Cooper Basin Unconventional Gas Prospectivity Review

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Cooper Basin

- Australia’s largest onshore conventional gas and oil producer (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 all basin remains poorly defined.
Cooper Basin Unco. Gas Prospectivity Review

Project Aims

Review of basin geology and petroleum systems elements, focusing on unconventional gas plays in the Permian

1. Review of regional basin architecture (structure surfaces, isopachs)
2. Evaluation of Permian source rocks
   - Source distribution, type, quality
   - Source maturity (petroleum systems modelling)
3. Predict the possible extent of Permian unconventional gas plays:
   - Play fairway / chance of success maps

⇒ Improve understanding of basin scale prospectivity
⇒ Australia source rock study
⇒ Underpin future resource assessment studies
Structural Elements/ Tectono-stratigraphy

Base Cooper Depth
- 91 m
- 4497

Cooper Basin Unconventional Gas Prospectivity
Permian Shows

- High resistivity of the Gidgealpa Group (>20Ωm over large intervals) => gas saturation (Hillis et al., 2001)
- Tests recovered gas with no water
- Overpressure
**Basin Centred Gas Play** *(Pervasive tight gas)*
- Hosted in low perm sands
- Migrated hydrocarbons
- Trapping mechanism: relative perm. of gas and water in low perm. reservoirs
- Primary mig. rate > secondary mig. rate

**Shale Gas Play**
- Hosted in shales/ fine siltstones
- Self sourced hydrocarbons
- Trapping mechanism: partly a sorbed gas reservoir
- Gas generation rate exceeds primary migration

**Coal Seam Gas Play** *(Dry)*
- Coal hosted
- Self sourced hydrocarbons
- Trapping mechanism: primarily a sorbed gas reservoir
- Primary mig. rate > secondary mig. rate
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)
Basin Architecture

- Regional update of key structure surfaces and isopachs
- Better integration of datasets across the state border
- Update of older interpretations in QLD to incorporate new seismic and well picks
New Structure Surfaces

Toolachee

Daralingie

Roseneath

Epsilon

Murtere

Patchawarra

=> Defines limit of Gidgealpa hybrid play
Regional Reservoir/ Seal

Nappamerrri Gp Isopach
Regional Seal Thickness

Gidgealpa Gp Isopach Hybrid Play
Gross Reservoir Thickness

Patchawarra Sands (Heath, 198x)
- POROSITY < 9%
- PERMEABILITY <0.1mD (tight gas reservoirs)
Source Rock Characterisation

Toolachee/ Patchawarra:
- Coals/ shales (TOCs: 1 – 80%)
- HI values >250
- Type II/III kerogen => Good to very good oil + gas source potential

Roseneath/ Murteree “shales”
- Majority of TOCs 0.8 - 12 %
- HI’s < 200
- Type III kerogen => Gas prone

Toolachee/ Patchawarra – the best quality source rocks

Some potential in the Roseneath/ Murteree
Source Rock Distribution

- Compare isopachs with viable source rock samples
- Good source distribution across all formation extents
  - Toolachee/Patchawarra: good source distribution across all basin
  - Roseneath/Murteree "shales": Restricted to southern Cooper Basin, although some potential north of the JNP trend
- Further integration with facies mapping still required

Average TOC %

- Roseneath Shale: Av TOC: 9.1%
- Murteree Shale: Av TOC: 8%
- Toolachee Formation: Av TOC: 21%
- Patchawarra Formation: Av TOC: 24%
Petroleum Systems Modelling

- Multi-1D basin modelling study in progress: (Trinity-Genesis).
  - 91 1D genesis models. Calibration: Corr. temp., VR etc.
  - New compositional kinetic models (Mahlstedt et al., in prep)
- Major differences in thermal history between depocentres

**Cooper Trinity Model**

**Vitrinite Ro(%)**

[Graph showing Vitrinite Ro(%) values with color gradient]

1. Toolachee
2. Roseneath
3. Murteree
4. Patchawarra

**Windorah Trough/ Ullenbury Depression Gas mature**
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)
## Composite Resource Play - Selection Criteria

<table>
<thead>
<tr>
<th>Play element</th>
<th>Input Dataset</th>
<th>Best estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source (thickness and TOC)</td>
<td>Toolachee/ Patchawarra isopachs and TOC maps</td>
<td>Toolachee OR Patchawarra &gt;15m thick AND &gt;2% TOC</td>
</tr>
<tr>
<td>Source maturity</td>
<td>Maturity maps</td>
<td>Wet gas (VR = 1.2) at top Patchawarra</td>
</tr>
<tr>
<td>Reservoir thickness</td>
<td>Gidgealpa Gp Isopach</td>
<td>&gt;100-200m</td>
</tr>
<tr>
<td>Seal thickness</td>
<td>Nappamerri Gp Isopach</td>
<td>&gt;80-100m</td>
</tr>
</tbody>
</table>

**Play elements missing:**
- Reservoir quality
- Seal quality
- Migration distance

+ uncertainty due to data quality/ level of knowledge

### Relative Chance of Success
- **High**
- **Low**
Gidgealpa Composite Resource Play - Play Fairway Map

- First draft play fairway map:
  - Nappamerri Trough and surrounds
  - Areas in northern Queensland
  - Extent of gas window major limiting factor

- Revisions required to include:
  - Updated basin architecture
  - New maturity maps
  - Improved common risk segment selection criteria

Still lots of potential for other play types in outside the play fairway!

Moomba production

Tamarama 1 and Queenscliff 1; gas saturated section off structure

QLD potentially prospective but higher uncertainty due to limited data

Relative Chance of Success

- High
- Low

DRAFT
SANS (Small Angle Neutron Scattering) Pilot Study

Aim: use SANS/ USANS to investigate pore sizes/ pore fluids within source rocks to determine their petroleum potential.

- Assess pore accessibility (1 nm to 20 µm) to HCs
- Measure quantitatively the pore-size-dependent adsorption and desorption of methane
- Observe changes in pore sizes and connectivity under reservoir simulated conditions while fracturing rock

⇒ Determine which source rocks can produce HCs
⇒ Determine rock properties before and after induced fracture
⇒ Determine what resource is recoverable
Summary of Results To Date

• Revised basin architecture
• Plenty of good quality, mature source rock across the basin.
• Draft play fairway map for the Gidgealpa Group composite resource play:
  • Potential for significant amounts of unconventional GIP in the Permian section across the basin,
  • Further updates to come.
• Pilot SANS project to investigate what is recoverable – future work program?
Questions/ feedback?

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