Natural Gas and Oil in Unconventional Reservoirs
Context and South Australian Regulation

Ted Beaumont, President AAPG (July 2012 Explorer pp 3)

...outside North America, industry is just beginning to explore resource plays.

...organic matter, maturity and brittleness

...the USA is now producing more gas than ever

Barry Goldstein
Executive Director

Michael Malavazos
Director Engineering

Energy Resources Division, Dept. of State Development

Australia leads in using CSG as feedstock for LNG
Purpose of Briefing

• Who is the Regulator?

• Part 1
  ➢ What is unconventional gas?
  ➢ What is hydraulic fracturing?
  ➢ Background and history of gas extraction and drilling in SE
  ➢ State Government approval and regulatory processes, including the information requirements and local consultation

• Part 2
  ➢ What are the risks associated with unconventional gas exploration, drilling and related activities

• Part 3
  ➢ Roundtable for oil and gas projects
Part 1
What are unconventional reservoir targets that contain gas and oil?
Oil and Gas
Conventional and Unconventional
A Natural Gas Revolution is Underway

Vision:

• Secure and competitive gas;
• Improved balance of trade;
• Australia’s supplants imports with gas-based transport fuel;
• $ Billions in ESD projects;
• Thousands of jobs;
• Royalties/tax for public good;
• Risks to natural, social & economic environments reduced to ALARP & operations meet community expectations for net outcomes.

2014 Context:
Eastern Australia 2P Gas Reserves

Conventional

Unconventional (Coal Seam Gas)

Core Energy Group June 2013 statistics

13%

87%

Total = 52,522 PJ

52,522 PJ

Core Energy Group June 2013 statistics
Natural gas in unconventional rock-reservoirs

EIA / ARI 2013

<table>
<thead>
<tr>
<th>Technically Recoverable Shale Resource Estimates</th>
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<td>Gas (TCF)</td>
<td>Oil (Billion Bbls)</td>
</tr>
<tr>
<td>1     USA 1,161</td>
<td>1 Russia 75</td>
</tr>
<tr>
<td>2     China 1,115</td>
<td>2 USA 48</td>
</tr>
<tr>
<td>3     Argentina 802</td>
<td>3 China 32</td>
</tr>
<tr>
<td>4     Algeria 707</td>
<td>4 Argentina 27</td>
</tr>
<tr>
<td>5     Canada 573</td>
<td>5 Libya 26</td>
</tr>
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<td>6     Mexico 545</td>
<td>6 Australia 18</td>
</tr>
<tr>
<td>7     Australia 437</td>
<td>7 Venezuela 13</td>
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<td>8 Mexico 13</td>
</tr>
<tr>
<td>9     Russia 285</td>
<td>9 Pakistan 9</td>
</tr>
<tr>
<td>10    Brazil 245</td>
<td>10 Canada 9</td>
</tr>
<tr>
<td>11    Others 1,535</td>
<td>11 Others 65</td>
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<tr>
<td>Total 7,795</td>
<td>Total 335</td>
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Fast follower criteria outside North America

- The right rocks (liquids rich better)
- Markets
- Supportive investment frameworks
- Trusted regulatory frameworks
- Pre-existing infrastructure
- Capacity to move down cost curve
What is Hydraulic Fracturing

“..is a technique in which a mixture of mainly water mixed with sand (99.5% vol.) and chemicals (0.5% vol.) is injected at high pressure into a well to create small fractures (typically less than 1-2 mm), along which fluids such as gas and oil may migrate to the well.”

In SA Cooper Basin over 700 wells (circa 1400 stages) have been fracture stimulated
Separation of fracture stimulation in the Cooper Basin from fresh water supplies

No evidence or realistic expectation of fracture stimulation resulting in the contamination of fresh water supplies or damaging induced seismicity in the far northeast of South Australia where 700+ deep petroleum wells and a few geothermal (hot rock) wells have been fracture stimulated.

Number of fracture stimulated stages in 717 fracture stimulated wells in the Cooper Basin to end Aug.’14
South East Source of Gas

[Diagram showing stratigraphy with labeled formations and hydrocarbon targets.]
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<th>Main Compound(s)</th>
<th>Purpose</th>
<th>Common Use of Main Compound</th>
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<td>Hydrochloric acid or muriatic acid</td>
<td>Help dissolve minerals and initiate cracks in the rock</td>
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<td>Biocide</td>
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<td>Eliminates bacteria in the water that produce corrosive byproducts</td>
<td>Disinfectant; sterilize medical and dental equipment</td>
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<td>Breaker</td>
<td>Ammonium persulfate</td>
<td>Allows a delayed break down of the gel polymer chains</td>
<td>Bleaching agent in detergent and hair cosmetics, manufacture of household plastics</td>
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<td>Corrosion</td>
<td>N, n-dimethyl formamide</td>
<td>Prevents the corrosion of the pipe</td>
<td>Used in pharmaceuticals, Acrylic fibers, plastics</td>
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<td>inhibitor</td>
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<td>Crosslinker</td>
<td>Borate salts</td>
<td>Maintains fluid viscosity as temperature increases</td>
<td>Laundry detergents, hand soaps, and cosmetics</td>
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<td>Friction</td>
<td>Polyacrylamide</td>
<td>Minimizes friction between the fluid and the pipe</td>
<td>Water treatment, soil conditioner</td>
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<td>reducer</td>
<td>Mineral oil</td>
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<td>Make up remover, laxatives, candy</td>
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<td>Gel</td>
<td>Guar gum or hydroxyethyl</td>
<td>Thickens the water in order to suspend the sand</td>
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<td>Removes oxygen from the water to protect the pipe from corrosion</td>
<td>Cosmetics, food and beverage processing, water treatment</td>
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<td>Scavenger</td>
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<td>pH Adjusting</td>
<td>Sodium or potassium carbonate</td>
<td>Maintains the effectiveness of other components, such as crosslinkers</td>
<td>Washing soda, detergents, soap, water softener, glass and ceramics</td>
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<td>Agent</td>
<td></td>
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<td>Proppant</td>
<td>Silica, quartz sand</td>
<td>Allows the fractures to remain open so the gas can escape</td>
<td>Drinking water filtration, play sand, concrete, brick mortar</td>
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<td>Scale inhibitor</td>
<td>Ethylene glycol</td>
<td>Prevents scale deposits in the pipe</td>
<td>Automotive antifreeze, household cleansers, and de-icing agent</td>
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<td>Surfactant</td>
<td>Isopropanol</td>
<td>Used to increase the viscosity of the fracture fluid</td>
<td>Glass cleaner, antiperspirant, and hair color</td>
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History of Gas Extraction in SE
Otway Basin
Kalangadoo #1 1964
Conventional Oil and Gas Exploration Nothing New
Key History Milestones

- Exploration commenced in 1866 in the South East with a well drilled near Salt Creek
- First flow at Kalangadoo-1 in 1965 and Caroline-1 in 1966 – both CO2
- First commercial flow of hydrocarbons in 1987 at Katnook-1
- Katnook Plant built and commissioned in 1991 – now mothballed
- Oil recovered from Sawpit-1 in 1992, flowed from Wynn-1 in 1994 – neither well commercial
Source of Gas

- Gambier Limestone
- Dilwyn Formation
- Pember Mudstone
- Sherbrooke Group
- Eumeralla Formation
- Katnook Sandstone
- Laira Formation
- Pretty Hill Sandstone
- Upper Sawpit Shale
- Sawpit Sandstone
- Lower Sawpit Shale
- Casterton Formation
- Basement

Potential aquifer bed
Surface aquifers
Main hydrocarbon targets

Conventional Targets
Unconventional Targets
Historical Gas Production

Southeast Gas Production

Gas Production (mmcf/day)

Jan-91 Jan-93 Jan-95 Jan-97 Jan-99 Jan-01 Jan-03 Jan-05 Jan-07 Jan-09 Jan-11 Jan-13

- Katnook
- Haselgrove
- Redman
- Redman
- Jacaranda Ridge
- Limestone Ridge
Caroline#1 CO2 Production
Where to Next?

Oil or liquids rich gas
South East Geology
Pressure-Transient Response in Compartmentalised Gas Reservoirs: A South Australian Field Example

M. Melizou and R.G.M. McDonough, South Australia Dept. of Mines & Energy
SPE Members

Abstract

The long-term, production tests of the Katnock gas field in the South-East of South Australia are analysed to enable a better understanding of the reservoir geometry.

The pressure-transient responses are interpreted to indicate a compartmentalised reservoir, comprising a series of high-permeability sand bodies in relatively poor communication. This is consistent with the geological model, which describes the stacked-channel reservoirs having been formed in a low-sinuosity, braided-stream palaeo-environment.

Estimates of channel width and reservoir separability are made using the correlation of type...

The initial discovery was made in the Windermere Sandstone of the basal Eumenalla Formation. The subsequent drilling of Katnock #2 and #3 discovered and confirmed that the major gas reserves are located in a faulted anticlinal structure of the Pretty Hill Sandstone, covering an area of about 4 km².

A drill stem test gas flow of 16.4 MScfd (462,000 m³/d) on a half inch (12.7 mm) choke was measured during DST #12 in Katnock #2. This is a record for a well drilled onshore in South Australia.

Delivery of natural gas from Katnock to the industrial, commercial and domestic markets in the South-East of South Australia commenced in March 1981. Under the terms of the contract the producers will supply 22.5 PJ over a 15 year period.
Fig. 2  Schematic section of the Katnook field (Pretty Hill Sandstone reservoir).
South East Geology

Fig. 3  Block diagram of channel sands in a braided fluvial environment (Scholle and Spearing').
Legislative Controls
VISION: Deep unconventional gas delivering decades of safe, secure and competitive gas

To reach this vision

• **Must demonstrate:** Potential risks to social, natural and economic environments are *reduced to as low as reasonably practical* (ALARP); and meet community expectations;

• Stakeholders get timely information describing risks to enable informed opinions/decisions
Regulatory Objectives/Conditions

Avoid:

• Contamination of aquifers
• Adversely impacting other land users and uses
• Contamination of soil
• Disturbance of heritage sites
• Adversely impacting vegetation
• etc

Aim of regulatory processes is to have licensees demonstrate that they can and are achieving these objectives
Regulatory Framework

In South Australia
Petroleum Exploration and Production Activities regulated under:

- Petroleum and Geothermal Energy Act 2000 (PGE Act);
- Environment Protection Act 1993;
- Natural Resources Management Act 2004;
- National Parks and Wildlife Act 1972;
- Aboriginal Heritage Act, 1988;
- Development Act, 1993;
- Work Health and Safety Act 2012;
- Public and Environmental Health (Waste Control) Regulations 2010;
- EPBC Act 1999

Interaction between PGE Act and other South Australian Acts administered through Administrative Arrangements with respective agencies.
PGE Act defines the *environment* as:

- land, air, water, soil;
- plants & animals;
- social, cultural & heritage features;
- visual amenity;
- economic & other land uses.
Statements of Environmental Objectives (SEO)

- Regulated Activities cannot be carried out unless there is an approved SEO in place.
- SEO’s set approval conditions for regulated activities e.g. seismic, well operations, production, processing, pipelines, gas storage, etc.
- Activity notifications – licensee demonstrates how it will achieve SEO before approval granted
Approval Process
PGE Act Approval Processes

Two approval stages – Petroleum & Geothermal Act:

1. Licence approvals
   • Exploration, Retention
   • Production, Gas Storage, Pipeline, Special Facility Licences

2. Activity approvals
   • SEO Approval Process
     – what they must achieve
   • Activity Notification Process
     – demonstrate how they will achieve
SEO Approval

EIR & Draft SEO

Environmental Significance Assessment

LOW IMPACT
Internal Govt Consultation

MEDIUM IMPACT
Public Consultation

HIGH IMPACT
EIS Process

Statement of Environmental Objectives

APPROVAL
Significance Criteria

**PREDICTABILITY**
Level of confidence that for each impact and consequence these issues have been addressed:

- Size
- Scope
- Duration
- Likelihood/Frequency
- Stakeholder Concerns

**MANAGEABILITY**
Extent to which consequences can be managed:

- Avoidance
- Probability
- Duration
- Size
- Scope
- Cumulative Effects
- Stakeholder concerns
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SEO Objectives Include:

Avoid:

• Contamination of aquifers
• Adverse impacts on other land users and uses
• Contamination of soil
• Disturbance to heritage sites
• Adverse impacts on vegetation
• etc

Breaching these objectives is a PGE Act offence
Notices of Entry (NoEs)

• **Owners of land** means all persons and enterprises potentially directly affected by regulated activities,

• **NoEs** must provide timely information to enable potentially affected people and enterprises to reach informed views regarding impacts on their interests.

• **Owners of land** must be given **NoEs** at least 21 days in advance of the start of any activities – and have 14 days to lodge objections.

• All potentially directly affected people and enterprises have **rights to object** to the approval of land access for regulated activities, and all such objections are a show-stopper until objections are resolved.
Notices of Entry (NoEs)

- These **Owner of Land** rights are sustained without support for vexatious objections.

- **Owners of land** are due compensation from relevant PGE Act licence holders for reasonable costs of assessing NoEs (including the cost of legal advice) and for any loss or deprivation that might result from activities regulated pursuant to the PGE Act.

- The **dispute resolution process** for objections to NoEs
  - starts with **engagement** between the concerned stakeholder and the relevant PGE Act Licence holder;
  - can escalate to **mediation** stewarded by the Minister; but
  - **court proceedings** are the ultimate dispute resolution process.
## Best Practice Regulatory Principles

### Delivering Regulatory Best Practice through 6 Principles:

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<th>1) Certainty</th>
<th>4) Practicality</th>
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<tr>
<td>2) Openness</td>
<td>5) Flexibility</td>
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<td>3) Transparency</td>
<td>6) Efficiency</td>
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Inclusive stakeholder consultation in establishing regulatory objectives, broad community engagement on addressing potential environmental, economic and social/cultural impacts.
Transparency

Public Access to regulatory decision making.

- Criteria for classifying the level of Environmental Impact
- All Environmental Impact Reports, assessments and Statements of Environmental Objectives (Approval Conditions) are online

Community access to industry performance information:

- environmental performance
- regulatory enforcement actions
- surveillance activity information

- Licensee Annual Compliance Reports
- PGE Act compliance policy
- PGE Act Annual Compliance report
Appropriate range of regulatory enforcement tools to elicit compliant behaviour.

- **PGE Act compliance policy**
- **PGE Act Annual Compliance report**
Part 2
What are the risks?
How do we identify and manage the risks?

Beach Energy Shale Gas Fracking - EIR

Beach Energy Shale Gas Fracking - SEO
# EIR Summary

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Contained
Wells have as many as eight layers of steel casing and cement that form a continuous, protective barrier between the well and the surrounding rock. The well design and program is reviewed, approved and monitored by the State or Territory regulator.
Best Practice Industry Standards


Hydraulic Fracturing Operations—Well Construction and Integrity Guidelines

API GUIDANCE DOCUMENT HF1
FIRST EDITION, OCTOBER 2009
Recommended Well Construction Practice

All surface aquifers behind cemented casing to surface

All other strings cemented casing above shoe across aquifers or productive zones
Approved Practice for All future Wells

• Well will be drilled through the surface sediments into the Eumeralla Formation and casing run so that the surface aquifers are not in communication with the well bore

• All casing strings will be cemented to surface

• Beyond recommended practice
What are the risks

Casing and cement integrity

Not acceptable or tolerable...
BRIEF OF EVIDENCE

Investigation into the circumstances surrounding the Uncontrolled Release of Oil and Gas from the Montara Wellhead Platform

MONTARA DEVELOPMENT PROJECT

located in the Timor Sea approximately 250 km north-west of the Western Australian coast, almost 700 km from Darwin in the offshore area of the Territory of Ashmore and Cartier Islands

Owned and Operated

By

PTTEPAA Australasia (Ashmore Cartier) Pty Ltd
PTTEPAA

(ACN 004 210 164)

On

21st AUGUST 2009
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Offset Well Microseismic Mapping

Microseismic Monitoring Is Applied Earthquake Seismology

- A Microseism is a Micro-Earthquake, a Shear Slippage Along An Existing Plane Of Weakness.
- Microseisms That Occur During Hydraulic Fracturing Are Caused By:
  - Changes In Stress And Pressure As A Result Of The Treatment

Recorded Events
Fracture half length and complexity is controlled by:

- Frac fluid viscosity (gel vs “slickwater”)
- Pump rate
- Pump pressure
- Proppant “mesh” size
- In situ stresses
- Existing natural fractures
- Natural frac barriers (ductile rocks that don’t break easily)
- Rock brittleness
Figure 24: Typical fracture height growth measured during shale gas stimulation in the Eagle Ford (USA) with Nappamerri Trough well section superimposed.
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<td>Sodium or potassium carbonate</td>
<td>Maintains the effectiveness of other components, such as crosslinkers</td>
</tr>
<tr>
<td>Proppant</td>
<td>Silica, quartz sand</td>
<td>Allows the fractures to remain open so the gas can escape</td>
</tr>
<tr>
<td>Scale inhibitor</td>
<td>Ethylene glycol</td>
<td>Prevents scale deposits in the pipe</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Isopropanol</td>
<td>Used to increase the viscosity of the fracture fluid</td>
</tr>
</tbody>
</table>

## EIR Summary (cont)

<table>
<thead>
<tr>
<th>HAZARDOUS EVENTS</th>
<th>POTENTIAL CONSEQUENCES</th>
<th>MITIGATION MEASURES</th>
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<td>Frac fluid contained within lined pits</td>
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<td>Refuel in designated bunded area.</td>
</tr>
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Green Completion
Its all about Containment
Well and Fracking Operation Standards
Are Earthquakes are risk?
Impacts on Other Landowners
Environmental Footprint

It's not CSG
Environmental Footprint

It's not CSG

Diagram not to scale

Source: Styles, Keele University, UK
Presence of Hydrocarbon in Shallow Aquifers
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPORT BOOK 95/17

GAS SAMPLING FROM WATER BORES
IN THE NORTHERN GAMBIER BASIN,
SOUTH AUSTRALIA

by

A.J. HILL
Petroleum Division

D.R. VINALL
Petroleum Division

JUNE 1995

Available on DMITRE SARIG Web site
**Head Space Gas Sampling**

*Dilwyn Formation*

**Table 1:** Compositional analysis of water bores sampled in 1987 survey.

<table>
<thead>
<tr>
<th>Sample</th>
<th>RIV 11 sample 1</th>
<th>SYM 61 sample 1</th>
<th>SMT 29 sample 2</th>
<th>SMT 29 sample 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂ + O₂</td>
<td>92.67</td>
<td>99.39</td>
<td>94.51</td>
<td>98.92</td>
</tr>
<tr>
<td>CO₂</td>
<td>0.96</td>
<td>0.32</td>
<td>3.12</td>
<td>0.39</td>
</tr>
<tr>
<td>CH₄</td>
<td>5.39</td>
<td>0.29</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C₂H₆</td>
<td>0.30</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>C₃H₈</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C₄⁺</td>
<td>0.68</td>
<td>0.00</td>
<td>2.37</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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</tbody>
</table>
Table 2. Heatspace gas volumes, 1993 survey.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOY-17-1</td>
<td>100</td>
</tr>
<tr>
<td>JOY-17-2A</td>
<td>800</td>
</tr>
<tr>
<td>SMT-29-1</td>
<td>50</td>
</tr>
<tr>
<td>SMT-29-2</td>
<td>450</td>
</tr>
<tr>
<td>SMT-29-1A</td>
<td>950</td>
</tr>
<tr>
<td>6824-1549-1</td>
<td>100</td>
</tr>
<tr>
<td>6824-1549-2</td>
<td>1100</td>
</tr>
<tr>
<td>FOX-10-2</td>
<td>1150</td>
</tr>
<tr>
<td>SYM-61-1</td>
<td>400</td>
</tr>
<tr>
<td>MTB-18-1</td>
<td>1000</td>
</tr>
</tbody>
</table>
Methane
Dilwyn Formation

Table 3: Bulk composition, water bore gases

<table>
<thead>
<tr>
<th>Components</th>
<th>JOY-17-1</th>
<th>JOY-17-2A</th>
<th>SMT25-1</th>
<th>SMT29-2</th>
<th>SMT29-1A</th>
<th>6824-1549-1</th>
<th>6824-1549-2</th>
<th>FOX10-2</th>
<th>SYM61-1</th>
<th>MTB18-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂ (mol %)</td>
<td>52.3</td>
<td>50.9</td>
<td>47.2</td>
<td>46.2</td>
<td>48.3</td>
<td>7.74</td>
<td>10.2</td>
<td>35.1</td>
<td>72.5</td>
<td>95.5</td>
</tr>
<tr>
<td>O₂ + Ar (mol %)</td>
<td>4.79</td>
<td>1.03</td>
<td>2.46</td>
<td>2.87</td>
<td>1.17</td>
<td>0.42</td>
<td>0.50</td>
<td>0.80</td>
<td>1.38</td>
<td>1.45</td>
</tr>
<tr>
<td>CO₂ (mol %)</td>
<td>0.18</td>
<td>1.86</td>
<td>0.05</td>
<td>0.15</td>
<td>0.09</td>
<td>0.04</td>
<td>0.06</td>
<td>0.08</td>
<td>0.56</td>
<td>2.90</td>
</tr>
<tr>
<td>C₁ (mol %)</td>
<td>42.7</td>
<td>46.2</td>
<td>50.3</td>
<td>50.8</td>
<td>50.4</td>
<td>91.8</td>
<td>90.2</td>
<td>64.0</td>
<td>25.6</td>
<td>0.16</td>
</tr>
<tr>
<td>C₂ (µL/L)</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>3</td>
</tr>
<tr>
<td>C₃ (µL/L)</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>C₄ (µL/L)</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>C₅ (µL/L)</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>C₆ (µL/L)</td>
<td>&lt;1</td>
<td>60</td>
<td>30</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>20</td>
<td>4</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>
Methane
Dilwyn Formation

Table 4. Stable Carbon isotope analyses, $\delta^{13}\text{C}/_{\infty}$ PDB

<table>
<thead>
<tr>
<th>Sample</th>
<th>Methane $\delta^{13}\text{C}$</th>
<th>Carbon Dioxide $\delta^{13}\text{C}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOY-17-2A</td>
<td>-77.7</td>
<td>-20.2</td>
</tr>
<tr>
<td>SMT-29-1A</td>
<td>-72.4</td>
<td>-</td>
</tr>
<tr>
<td>6824-1549-2</td>
<td>-52.4</td>
<td>-</td>
</tr>
<tr>
<td>FOX-10-2</td>
<td>-64.1</td>
<td>-</td>
</tr>
<tr>
<td>SYM-61-1</td>
<td>-99.8</td>
<td>-</td>
</tr>
<tr>
<td>MTB-18-1</td>
<td>-63.3</td>
<td>-18.6</td>
</tr>
</tbody>
</table>

Carbon Isotope Thresholds
• < -60 Biogenic Source
• > -60 Thermogenic Source
Salamander #1 Geothermal Well
Download the Roadmap for Unconventional Gas Projects in South Australia

Google DSD & Unconventional Gas

Informed by a Roundtable with members from: industry; all Australian State, NT and Federal Governments; peak representative bodies for protecting environments and aboriginal people; research institutions and a few individuals

212 members in Dec 2012

Now >440 members in working groups (implementing recommendations)
Leading Operators in the Cooper Basin (Santos, Beach and Senex) have agreed to contribute an aggregate of > $1 million in cash and in kind to establish shared training facilities at Tonsley. Co-located with new core library

Strengthening capabilities in local Universities –

- SA Research Fellow in Unconventional Resources
- SA Chair – Petroleum Geology
- $s for Visiting Experts
- CO2CRC (cognate)
- SA Centre for Geothermal Energy Research (cognate)
Recap Working Groups #2 - Supply hubs, roads, rail and airstrips, Cooper-Eromanga basins

• Have mapped existing supply options (road, rail, air, ship);
• Used *Roadmap* details to inform probabilistic dimensions, weights and timing for transport scenarios – in turn enabling optimisation modelling for road, rail and air for minimum 6,000 pj unconventional gas ex-Cooper Basin to supply a 15 year gas contract. *Also accounting for oil*

• Special facility licences (SFLs) enable additional depots, airstrips and petroleum handling facilities

• DPTI has estimated requirements to seal the Strzelecki Track as part of SA’s Integrated Transport and Land Use Plan. *Looking at intra-basin requirements, too*

• Building economic models to elucidate public vs private benefit in context of Infrastructure Australia criteria Federal funding.
Leading operators have met / are planning to pool water use forecasts for Cooper-Eromanga (SA-Qld) basin-wide modelling of water supply: demand balance, to deduce cost- and water-saving options.

This is a first, fundamental step towards life-cycle water-use planning – will inevitably foster environmental sustainability, project economics, transparency/trust, and business opportunities.

Santos coordinating. Golders contracted for modelling with SA G’ment funding
Recap Working Groups #4  SA-Qld 'wharf to well' corridors for the Cooper-Eromanga basins

Need traction with colleagues in Qld

Qld regulators at Roundtable in Adelaide, 2-3 Dec 13

**Upstream**: Mike Malavazos (DMITRE) in direct discussions with Qld’s Coal Seam Gas Compliance Unit, Department of Natural Resources and Mines

**Transport**: DPTI in direct discussions with new National Heavy Vehicle Regulator and Qld counterparts
Recap Working Groups #5
Cost-effective, trustworthy GHG detection

ARC Linkage grants worth ~A$1 million awarded for University of Adelaide research to develop more cost-effective GHG monitoring, including detection of natural seeps

Subsequent to discussions – a sub-set of WG#5 members agreed revisit NGERS and other data develop FAQ s to better inform the public, business leaders and policy makers as to the materiality of various sources of GHG emissions. No doubt, all mitigation contributes to lowering carbon intensity. The objective of market-based GHG emissions mitigation policies are to reduce maximum GHG at the lowest costs. SA Government providing resources for this compilation and assessment
Creating this in August 2014 – with its first meeting in Adelaide on 22 October 2014

The Suppliers’ Forum will foster local content in local and international supply-chains for the upstream oil and gas industry