Update on Prospectivity Studies of the Georgina and Cooper Basins

Dianne Edwards, Lisa Hall, Bridget Ayling
and the Onshore Energy Systems Group, Resources Division
Northern Territory, Queensland and South Australian Governments
Georgina and Cooper Basins

The map is intended as a schematic depiction of the location of sedimentary basins with prehistoric potential for shale oil or gas based on their gross geological characteristics. Many basins highlighted do not have proven potential for shale oil or gas, and not all of the highlighted areas are necessarily prospective. Shale oil or gas may also occur outside of the highlighted areas.

Drilling Commenced at Whiteley-1 Southern Georgina Basin
Southern Georgina Basin

Neoproterozoic–Paleozoic

Exploration Activity

- Statoil
  - OzAlpha 1
  - OzBeta 1
  - OzGamma 1
  - OzDelta 1
  - OzEpsilon 1

- Central Petroleum JV Total
  - Whiteley 1
  - Gaudi 1 (Sept)
Southern Georgina Basin

Petroleum System Elements

- Middle Cambrian marine source rocks
- Arthur Creek Fm
- Type II kerogen
- Paleozoic oil and gas generation
Georgina Basin Project Overview

Aim:

- Reduce exploration risk by improving the understanding of conventional and unconventional hydrocarbon prospectivity

Activities:

- Compile regional datasets
  - HyLogging data package; reprocessing and interpretation
- Characterise and map effective source rocks (oil & gas mature pods)
- Map limit of petroleum systems i.e. correlation of hydrocarbon fluids generated by source rocks either in-place or migrated
Georgina Basin Petroleum Systems Elements

Smith et al., APPEA 2013
Source Rock Characterisation

Arthur Creek Fm “shales”
- HI >300 to 750 mg/gTOC
- Type II kerogen, excellent oil & gas source potential

Thorntonia/Hay River “carbonates”
- HI >300 to 700 mg/gTOC
- Type II kerogen, excellent oil & gas source potential
Georgina HyLogging Study Aims

• Refine the source/reservoir units in Arthur Creek ‘hot shales’ via Hylogger spectral and mineralogical characterisation

• Examine inter-relationships between HyLogging spectra, gamma logs and geochemistry (TOC, XRD, XRF) data.
HyLogging Project: 25 wells interpreted

Arthur Ck Fm  Thorntonia  RHD  Mt Baldwin

Gp1 TIR Minerals
Calcite  dolomite
Quartz
White micas
Feldspars

Hunt 1 Mineralogy
Hunt 1: observed relationships

Gamma

SWIR albedo

TOC

Core colour

Arthur Creek

Thorntonia

Good Oil 9-10 September 2014
Characterising the Arthur Creek Formation
Cooper Basin

Late Carboniferous-Triassic

**Exploration Activity**
- Beach Energy Ltd
- Santos
- Stuart Petroleum
- Victoria Oil Exploration

**Current Drilling**
- Nappamerri Tr
- Patchawarra Tr
Cooper Basin

- Australia’s largest onshore conventional gas and oil producer ~6Tcf (QLD, SA)
- Infrastructure: pipelines to E Coast gas market/ Gladstone LNG

- Revival in unconventional hydrocarbon exploration
- Permian targets: shale gas, basin centred gas, deep coal seam gas plays.
- Unconventional gas resources potential across the basin remains poorly defined.

Proven flow from multiple unco. gas targets
Moomba 191, 194, Encounter 1, Holdfast 1

Image source: DMITRE
Cooper Basin Unco. Gas Prospectivity

Aim:

• Review of the regional geology and petroleum systems elements; focussing on the Permian unconventional gas plays

Activities:

• Review of regional basin architecture; structure surfaces, isopachs
• Characterise & map effective source rocks, petroleum systems
• Undertake petroleum systems modelling of the Cooper PSs
• Predict the possible extent of Permian unconventional gas plays, play fairway / chance of success maps

⇒ Improve understanding of basin scale prospectivity
⇒ Underpin future resource assessment studies
Tectono-stratigraphy

Base Cooper Depth
91 m
-4497

Cooper Basin Outline

Depositional Environment

Good Oil 9-10 September 2014
Cooper Petroleum System

- High resistivity of the Gidgealpa Group (>20Ωm over large intervals) => gas saturation (Hillis et al., 2001)
- Tests recovered gas with no water
- Overpressure
Cooper Basin Unconventional Gas Plays

Unco. play types:
1) Basin centred gas
2) Shale gas
3) Deep coal seam gas

Gidgealpa Gp composite resource play:
Basin centred gas accumulation +/- shale +/- deep coal seam gas +/- natural fracture play
(Menpes et al., URTec, 2013)
Permian Formation Extents & Isopachs

- Defines limit of Gidgealpa Gp composite resource play
- Permian formations extend further north in QLD than previously mapped
Source Rock Characterisation

Toolachee/ Patchawarra coals/ shales
• HI values >250
• Type II/III kerogen => Good to very good oil + gas source potential

Roseneath/ Murteree “shales”
• HI’s < 200
• Type III kerogen => Gas prone

Toolachee/ Patchawarra – best quality
Some potential in Roseneath/ Murteree
Source Distribution

• Compare isopachs with viable source rock samples

• Regional Toolachee/ Patchawarra coals & shales:

  • Roseneath/ Murteree “shales”:
    • Restricted to southern Cooper Basin

<table>
<thead>
<tr>
<th>Average TOC %</th>
<th>2 - 5</th>
<th>6 - 10</th>
<th>10 - 20</th>
<th>20 - 30</th>
<th>&gt;30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roseneath Shale</td>
<td>Av TOC: 9.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Murteree Shale</td>
<td>Av TOC: 8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Petroleum Systems Modelling

- Multi-1D basin modelling study in progress.
  - ~100 1D models, calibrated with corr. temperature, VR etc.
  - New kinetic models (Mahlstedt et al., in prep)
Maturity Maps

Nappamerri Tr
• dry gas - over mature

Patchawarra Tr
• imm - dry gas

Windorah Tr
• late oil - dry gas

<table>
<thead>
<tr>
<th>Maturity Ro (%)</th>
<th>Present Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immature</td>
<td>0 - 0.8</td>
</tr>
<tr>
<td>Early Oil</td>
<td>0.8 - 0.9</td>
</tr>
<tr>
<td>Peak Oil</td>
<td>0.9 - 1</td>
</tr>
<tr>
<td>Late Oil</td>
<td>1 - 1.2</td>
</tr>
<tr>
<td>Wet Gas</td>
<td>1.2 - 1.4</td>
</tr>
<tr>
<td>Dry Gas</td>
<td>1.4 - 3</td>
</tr>
<tr>
<td>Overmature</td>
<td>3 - 8</td>
</tr>
</tbody>
</table>
Thank you

Resources Division

dianne.edwards@ga.gov.au
Phone: +61 2 6249 9111
Web: www.ga.gov.au
Email: feedback@ga.gov.au
Address: Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609
Postal Address: GPO Box 378, Canberra ACT 2601