EMERGING CONTINUOUS GAS PLAYS IN THE COOPER BASIN, SOUTH AUSTRALIA

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DMITRE

APPEA 2012 Conference and Exhibition
OUTLINE

• Cooper Basin Overview
• Exploration for Unconventional Gas
• Shale Gas
• Tight Gas (Basin-centred gas)
• Coal Seam Gas
• Resource Estimates
• 2012 Drilling Activity
COOPER BASIN OVERVIEW

(a) Datum V horizon (Top Patchawarra)
(b) Datum P horizon (Near Top Permian)
(c) Datum C horizon (Top Cadna-owie)
COOPER BASIN OVERVIEW

Palaeogeographic reconstruction of the Australian Plate, Late Carboniferous to Early Permian (after Vevers, 1984 and Baillie et al., 1994).

Geological summary of the Cooper Basin.

Maximum Thickness 450m
Average Thickness 180m

Shale Gas  Tight Gas  CSG

Government of South Australia
Department for Manufacturing, Innovation, Trade, Resources and Energy
EXPLORATION FOR UNCONVENTIONAL GAS

- 1998: Cooper Basin JV - 4m Patchawarra coal seam cored for desorption analysis (Dorodillo 2 gas appraisal well).

- 2006: Cooper Basin JV - 9.4m Roseneath Shale core (Moomba 175 gas development well).

- 2007: Cooper Basin JV – 100,000 scf/day from a fracced Patchawarra Formation coal (Moomba 77 gas development well).

- 2010: Strike Energy drilled the first dedicated CSG well in the Cooper Basin – Forge 1

- 2010: Beach Energy drilled the first dedicated shale gas well – Encounter 1

Moomba 77 – Patchawarra Formation

Moomba 77 – Coal Frac, 100,000 scf/d, 9000 ft

10m coal seam at ~2900m ~900 units Total Gas

SHALE GAS

Moomba 73

Rassibility

Formaon Togas

Roseneath Shale
Epsilon Formation
Murereee Shale

50 m

Datum GDA 94 - Projection MGA Zone 54

Government of South Australia
Department for Manufacturing, Innovation, Trade, Resources and Energy
SHALE GAS

Adsorption isotherm for Roseneath Shale core sample, Moomba 175

~ 24 scf/t at 3800 psi, T = 167.8°C
TIGHT GAS

High resistivities in the Permian succession of the Nappamerri Trough suggest gas saturation (from Hillis et al, 2001)
TIGHT GAS

WIMMA 1 (from WCR)
• High mud gas readings in Permian sandstones
• Log interpretation indicates tight section, with low Sw (30-40%)
• Small gas flows from Permian sands on DST
• DST pressure charts indicate LOW PERMEABILITIES but HIGH FORMATION PRESSURES
Regional east-west cross section through the northern Piceance Basin depicting the regional distribution of gas and water within the Mesaverde (from Yurewicz et al, 2008. AAPG © 2008. Reprinted by permission of the AAPG whose permission is required for further use).
TIGHT GAS

Figure from Strong et al, 2002
TIGHT GAS

Patchawarra Formation
Tmax vs HI cross plot

Base Patchawarra Formation maturity

- Andree 2 (8)
- Gidgealpa 1 (3)
- Kurunda 1 (11)
- Murere 2' (20)
- Pondinie 2 (17)
- Snake Hole 1 (20)
- Sturt 3 (1), Sturt 4 (1), Sturt 6 (1), Sturt East 4 (1)
- Tibouchina 1 (3)
- Tirrawarra West 1 (22)
- Baratta 1 (4), Callabonna 1 (3), Cuttapinne 1 (5), Dirkala 1 (1), Fly Lake 3 (1), Gidgealpa 17 (1), Kanowana 1 (2), Kerinna 1 (8), Kobari 1 (6), Lake MacMillan 1 (3), Leelptan 1 (10), Maniku 1 (4), Munkari 4 (7), Nulla 1 (7), Papyrus 1 (7), Spectre 1 (14), Tindilie 2 (10), Tinga Tingana 1 (30), Tirrawarra 2 (2), Tirrawarra 16 (1), Tirrawarra North 1 (12), Toolachee East 2 (21), Toonman 1 (1), Wanocooca 1 (7)
TIGHT GAS

Oil expulsion versus time, Cooper Basin (PGSA Volume 4: Cooper Basin – Figure 9.32)

Gas expulsion versus time, Cooper Basin (PGSA Volume 4: Cooper Basin – Figure 9.33)
TIGHT GAS

Nappamerri Group

Regional Seal

Roseneath Shale

Regional Seal

Murteree Shale

Regional Seal
TIGHT GAS

Merrimelia Ridge  Nappamerri Trough  Della - Nappacoongee Ridge

N H Horizon  P H Horizon  Vc H Horizon  Z H Horizon

Nappamerri Group  Permian  Basement

20km
# Coal Seam Gas

<table>
<thead>
<tr>
<th>AGE</th>
<th>SERIES</th>
<th>STAGE</th>
<th>PALAEONTOLOGICAL ZONE</th>
<th>ROCK UNIT</th>
<th>DEPOSITIONAL ENVIRONMENT</th>
<th>LITHOLOGY</th>
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<tbody>
<tr>
<td>TRIASSIC</td>
<td>Late</td>
<td>Nantlian</td>
<td>Shielandian</td>
<td>Cuddapan Formation</td>
<td>Reworked, reworked</td>
<td>Shale, sandstone</td>
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<tr>
<td></td>
<td>Middle</td>
<td>Latobian</td>
<td>Aviean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Early</td>
<td>Southian</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>JURASSIC</td>
<td>Late</td>
<td>Tatelian</td>
<td>Karrianian</td>
<td>Daralingie Formation</td>
<td>Meandering fluvial</td>
<td>Fluvio-deltaic, lacustrine</td>
</tr>
<tr>
<td></td>
<td>Early</td>
<td>Artinskian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PERMIAN</td>
<td>Early</td>
<td>Silurian</td>
<td></td>
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<tr>
<td></td>
<td>Late</td>
<td>Stephanian</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CARBONIFEROUS</td>
<td>Late</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**WARBURTON BASIN**

- Maximum thickness: 420 m
- Average thickness: 55 m

**EROMANGA BASIN**

- Lake Eyre Basin

**GOOGLE GROUP**

- Daralingie Formation
- Epsilon Formation
- Murteree Shale
- Patchawarra Formation

**COOPER BASIN**

- Toolachee Formation
- Murteree Shale
- Patchawarra Formation

**CSG**

- Meandering fluvial, deltaic in part
- Daralingie unconformity
- Fluvio-deltaic
- Lacustrine
- Stratigraphic, lacustrine
- Proglacial outwash, braided fluvial
- Peatswamp, Vc coal
- Proglacial outwash, braided fluvial

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*Image credit: Government of South Australia, Department for Manufacturing, Innovation, Trade, Resources and Energy.*
Wireline log correlation for the Patchawarra Formation highlighting the lateral continuity of the VC50 coal seam over 8 km at this location (sonic >115 microseconds/ft shaded black to highlight coals)
COAL SEAM GAS
Patchawarra Formation – coal isopach

Ro = 0.95%

Base Patchawarra Formation maturity
# Coal Seam Gas

<table>
<thead>
<tr>
<th>Well name</th>
<th>VC50 seam thickness (m)</th>
<th>Total gas (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bindah–3</td>
<td>19</td>
<td>80–500</td>
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<tr>
<td>Meranji South–1</td>
<td>16</td>
<td>1,000</td>
</tr>
<tr>
<td>Cowrall–1</td>
<td>18</td>
<td>1,000–2,000</td>
</tr>
<tr>
<td>Cowrall–10</td>
<td>16</td>
<td>2,065–3,550</td>
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<tr>
<td>Kanowana–2</td>
<td>18</td>
<td>600–900</td>
</tr>
<tr>
<td>Tindilpie–7</td>
<td>16</td>
<td>1,000</td>
</tr>
<tr>
<td>Dorodillo–4</td>
<td>13</td>
<td>100–1,000</td>
</tr>
<tr>
<td>Battunga–1</td>
<td>23</td>
<td>1,835</td>
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<tr>
<td>Wimma–1</td>
<td>14</td>
<td>2,800</td>
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</tbody>
</table>
COAL SEAM GAS

Bindah 3 VC50 coal (8971’ 5”), SEM micrograph showing microporosity (from Weatherford Laboratories petrology report in Bindah 3 Well Completion Report).

Bindah 3 VC50 coal (8977’ 5”), SEM micrograph showing microporosity (from Weatherford Laboratories petrology report in Bindah 3 Well Completion Report).
COAL SEAM GAS

Toolachee Formation – coal isopach

Top Toolachee Formation maturity

Ro = 0.95%
RESOURCE ESTIMATES

• Cooper Basin JV Unconventional Gas Project operated by Santos – 2C unconventional gas resource of 3.3 Tcf gas (shale gas, tight sands and deep coal)

• Beach Energy’s Nappamerri Trough Project - initial gross contingent resource of 2 Tcf of sales gas constrained to a 10x10km area around Holdfast 1 and Encounter 1 (shale gas and tight sands)

• Beach has stated that there is potential for at least 15-20 Tcf gas in terms of probable contingent (2C) resources in PEL 218 (Gas Today Article, Nov 2011).

• The US Energy Information Administration has estimated that the entire Cooper Basin (SA and QLD) has a risked recoverable shale gas resource of 85 Tcf
2012 DRILLING ACTIVITY

• ~16 vertical wells planned to test continuous gas plays in the Cooper Basin (4 completed, 3 in progress)
• 3 horizontal wells to test shale gas deliverability
PACE 2020: ENERGY

- New PACE 2020 program with a clear focus on South Australia’s Energy resources
- Research into:
  - Unconventional gas resources
  - Investigation of State’s frontier basins
  - Geothermal Reservoirs and rock/fluid mechanics
  - State Uranium resources and exploration modelling
  - Gas storage
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BOOTH 3

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