"	115°07'07"	192	609	Lower Permian	1964	WAPET	Dry	P&A	Nil	Nil
Mungarra 2	174	STR	28°54'30"	115°05'05"	234	613	Lower Permian	1965	WAPET	Dry	P&A	Nil	Nil
Mungarra 3	174	STR	28°57'52"	115°05'05"	248	631	Lower Triassic	1965	WAPET	Dry	P&A	Nil	Nil
Mungarra 4	174	STR	28°54'15"	115°16'01"	264	643	Upper Jurassic	1965	WAPET	Dry	P&A	Nil	Nil
Mungarra 5	174	STR	28°53'41"	115°08'17"	235	622	Lower Permian	1965	WAPET	Dry	P&A	Nil	Nil
Murrumbah 1	20494	NFW	29°09'27"	115°10'47"	201	2 145	Upper Permian	1998	Premier	Dry	P&A	Nil	Nil
Narkarino 1	2523	NFW	29°07'01"	114°54'05"	29	600	Lower Triassic	1984	Command	Dry	P&A	Nil	Nil
Narlingue 1	701	NFW	29°04'10"	115°06'15"	197	2 130	Lower Permian	1972	Abrolhos	Dry	P&A	Nil	Nil
North Erregulla 1	383	NFW	29°14'40"	115°19'39"	167	3 444	Lower Permian	1967	WAPET	Dry	P&A	Poor	Good
North Yardanogo 1	3995	NFW	29°27'59"	115°06'10"	42	2 387	Upper Triassic	1990	Barrack Energy	Oil	Susp	Nil	Excellent
North Yardarino 1	1801	NFW	29°11'19"	115°02'29"	63	2 207	Lower Permian	1981	WAPET	Dry	P&A	Nil	Nil
Ocean Hill 1	20066	NFW	29°56'08"	115°23'22"	220	3 840	Lower Jurassic	1991	Arrow	Dry	P&A	Good	Fair
Peron 1	2313	NFW	29°57'04"	115°09'39"	58	2 600	Lower Permian	1983	Hudbay	Dry	P&A	Nil	Nil
Point Louise 1	1888	NFW	30°02'20"	115°04'14"	42	950	Lower Permian	1981	Mesa	Dry	P&A	Nil	Nil
Rakrani 1	3983	NFW	29°10'13"	114°54'04"	16	1 202	Precambrian	1990	Lassoc	Dry	P&A	Nil	Nil
Robb 1	2285	NFW	29°32'43"	115°02'18"	33	1 981	Precambrian	1985	Strata	Dry	P&A	Poor	Poor
Rosslyn 1	20333	NFW	29°04'07"	115°02'51"	114	1 030	Lower Triassic	1996	Victoria	Dry	P&A	Nil	Nil
South Turtle Dove 1A	1104 A2	NFW	30°07'42"	114°38'16"	30	330	Upper Permian	1975	WAPET	Dry	P&A	Nil	Nil
South Turtle Dove 1B	1104 A3	NFW	30°07'42"	114°38'16"	30	1 830	Upper Permian	1975	WAPET	Dry	P&A	Nil	Nil
South Yardanogo 1	20055	NFW	29°29'53"	115°06'16"	52	2 350	Upper Triassic	1990	Arrow	Dry	P&A	Nil	Nil
Strawberry Hill 1	480	NFW	29°15'12"	115°07'21"	63	2 903	Upper Permian	1969	WAPET	Dry	P&A	Nil	Nil
Tabletop 1	20264	NFW	29°05'29"	115°07'18"	224	1 825	Lower Permian	1994	Discovery	Dry	P&A	Nil	Poor
Wakeford 1	3370	NFW	29°00'51"	114°54'03"	16	27	Precambrian	1988	Lassoc	Dry	P&A	Nil	Nil
Walyering 1	627	NFW	30°42'53"	115°28'00"	99	3 643	Lower Jurassic	1971	WAPET	Gas	P&A	Excellent	Nil
Walyering 2	643	EXT	30°42'08"	115°28'31"	99	4 115	Lower Jurassic	1971	WAPET	Gas	P&A	Excellent	Nil
Walyering 3	673	EXT	30°44'01"	115°29'44"	99	4 187	Lower Jurassic	1972	WAPET	Gas	P&A	Good	Nil
Walyering 4	20752	EXT	30°42'55"	115°28'14"	103	3 350	Lower Jurassic	2001	AWE	Dry	P&A	Poor	Nil
Warradong 1	1700	NFW	29°18'01"	115°10'22"	103	3 717	Lower Permian	1981	Mesa	Dry	P&A	Good	Nil
Warramia 1	20121	NFW	30°11'04"	115°43'46"	308	1 498	Upper Jurassic	1992	Ampolex	Dry	P&A	Nil	Nil
Warro 1	1331	NFW	30°10'02"	115°44'16"	299	4 385	Middle Jurassic	1977	WAPET	Dry	P&A	Fair	Nil
Warro 2	1370	NFW	30°10'01"	115°44'08"	299	4 854	Lower Jurassic	1978	WAPET	Gas	P&A	Good	Nil
Wattle Grove 1	2752	NFW	29°08'34"	114°54'23"	37	822	Precambrian	1985	Balmoral	Dry	P&A	Nil	Nil
Wayvanerry 1	20465	NFW	29°08'45"	115°17'51"	194	2 748	Upper Permian	1998	Premier	Dry	P&A	Nil	Poor
Wedge Island 1A	606	STR	30°49'09"	115°11'37"	6	486	Upper Triassic	1970	WAPET	Dry	P&A	Nil	Nil
West Erregulla 1	20020	NFW	29°25'33"	115°18'37"	227	4 065	Upper Permian	1990	Arrow	Gas	P&A	Excellent	Poor

Appendix 4 (continued)

Well name	*S no.*	*Type*	*Latitude (S)*	*Longitude (E)*	*Kelly bushing elevation (m AHD)*	*Total depth (m)*	*Bottomed in*	*Year*	*Company*	*Status 1*	*Status 2*	*Gas show*	*Oil show*
West White Point 1	628	NFW	29°20’42"	115°02’28"	79	2 248	Upper Permian	1971	WAPET	Dry	P&A	Poor	Nil
West White Point 2	631	NFW	29°22’44"	115°02’35"	36	2 355	Lower Permian	1971	WAPET	Dry	P&A	Nil	Nil
Wicherina 1	104	NFW	28°49’53"	115°14’31"	266	1 686	Lower Permian	1964	WAPET	Dry	P&A	Nil	Nil
Woodada 1	1624	NFW	29°47’41"	115°08’26"	40	2 546	Lower Permian	1980	Hughes	Gas	P&A	Producer	Nil
Woodada 2	1667	EXT	29°47’38"	115°09’13"	42	2 460	Lower Permian	1980	Hughes	Gas	Susp	Producer	Nil
Woodada 3	1742	EXT	29°45’12"	115°09’26"	47	2 540	Lower Permian	1981	Hughes	Gas	P&A	Good	Fair
Woodada 4	1778	EXT	29°50’02"	115°08’39"	46	2 271	Lower Permian	1981	Hughes	Gas	Susp	Good	Nil
Woodada 5	2028	EXT	29°46’17"	115°08’28"	57	2 808	Lower Permian	1982	Hudbay	Gas	Susp	Excellent	Fair
Woodada 6	2091	EXT	29°48’38"	115°08’31"	45	2 708	Lower Permian	1982	Hudbay	Gas	Well	Producer	Nil
Woodada 8	2456	EXT	29°51’43"	115°08’48"	43	2 271	Lower Permian	1983	Strata	Gas	Well	Producer	Nil
Woodada 9	2535	DEV	29°52’58"	115°09’41"	46	2 350	Lower Permian	1984	Strata	Gas	P&A	Good	Nil
Woodada 10	2547	DEV	29°48’56"	115°07’50"	39	2 340	Lower Permian	1984	Strata	Gas	Well	Producer	Nil
Woodada 11	20076	DEV	29°49’42"	115°08’37"	44	2 191	Lower Permian	1991	Consolidated	Gas	Susp	Producer	Nil
Woodada 12	20090	EXT	29°50’06"	115°07’47"	38	2 300	Lower Permian	1991	Consolidated	Gas	Well	Producer	Poor
Woodada 14	20245	DEV	29°50’04"	115°08’27"	42	2 265	Lower Permian	1994	Consolidated	Gas	Susp	Poor	Nil
Woodada 15	20298	DEV	29°49’15"	115°08’57"	48	2 260	Lower Permian	1995	Consolidated	Gas	Susp	Excellent	Poor
Woodada 16	20561	DEV	29°50’52"	115°09’11"	45	2 314	Lower Permian	1999	Phoenix	Gas	Susp	Good	Nil
Woodada 17	20758	EXT	29°51’43"	115°08’48"	44	1 364	Lower Permian	2002	Hardman	Dry	P&A	Nil	Nil
Woodada 18	20758	EXT	29°51’43"	115°08’44"	44	2 024	Lower Permian	2002	Hardman	Dry	P&A	Fair	Poor
Woodada 19	20776	EXT	29°51’46"	115°08’22"	8	2 841	Lower Permian	2002	Hardman	Gas	Susp	Excellent	Fair
Woolmulla 1	49	NFW	30°01’28"	115°11’34"	120	2 812	Precambrian	1963	WAPET	Dry	P&A	Fair	Nil
Wye 1	20337	NFW	29°06’46"	114°59’28"	63	766	Lower Permian	1996	Discovery	Gas & oil	P&A	Excellent	Good
Yallallie 1	20029	NFW	30°20’36"	115°46’22"	222	3 321	Upper Jurassic	1990	Ampolex	Dry	P&A	Nil	Nil
Yardarino 1	154	NFW	29°13’19"	115°03’18"	47	2 377	Lower Permian	1964	WAPET	Gas & oil	Shut in	Producer	Excellent
Yardarino 2	163	EXT	29°12’15"	115°03’56"	92	3 075	Lower Permian	1964	WAPET	Dry	P&A	Poor	Poor
Yardarino 3	169	EXT	29°13’52"	115°03’18"	45	2 700	Lower Permian	1964	WAPET	Oil & gas	Susp	Good	Excellent
Yardarino 4	183	EXT	29°12’58"	115°02’58"	44	2 490	Lower Permian	1964	WAPET	Gas	P&A	Good	Poor
Yardarino 5	20716	DEV	29°13’11"	115°03’38"	66	2 560	Lower Permian	2001	Arc Energy	Gas	Susp	Excellent	Nil

NOTES: S no.:Geological Survey of Western Australia statutory petroleum exploration report number

Abrolhos: Abrolhos Oil Pty Ltd
Agnew Clough: Agnew Clough Ltd
Amax: Amax Exploration Australia Inc
Ampolex: Ampol Exploration Ltd
Aquitaine: Australian Aquitaine Petroleum Pty Ltd
Arc Energy: Arc Energy NL
Arrow: Arrow Petroleum Ltd
AWE: Australian Worldwide Exploration Petroleum Pty Ltd
Balmoral: Balmoral Resources NL
Barrack: Barrack Energy Ltd
Barrack House: Barrack House Group
BMR: Bureau of Mineral Resources
Boral: Boral Energy Resources Ltd
Command: Command Petroleum Holdings NL
Consolidated: Consolidated Gas Pty Ltd
Diamond: Diamond Shamrock Oil Company (Australia) Pty Ltd
Discovery: Discovery Petroleum NL
Doral: Doral Resources NL
Empire Empire Oil Company (WA) Ltd
French: French Petroleum Company (Australia) Pty Ltd
Hardman: Hardman Resources NL
Hudbay: Hudbay Oil (Australia) Ltd
Hughes: Hughes and Hughes Australia Pty Ltd
Jervois: Jervois Sulphates N.T. Ltd
Lassoc: Lassoc Pty Ltd
Mesa: Mesa Australia Ltd
Origin: Origin Energy Developments Pty Ltd
Pancontinental: Pancontinental Petroleum Pty Ltd
Phoenix: Phoenix Energy Pty Ltd
Premier: Premier Petroleum (Australia) Pty Ltd
Roc Oil: Roc Oil (WA) Pty Ltd
Royal: Royal Resources Exploration Inc
Sagasco: Sagasco Resources Ltd
Strata: Strata Oil NL
Victoria: Victoria International Petroleum NL
WAPET: West Australian Petroleum Pty Ltd
WMC: Western Mining Corporation Ltd
Xlx: Xlx NL
Abd: abandoned
P&A: plugged and abandoned
Susp: suspended
DEV: development
EXT: extension
NFW: new field wildcat
STR: stratigraphic

Appendix 5

Summaries of wells relevant to prospects and leads

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
Allanooka 1	1965	WAPET	Allanooka fault block. A combination of a structural trap and pinch-out	Bookara Sandstone Member and Lower Permian section	Minor oil shows in the Dongara Sandstone. The Bookara Sandstone Member was water-wet and flowed brackish water. The High Cliff Sandstone had good porosity and permeability	A stratigraphic well that penetrated the Nangetty Formation. The well failed because the objectives were flushed
Allanooka 2	1965	WAPET	Allanooka fault block. A combination of a structural trap and pinch-out	Bookara Sandstone Member and Lower Permian section	No hydrocarbons were detected. The objectives had low porosities and permeabilities, and were water-wet. The High Cliff Sandstone was tight	The well was dry due to lack of structure and the objectives were flushed. The objective is structurally higher than in Allanooka 1
Arramall 1	1989	Barrack	Anticline on the eastern downthrown side of the Beagle Fault	Dongara Sandstone. The secondary objective was the Jurassic Cattamarra Coal Measures	The well penetrated a thin section of Irwin River Coal Measures just above basement. Minor oil and gas shows were recorded	The well did not test a valid trap or penetrate the Permian objective as it was faulted out by the Beagle Fault
Arrowsmith 1	1965	French	Elongate, seismically defined structural closure sealed by the Beagle Fault	Permian objectives	The 5 m of Carynginia Formation penetrated proved to be a good reservoir (porosities up to 24%). A DST over this interval (2816–2821 m) flowed gas at 113 km^3/day (4 MMcf/day). In a production test the flow rate and pressure rapidly declined. Minor shows and oil fluorescence were recorded in the Irwin River Coal Measures and High Cliff Sandstone	The well did not test a valid trap and was drilled 200 m downdip from the original structure. Based on the production test, the reservoir appears to be of limited extent. An unconformity is present between the Lower Triassic and Lower Permian units. The Upper Permian units were probably not deposited or were removed by erosion
Barberton 1	1990	Ampolex	Faulted anticlinal closure controlled by a series of en echelon, northeasterly trending faults	Basal sands of the Kockatea Shale	The well failed to reach its objective as the Upper Triassic Lesueur Sandstone was unexpectedly thick (probably over 3000 m). No hydrocarbon shows were detected and the reservoirs penetrated were water-wet	The well did not reach its objective
Beharra 1	1966	French	Northern part of the Beharra structure on a faulted anticline,west of the Beagle Fault	Dongara Sandstone	The well failed to reach the objective due to the displacement of the Permian–Triassic section by the Beagle Fault. No hydrocarbon shows were detected, but good quality reservoir was intersected in the High Cliff Sandstone	The well did not reach its objective

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
Beharra 2	1967	French	Southern part of the Beharra structure on an anticline to the west of the Beagle Fault	Dongara Sandstone	The well did not intersect the objective; however, good quality, but water-wet reservoir was intersected in the High Cliff Sandstone and Irwin River Coal Measures. No hydrocarbon shows were noted	The objective was absent due to a stratigraphic pinch-out between this locality and the Dongara and Yardarino oil- and gasfields
Beharra Springs 1	1990	Arrow	Northerly trending tilted anticline between the Beharra Springs and Mountain Bridge Faults	Beekeeper Formation	A 20 m gross hydrocarbon column, comprising 12.5 m of net gas pay, was intersected in the Beekeeper Formation. A production test (3298–3303 m) flowed gas at 241 km^3/day (8.5 MMcf/day). Minor hydrocarbon shows were recorded in the Woodada Formation and Kockatea Shale	The well was brought into production in January 1991
Beharra Springs 2	1991	Arrow	Northerly trending tilted anticline between the Beharra Springs and Mountain Bridge Faults	Dongara Sandstone	The well penetrated a separate pool south of Beharra Springs 1 with 5 m of net pay within the Dongara Sandstone. A production test (3354.9 – 3363.5 m) flowed 660 km^3/day (23 MMcf/day). Good oil shows were recorded in the Woodada Formation and minor gas shows in the Kockatea Shale	The well tested the southern extent of the Beharra Springs gasfield and was brought into production in March 1992
Beharra Springs 3	1992	Arrow	Northerly trending tilted anticline between the Beharra Springs and Mountain Bridge Faults	Caryngingia Formation	The well intersected 7.9 m of good-quality gas pay and 3 m of moderate-quality gas pay in the Caryngingia Formation. A production test recorded 589 km^3/day (20.8 MMcf/day)	The well tested the northern extent of the Beharra Springs gasfield. Beharra Springs 3 is within the same pool as Beharra Springs 1
Bootine 1	1981	Mesa	Fault block within the Gingin–Bullsbrook trend	Cattamarra Coal Measures	Strong gas shows were noted in the Cattamarra Coal Measures and flowed 63.7 km^3/day (2.25 MMcf/day) from a 6 m-thick interval. About 39.75 L (0.25 bbl) of 38.7° API oil were recovered from a 4.5 m-thick sandstone. Hydrocarbons were noted in the Cadda Formation. Porosities range between 15% in the Yarragadee Formation, 13% in the Cadda Formation, and 10% in the Cattamarra Coal Measures	Bootine 1 was drilled at, or near spill point. The well did not test a valid trap probably due to the intense faulting within the area
Bullsbrook 1	1972	WAPET	Southern culmination of the elongate, northerly trending Gingin–Bullsbrook	Cattamarra Coal Measures	No significant hydrocarbon shows were noted during drilling. Four discrete, thin sandstone intervals with gas saturations greater than	Recent mapping shows the well did not test a valid trap. Bullsbrook 1 may not have been properly charged as the

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
			trend; a large anticlinal structure		43% between 4050 m and total depth, totalling 12 m, were noted in the Cattamarra Coal Measures. Porosities range from 10 to 12%	geothermal gradient is lower than in the surrounding wells, suggesting that the source rocks in this well may not be mature
Cataby 1	1994	Discovery	Jurassic faulted anticline	Cattamarra Coal Measures and Eneabba Formation	803.5 m of gross seal was penetrated in the Cadda Formation. Below this the well intersected a thin sandstone within the Cattamarra Coal Measures (1689.5 – 1697.5 m), which gave oil fluorescence in the cuttings and oil traces in the drilling mud. A DST yielded 1113 L (7 bbl) of 38° API oil at 4–5 kL/day (25–30 bbl/day) with rapid depletion. Minor gas was recorded	The structure is similar to, and updip from, the Walyering accumulation. The Cadda Formation has numerous interbedded sandstone beds reducing its effectiveness as a lateral seal
Conder 1	1988	Doral	Four-way dip closure caused by rollover on a southeastern down-thrown block of a large easterly trending fault	Primary objectives were the Dongara Sandstone and base of the Kockatea Shale. Secondary objectives were the Cattamarra Coal Measures	Oil scum was recovered and fluorescence was noted at the base of the Kockatea Shale and throughout the Bookara Sandstone Member. Geochemical analysis indicates the oil may be biodegraded	Recent mapping suggests that the well did not test a valid structure
Connolly 1	1988	Doral	Fault-bound trap	Base of the Kockatea Shale. The secondary objective was the Cattamarra Coal Measures	40 m of Bookara Sandstone Member directly overlies basement. Fluorescence was noted in the Cattamarra Coal Measures and Kockatea Shale. An analysis of the oil in the cuttings indicates it is similar to that in the Dongara oil- and gasfield	The well did not test a valid trap. The Kockatea Shale is immature in this well and probably similarly immature north of the Bookara Fault, suggesting the oil was generated within the Dandaragan Trough to the south
Cypress Hill 1	1988	Ampolex	Upthrown side of a fault-bound, three-way dip closure	Upper Yarragadee Formation	No significant hydrocarbons were intersected. Potential reservoir rocks were present in the Carnac Formation of the Parmelia Group	The well was not drilled within structural closure, but it did intersect reservoir quality sandstone and sealing shale. Cypress Hill 1 is not relevant to the nearby Dandaragan Deep prospect as it did not penetrate the lower Yarragadee Formation
Dandaragan 1	1995	Discovery	Semi-symmetrical anticline at top Otorowiri Formation level	Yarragadee Formation	The well recovered heavily biodegraded, 10.3° API oil in thin basal sandstones of the Otorowiri Formation, as well as oil shows over a 13 m-thick interval at the top of the Yarragadee Formation just prior to mechanical problems at 949 m. Logs	The well did not penetrate the lower Yarragadee Formation, but provides evidence of hydrocarbon generation and migration into the area, and the ability of the Otorowiri Formation to seal

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
					indicate a 14 m oil column in the Yarragadee Formation sealed by the Otorowiri Formation. Minor strongly biodegraded 100° API oil was recovered on test	
Depot Hill 1	1983	Mesa	Elongate, low-relief structure on the upthrown side of the Wicherina Fault. The structure has four-way dip closure on the crest	Upper Permian reservoir. The secondary objective was the Lower Permian High Cliff Sandstone within a fault-bound structure	The well was water-wet at both objectives. Reservoir intervals within the Dongara Sandstone, High Cliff Sandstone, and Nangetty Formation have good porosity and permeability	The well failed because no seal was present across the fault. Geochemical analysis show the source rock in Depot Hill 1 is gas prone, and within the oil window
Dongara 7	1968	WAPET	Faulted anticline	Dongara Sandstone	Water-saturated Dongara Sandstone was intersected below the hydrocarbon–water contact. The well penetrated a thicker Lower Jurassic, Lower Triassic, and Upper Permian stratigraphic section than anticipated. A DST (2103–2108 m) recovered 10.2 kL (64.1 bbl) of formation water and 2.6 kL (16.45 bbl) of water cushion	The well tested the southern extent of the Dongara oil- and gasfield. The objective was 37.5 m thick and 403 m lower than predicted, probably due to regional thickening south and southeast of the Dongara oil- and gasfield
Dongara 17	1969	WAPET	Faulted anticline	Dongara Sandstone	The well penetrated a 28 m gross hydrocarbon column consisting of 13 m of net oil pay in the Dongara Sandstone. Porosities of 18 and 28% were recorded from the log and core	The well was brought into production in September 1975 and suspended in August 1983
Dongara 18	1970	WAPET	Faulted anticline	Dongara Sandstone	The well penetrated a 34 m gross and net gas column in the Dongara Sandstone. Porosities of 18 and 29% were recorded from the log and core respectively	The well was brought into production in October 1971
Dongara 19	1970	WAPET	Faulted anticline	Dongara Sandstone	The well penetrated a 55 m gross hydrocarbon column consisting of 19 m of net oil pay. Porosities of 17 and 22.1% were recorded from the log and core respectively	The well was brought into production in March 1980 and suspended in February 1985
Dongara 26	1990	WAPET	Faulted anticline	Dongara Sandstone	The primary objective was absent and the base of the Triassic was 30.5 m lower than expected	The well demonstrates the western limit of the Dongara Sandstone. No productive zones were encountered

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
East Heaton 1	1985	WMC	Fault-bound, four-way dip closure east of the Heaton Fault	All known reservoirs from the Kockatea Shale down to the Irwin River Coal Measures	No significant gas or oil shows were recorded. All the reservoirs were water-wet, but all have good porosity and permeability	The section was mostly immature, implying that the trap was not on a migration pathway
Eganu 1	1963	WAPET	Fault trap defined by a gravity high	Permian and Lower Triassic units	The well was terminated at 600 m in the Cattamarra Coal Measures without any hydrocarbon shows	The absence of Permian rocks is attributed to a fault pinch-out due to Jurassic movement on the Darling Fault
Ejarno 1	1981	WAPET	Faulted anticline	Dongara Sandstone	The well intersected the Dongara Sandstone at 2727.5 m, where a substantial increase in gas readings was detected. The gas column is about 60 m thick. The Carynginia Formation was tested, but no flow was recorded	Water saturation calculations suggest that only the top 12 m of the Dongara Sandstone are relatively permeable and could be regarded as pay. Seismic interpretation shows that there is a substantial updip component to Ejarno 1
Erregulla 1	1966	WAPET	Tilted fault block within a broad anticline	Dongara Sandstone. Secondary objectives were the Eneabba Formation and other Permian units	A swab test over a perforated interval in the Eneabba Formation (3174–3181 m) recovered 3.6 kL (22.5 bbl) of 47° API crude oil. Further attempts to stimulate the well yielded a further 5.7 kL (36 bbl) of light-green oil. Several good reservoir/seal pairs were penetrated in the Cadda,Yarragadee, and Eneabba Formations (porosities 8–34%)	The structure is sub-economic and limited recovery is likely due to formation damage. The oil recovered is likely to be residual, locally trapped in a limited fault trap
Erregulla 2	1980	Mesa	Tilted fault block within a broad anticline	Re-evaluate the Erregulla structure and reassess potential reservoirs that may have been damaged during drilling and formation testing of the first well	There were no significant hydrocarbons, but shows were reported in the Cattamarra Coal Measures, Lesueur Sandstone, and Woodada Formation. All sands were water-wet	Undetected faulting and rapid changes in lithology are thought to have allowed breaching of the trap. The well was probably drilled outside the crest of the anticline
Gingin 1	1965	WAPET	Elongate, northerly trending anticline in the Gingin–Bullsbrook trend	Cattamarra Coal Measures	A 300 m gross hydrocarbon interval was intersected in the Cattamarra Coal Measures. Six DSTs over this interval yielded 63–109 km^3/day (2.25 – 3.85 MMcf/day) of gas. The sandstones were tight (average porosity 8%, low permeability). Some 46° API condensate was noted. The well has produced 48.7 MMm^3 (1.72 Bcf) gas from 1972 –76	The well did not test a valid trap as intense faulting has breached any closure that may have been present. The hydrocarbon accumulation is probably controlled by permeability barriers
Gingin 2	1965	WAPET	Elongate, northerly trending anticline in the Gingin–Bullsbrook trend	Cattamarra Coal Measures	The well intersected a gas column that initially flowed at 111 km^3/day (3.92 MMcf/day), but then declined rapidly	Gingin 2 proved the presence of gas-saturated sandstone in the southern part of the structure. However, on test it flowed at non-commercial rates

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
Gingin 3	1998	Empire	Elongate, northerly trending anticline in the Gingin–Bullsbrook trend	Cattamarra Coal Measures	The objective was 90–130 m updip, and water-wet. A DST (4025 – 4031.5 m) flowed water at 159 kL/day (1000 bbl/day), showing that the deeper sandstones have good permeability	Gingin 3 was drilled on a separate upthrown fault block to Gingin 1 and 2. Although the results were disappointing, flow rates from the reservoir sandstones indicate good permeability
Heaton 1	1972	Abrolhos	Four-way dip closure at the base of the Kockatea Shale	Dongara Sandstone	Good quality, but water-wet reservoir beds were intersected in the Dongara Sandstone	The well did not test a valid trap. The hydrocarbons probably migrated prior to completion of the structure
Horner West 1	1987	Barrack	Rollover anticline on the down-thrown side of the Mountain Bridge Fault	Cattamarra Coal Measures and Dongara Sandstone. Secondary objectives were the Woodada Formation and lower part of the Kockatea Shale	No significant hydrocarbons were noted, but there were minor gas shows in the Yarragadee and Cadda Formations, Cattamarra Coal Measures, and Lower Permian section. A DST (1289–1314 m) over the Holmwood Shale recovered 4.2 kL (26.7 bbl) of fresh water	This well did not test a valid trap as the Dongara Sandstone is deeply downthrown east of the Mountain Bridge Fault and does not form a significant pinch-out play against the fault
Jay 1	1993	Victoria	Fault independent closure on the downthrown side of the Mount Horner Fault	Cattamarra Coal Measures	Two DSTs within the Cattamarra Coal Measures each recovered formation water with a thin film of oil emulsion	Some of the oil shows were interpreted to be degraded residues left after water washing removed light-end volatiles
Leander Reef 1	1983	Diamond	Faulted anticline offshore, interpreted to rollover into a down-to-the-west fault	Upper Permian sandstones	Oil shows were noted in the Cattamarra Coal Measures, Eneabba Formation, and Lower Permian rocks. A DST (1415 m) in the Eneabba Formation recovered a strong gas blow, which decreased to zero after 147 minutes, and formation water. Source-rock analysis shows that the Kockatea Shale is a mature oil source and the Cattamarra Coal Measures are immature	The trap probably failed because of poor cross-fault seals due to the combination of severe faulting, thin shales, high sandstone/shale ratios, and the absence of the Upper Permian regional reservoir
Lockyer 1	1998	Premier	Updip edge of a titled fault block on the upthrown side of the North Erregulla Fault	Dongara Sandstone. Secondary objective was the Arranoo Member	The well intersected a 34 m oil column in tight sandstones of the Dongara Sandstone and had oil shows in the Woodada Formation. Gas shows were noted in the Dongara Sandstone	The closure was not filled to spill point, either due to cross-fault leakage or lack of adequate source generation and migration
Mondarra 1	1968	WAPET	Tilted fault block	Dongara Sandstone	A 16 m gross hydrocarbon column was intersected in the Dongara Sandstone with 11.1 m of net pay. A production test (2689 –2700.6 m) flowed 283 km^3/day (10 MMcf/day). Traces of oil and gas were	Production commenced in 1972 and ceased in 1994

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
					recorded in the Eneabba Formation, and there were gas shows in the Woodada Formation, Kockatea Shale, and Caryngina Formation	
Mondarra 2	1969	WAPET	Tilted fault block	Dongara Sandstone	A 2 m gross and net hydrocarbon gas column was intersected in a tight section of Dongara Sandstone, downdip and within a separate closure to Mondarra 1. A production test flowed 85 km^3/day (3 MMcf/day)	Production commenced in 1972 and ceased in 1994
Mondarra 3	1969	WAPET	Tilted fault block	Dongara Sandstone	A 4 m gross and net hydrocarbon column was intersected in a tight section of Dongara Sandstone downdip from Mondarra 1. A DST yielded 350 L (2.2 bbl) of formation fluid comprising water and 36° API oil	Recent mapping suggests that this well did not test a valid structure
Mondarra 4	1969	WAPET	Tilted fault block	Dongara Sandstone	Dongara Sandstone was intersected downdip from Mondarra 1. Oil shows were noted in tight, cemented sandstone at the base of the Kockatea Shale, but there was no flow from a DST	Mondarra 4 was drilled outside of the closure as currently mapped and therefore did not test a valid trap
Mountain Bridge 1	1993	Sagasco	Downthrown fault trap bound by the Beagle – Mountain Bridge Faults	High Cliff Sandstone. Secondary objectives were the Dongara Sandstone, Beekeeper Formation, Caryngina Formation, Irwin River Coal Measures, and Holmwood Shale	Gas was intersected in a tight reservoir. A DST (3185–3235 m) from the Caryngina Formation flowed gas at 7079 m^3/day (0.25 MMcf/day) and 318 kL (2000 bbl) of water. Intergranular porosity in the High Cliff Sandstone was very poor (1–8%), but overall the Permian sandstones maintained fair reservoir potential. Oil and gas shows were recorded in the Kockatea Shale, Dongara Sandstone, Beekeeper Formation, Irwin River Coal Measures, and High Cliff Sandstone	At Permian level the trap did not seal, and a fault cut out the western limb of the anticline. The presence of hydrocarbons confirms the viability of source rock in the area, but the accumulation was considered sub-economic
Mount Adams 1	1966	WAPET	Anticline defined by seismic data	Dongara Sandstone	The well intersected Dongara Sandstone as expected, with interbedded carbonate here assigned to the Beekeeper Formation. Minor hydrocarbons were recorded in the Kockatea Shale, Dongara Sandstone, Beekeeper Formation, and Caryngina Formation	At the time, it was extrapolated that the Dongara Sandstone would pinch-out in this area. The well was intended to test the production potential of such a pinch-out. Recent mapping suggests that the well was not drilled on a closed structure

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
Mount Hill 1	1964	WAPET	This well was drilled to obtain stratigraphic information and identify 2 prominent seismic horizons	Cattamarra Coal Measures and basal part of the Kockatea Shale	The well reached a total depth of 565.4 m in the Bookara Sandstone Member. No significant hydrocarbon shows were noted during drilling, although minor gas was detected in the Kockatea Shale	Recent interpretation shows that the well was not drilled on a valid trap
Mullering 1	1992	Arrow	Jurassic anticlinal structure that was similar to, and updip from, the Walyering accumulation	Cattamarra Coal Measures	Several high-porosity (18–25%) reservoir sandstones within the Cattamarra Coal Measures are present, but no significant hydrocarbons were noted, although traces of gas were recorded in this unit	A rollover against the Lesueur Fault was present. Mullering 1 did not fully test the deeper part of the objective due to drilling problems. The shallower section appears to be flushed by fresh water and an effective seal is absent
Mungenooka 1	1998	Boral	Faulted anticline at Dongara Sandstone level	Dongara Sandstone	The reservoir was gas saturated, but porosities averaged less than 2% over the entire interval	The well was initially suspended in July 1998 to evaluate its commercial potential, but geological studies indicate it is minimal
Murrumbah 1	1998	Premier	Faulted anticline on the up-thrown side of the Allanooka Fault	Dongara Sandstone	Good reservoir was intersected within the Dongara Sandstone, although no hydrocarbon shows were noted, and water saturation was above 80%. Porosity ranges from 10 to 21%	The absence of hydrocarbons is possibly due to the complex geometry of faults in the area directing migrating hydrocarbons from the southern source pod to the west, away from the structure
North Erregulla 1	1967	WAPET	Tilted fault block	Cattamarra Coal Measures. The secondary objective was the uppermost Permian sandstones	No hydrocarbon-bearing sandstones were intersected in the Lower Jurassic section, but 90 L of 38° API oil was recovered from tight sandstones near the top of the Kockatea Shale and 36 L of 38° API oil from the Dongara Sandstone. Moderate gas shows and fluorescence were noted below the Cadda Formation to total depth	There was no structural trap present. The small amount of oil was probably trapped in a permeability trap
North Yardanogo 1	1990	Barrack	Jurassic rollover anticline on the downthrown side of the Mountain Bridge Fault	Cattamarra Coal Measures	The sandy intervals were water-wet, except for a 1 m-thick, oil-bearing sandstone within the Cattamarra Coal Measures, which flowed 191 kL (1200 bbl/day) from a DST. A production test yielded a total of 306 kL (1925 bbl) of 34° API oil with a high pour-point, but increasing water-cut	A valid trap was not supported by the well results. The oil was probably present in a very small stratigraphic or fault trap, or in a high permeability sandstone interval within a poorer quality reservoir rock
Ocean Hill 1	1991	Arrow	Faulted anticline in the Coomallo Trough	Cadda Formation	Several gas-bearing reservoirs were inter-sected in the Cadda Formation and	This well suggests that there may be effec-tive intra-Yarragadee Formation seals. The

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
					Cattamarra Coal Measures. A DST (3063–3130 m) in the Cadda Formation flowed gas at 19.8 km^3/day (0.7 MMcf/day) for 104 minutes. DSTs over the Cattamarra, Coal Measures showed it is tight, and 822 m^3/day (0.03 MMcf/day) was recovered. The better quality reservoirs were water-wet. Some oil shows were noted in the Yarragadee Formation	structure at Cattamarra Coal Measures level may have failed because it is highly faulted and lacks lateral cross-fault seals. The poor results may be due to low permeability, as porosity and gas saturation were adequate
Robb 1	1985	Strata	Anticline in the northernmost part of the Beagle Ridge, near the Abrolhos Transfer Fault	Carynginia Formation and Irwin River Coal Measures. Secondary objectives were the Cattamarra Coal Measures, Woodada Formation, and Kockatea Shale	A DST (1749–1767 m) in Irwin River Coal Measures recovered minor gas-cut mud. A DST (1446–1464 m) in the Carynginia Formation tested a gas and fluorescence show. About 1.7 kL (11 bbl) of mud was recovered	The well did not test a valid trap
Rosslyn 1	1996	Victoria	Four-way, dip-closed anticlinal structure at Yarragadee Formation level	Yarragadee Formation. The secondary objective was the Cattamarra Coal Measures	Traces of fluorescence and oil staining were noted within the Cattamarra Coal Measures. Good potential reservoirs are present	The well failed because there was no closure. The structure at Cattamarra Coal Measures is questionable
South Yardanogo 1	1990	Arrow	Jurassic rollover anticline on the downthrown side of the Mountain Bridge Fault	Cattamarra Coal Measures. The secondary objectives were the Eneabba and Lesueur Formations	No significant hydrocarbons were detected and all the sandy intervals proved to be water-wet	The well did not test a valid trap, as either the anticlinal closure was not present at the depth of the objective, or the anticline was breeched by a crestal fault and the hydrocarbons migrated upwards
Walyering 1	1971	WAPET	Northerly trending, faulted anticline in the Coomallo Trough	Cattamarra Coal Measures	Two gas-bearing zones were intersected in the Cattamarra Coal Measures (porosities 4.4 –14.8%, permeabilities up to 93 mD, av. 1 mD). A DST (3367 m) flowed 382 km^3/day (13.5 MMcf/day), and the first production test flowed 300 km^3 (10.6 MMcf), but decreased to 2.5 – 8.1 MMcf. Minor 44.9° API condensate was noted	The well probably failed because of poor fault seals on the crest and flanks of the structure. The gas may have been trapped by a permeability barrier. The pressure buildup data indicate a complex permeability system and formation damage
Walyering 2	1971	WAPET	Northerly trending, faulted anticline in the Coomallo Trough	Cattamarra Coal Measures	Gas-bearing zones in the Cattamarra Coal Measures flowed at non-commercial rates of about 70.8 km^3/day (2.5 MMcf/day). There were abnormally high pressures below 3900 m with high gas readings and condensate in the mud	Recent mapping suggests that this well did not test a valid trap. There was significant formation damage during drilling, which inhibited gas flow

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
Walyering 3	1972	WAPET	Northerly trending, faulted anticline in the Coomallo Trough	Cattamarra Coal Measures	The zones of interest were water-wet. Weak flows between 17 km^3/day (0.6 MMcf/day) and 5000 m^3/day (0.2 MMcf/day) were recorded from deeper, overpressured zones	Recent mapping suggests that this well did not test a valid trap. Subsequent analysis suggests that high mud weights caused formation damage
Warramia 1	1992	Ampolex	Broad, north-northwesterly trending anticline on the eastern flank of the central part of the Dandaragan Trough	Yarragadee Formation below the Otorowiri Formation	The well was terminated at 1498 m in the Yarragadee Formation. The reservoir was water-wet. Minor gas shows and fluorescence were intersected below the objective to total depth. A DST (836–883 m) flowed 600 m of formation water over 32.73 minutes	The well did not test a valid trap
Warro 1	1977	WAPET	Broad, north-northwesterly trending anticline on the eastern flank of the central part of the Dandaragan Trough	Yarragadee Formation	No gas flows were established from the 178.5 m of possible gas pay. Abnormal pressures were recorded below 4300 m in the Cadda Formation. Low porosity (5–10%) and permeability (<0.1 – 1 mD) were evaluated over the possible pay zone	Formation damage hampered flow by destroying permeability. The Warro structure was probably tested 200 m down-dip from the crest at Yarragadee Formation level, or faults have destroyed the lateral seals
Warro 2	1978	WAPET	Broad, north-northwesterly trending anticline on the eastern flank of the central part of the Dandaragan Trough	Yarragadee Formation	300 m of net hydrocarbon column within a 393 m-thick section of Yarragadee Formation were intersected. Only subcommercial flows were noted (2832 m^3/day, 2266 m^3/day). The sandstones have an average porosity of 9–10% with low permeabilities	The Warro structure was not remapped after Warro 1, therefore Warro 2 probably failed for the same reasons as Warro 1
Wayvanerry 1	1998	Premier	Rollover anticline north of the Allanooka Fault	Cattamarra Coal Measures. The secondary objective was the Dongara Sandstone	The primary objective was intersected at the crest of the anticline and was water-wet. The Dongara Sandstone contained a 3 m hydrocarbon column that was tight and non-productive	The well was drilled on a valid trap, so the lack of hydrocarbon shows implies that this prospect is in a migration shadow associated with the Allanooka Fault
West Erregulla 1	1990	Arrow	Anticlinal feature west of the Erregulla accumulation	Dongara Sandstone	A DST (3944 – 3975.5 m) in the Dongara Sandstone flowed 510 m^3/day (0.02 MMcf/day)	The well failed because of poor production within a tight reservoir
West White Point 1	1971	WAPET	Upthrown side of the Mountain Bridge Fault on a positive gravity feature poorly defined by seismic data	Dongara Sandstone	The reservoir had an average porosity of 16.6%, but no significant shows. Core permeability was 2 mD. Minor gas shows were recorded in the Kockatea Shale and Dongara Sandstone	The gas was probably due to hydrocarbons dissolved in formation water or in a localized gas pocket in the Kockatea Shale
West White Point 2	1971	WAPET	Faulted anticline on the up-thrown side of the Mountain Bridge Fault	Dongara Sandstone	The Dongara Sandstone was tight and water-wet. There were no hydrocarbon shows	The well failed due to the lack of trap geometry. However, it did demonstrate the southward thickening of the Triassic units

Appendix 5 (continued)

Well name	*Year drilled*	*Company*	*Structure drilled*	*Stratigraphic objective*	*Results*	*Comments*
Woodada 1	1980	Hughes	The Woodada structure is a northerly plunging anticline cut by numerous northerly trending faults	Beekeeper Formation	Gas was intersected within the upper Beekeeper Formation. The sandstone reservoir beds interfinger with fractured limestone. A DST yielded 945.8 km^3/day (33.4 MMcf/day)	The reservoir is sealed and sourced by the Kockatea Shale. Production commenced in May 1982
Wye 1	1996	Discovery	Anticlinal structure with multiple objectives	The primary objectives were the Dongara Sandstone and Cattamarra Coal Measures. The secondary objective was the High Cliff Sandstone	Oil and gas shows were recorded between 375 and 693 m. Three zones of interest were delineated: 4 m bearing gas in the Bookara Sandstone Member, 20 m containing gas in the Arranoo Member, and three 1 m-thick oil sandstones in the Cattamarra Coal Measures. The Bookara Sandstone Member produced gas at a maximum rate of 124.6 km^3/day (4.4 MMcf/day). Subsequent testing showed rapid pressure depletion indicating a small gas accumulation of 7.1 – 8.5 MMm^3 (250–300 MMcf) in place. The Arranoo Member flowed gas at up to 48.1 km^3/day (1.7 MMcf/day). The Cattamarra Coal Measures yielded a film of oil on test	The gas accumulation was too small to be commercial
Yallallie 1	1990	Ampolex	Anticline under an impact crater	Yarragadee Formation	The well intersected intra-Yarragadee Formation reservoir–seal pairs, but no significant hydrocarbon shows	Dentith et al. (1999) discounted the anti-cline as a pull-up feature after a study of the velocities

NOTES:

Abrolhos:	Abrolhos Oil Pty Ltd
Ampolex:	Ampol Exploration Ltd
Arrow:	Arrow Petroleum Ltd
Barrack:	Barrack Energy Ltd
Boral:	Boral Energy Resources Ltd
Diamond:	Diamond Shamrock Oil Company (Australia) Pty Ltd
Discovery:	Discovery Petroleum NL
Doral:	Doral Resources NL
Empire	Empire Oil Company (WA) Ltd
French:	French Petroleum Company (Australia) Pty Ltd
Hughes:	Hughes and Hughes Australia Pty Ltd
Mesa:	Mesa Australia Ltd
Premier:	Premier Petroleum (Australia) Pty Ltd
Sagasco:	Sagasco Resources Ltd
Strata:	Strata Oil NL
Victoria:	Victoria International Petroleum NL
WAPET:	West Australian Petroleum Pty Ltd
WMC:	Western Mining Corporation Ltd