Cooper Basin Regional Petroleum Prospectivity Studies

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Geoscience Australia’s Petroleum Work Program

- Petroleum program strategic priorities – building Australia’s resource wealth:
  - Predict Australia’s energy resource potential and identify new energy provinces through pre-competitive data and analysis.
  - Provide independent information and advice to Government and other stakeholders and promote Australia’s energy resource potential.
- Geoscience Australia’s projects in South Australia:
  - Cooper Basin regional prospectivity assessment (Energy Systems Branch)
  - Resource assessments (Resources Advice and Promotions Branch)
  - Collaboration with Bioregional Assessment Program (Groundwater Branch)
- Relevance to Roadmap Themes and Recommendations:
  - Attract investment by improving our knowledge of the subsurface
Cooper Basin prospectivity assessment

- Improve understanding of basin scale hydrocarbon prospectivity
- Inputs for regional play mapping and resource assessment studies
  - Prospectivity study workflow:
    - 3D basin architecture and structural evolution
    - Geochemistry: source rock thickness, amount, quality
    - Integrated basin modelling: source rock maturity, hydrocarbon generation
Regional Basin Architecture

- Cooper Basin regional 3D model
  - Updated structure surfaces and isopachs:
  - Better integration of datasets across the state border
  - Incorporation of new open file well picks and seismic interpretation
- Stratigraphic ages:
  - Updated to GTS 2012, inclusion of revised spore pollen zone ages (e.g. Nicoll et al., 2015)
Regional Basin Architecture: Structure Surfaces

Depth (m)

- Basin boundary
- Formation boundary
- Contour (depth in metres)
Lithofacies

- Toolachee, Daralingie, Epsilon and Patchawarra Formations - coal, silt, shale and sand net thickness
- South Australia:
  - Sun and Camac (2004) electrofacies mapping,
  - updated coal thicknesses Weena Trough and surrounds
- QLD: new electrofacies maps consistent SA methodology

Net thickness by lithofacies (m)
High >100m
Low
Mapping the Cooper Basin’s Source Rocks

- Source rock thickness, richness, quality, maturity by formation and lithology
  - Update and QC GA’s ORGCHEM database
  - Map source richness – Total Organic Carbon (TOC)
  - Improve source rock characterisation
- Additional geochemical sampling to improve understanding of Patchawarra coals

Source Rock Richness (shales/ coaly shales)
Present Day %TOC

Good/ excellent source rock: TOC > 2%
Source Characterisation Using Organic Geochemistry

- Coals/ coaly shales
- Good quality (HI > 250 mg/gTOC)
- Kerogen type II/III (non-marine)
- Good gas to oil + gas source potential.

- Shales
- Moderate quality (HI’s < 200 mg/gC)
- Kerogen type III/IV (non-marine)
- Gas prone

- Shales
- High quality: HI > 300-500 mg/gC
- Kerogen type II, some Type I (marine)
- Oil prone

- **Toolachee/ Patchawarra coals and shales are the best quality source rocks**
- **Roseneath/ Murteree ‘shales’ do not behave like US shales**

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**Jarvie et al., 2005**
Petroleum Generation Potential & Oil/ Gas Windows

- Cooper basin kinetics (Malhstedt et al., 2015):
  - Characterises how kerogens transform to oil and gas with increasing temperature/maturity
- Cooper specific oil and gas maturity windows:
  - Later onset of oil and gas generation compared with US shales due to different kerogen type

<table>
<thead>
<tr>
<th>Source Rock Maturity (Ro %)</th>
<th>Cooper Basin</th>
<th>Barnett Shale (Jarvie et al., 2005)</th>
</tr>
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<tbody>
<tr>
<td>Early oil</td>
<td>Ro(%)</td>
<td>0.75 - 0.9</td>
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<tr>
<td></td>
<td></td>
<td>0.55 – 0.9</td>
</tr>
<tr>
<td>Peak oil</td>
<td>Ro(%)</td>
<td>0.9 - 1</td>
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<tr>
<td></td>
<td></td>
<td>0.9 – 1.15</td>
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<tr>
<td>Late oil</td>
<td></td>
<td>1 – 1.3</td>
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<tr>
<td>Wet gas</td>
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<td>1.3 - 2</td>
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<td></td>
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<td>1.15 - 1.4</td>
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<tr>
<td>Dry gas</td>
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<td>2 – 3.5</td>
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<td></td>
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<td>&gt;1.4</td>
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<tr>
<td>Over-mature</td>
<td></td>
<td>&gt; 3.5</td>
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</table>
Source Rock Maturity

- Regional basin and petroleum systems modelling study:
  - Calibrated using over 90 wells (SA & QLD)
- Source rock maturity (Ro%):
  - Maturity maps for key depth intervals
  - Large areas of the Nappamerri, Patchawarra Troughs are gas mature
- Temperature maps

Source Rock Maturity Maps for key surfaces (Ro%)
Hydrocarbon Generation Potential

- Total hydrocarbons generated by formation and lithology: the best source rocks are the Patchawarra coals and coaly shales, followed by those of the Toolachee Formation.

- Total Hydrocarbons generated from the Permian Gidgealpa Group > 2000 bboe.
Oil and Gas Expelled and Retained

- Addition of expulsion models to regional basin and petroleum systems model => maps of hydrocarbons expelled/retained
- May be used to map state wide play maps and OHIP (shale gas, deep dry coal gas, tight gas)

Patchawarra Formation - coal source rock

Work in progress
Cooper Prospectivity Study Outputs

Cooper Basin Prospectivity Report Series

• Mahlstedt et al., 2015. Multi-component kinetics and late gas potential of selected Cooper Basin source rocks. GA Record 2015/19
• Hall, Hill, Troup et al., in review. Cooper Basin architecture and lithofacies.
• Hall, Boreham, Edwards, Hill, Troup et al., in prep. Source rock geochemistry of the Cooper Basin
• Hall, Palu, Boreham et al., in prep. Cooper Basin petroleum systems modelling

Data products

• Source Rock Atlas of the Cooper Basin.

Recent conference presentations:

• Kuske et al., 2015. Source Rocks of the Cooper Basin. AAPG ICE.
• Hall et al., 2015. Petroleum systems modelling in Cooper Basin. AAPG ICE.
• Hall et al., 2015. Unconventional gas prospectivity of the Cooper Basin. APPEA 2015 extended abstract
Updated assessments required for the Cooper Basin

- Uses new data from recent exploration for shales;
- Incorporates tight oil and gas, deep coals; and
- Is completely transparent and reproducible

GA assessment

- Roseneath and Murteree shales
- Probabilistic Volumetric Analysis method
- Preliminary assessment now complete
- Assessments for other play types to follow

USGS assessment

- Data pack supplied to the USGS 2014
- Assessment to take place late 2015?

<table>
<thead>
<tr>
<th>Report</th>
<th>Unit</th>
<th>Total GIP (tcf)</th>
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<tr>
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Cooper subregion - Bioregional Assessment

• Collaboration between the Department of the Environment, the Bureau of Meteorology, CSIRO and Geoscience Australia

• Aim: to better understand the potential impacts of coal seam gas and large coal mining developments on water resources and water-related assets

• Support to GA’s bioregional assessment team through sharing of regional data

• Cooper subregion – Lake Eyre Basin Bioregional Assessment products to date:
  • Context statement
  • Coal and coal seam gas resource assessment
  • Data register

Contributions to Roadmap Recommendations: Subsurface Geology

• Update ORGCHEM database and conduct source rock geochemistry review (Recommendation 27)
• Development of regional maps at key stratigraphic levels for the following (Recommendation 52)
  • structure surfaces in depth
  • Ro%, temperature maps
  • characterize and map Original Hydrocarbons in Place for each play (OHIP)
• National play maps: development of regional maps delineating play-trend areas for shale gas, Deep CSG, Tight Gas, and Coals (Recommendation 31)
• Publications to attract investment focused on describing unconventional gas plays (Recommendation 45)
Thank you
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