The Challenges and Opportunities of Bringing North American Unconventional Expertise ‘Down-Under’

Ian Cockerill
Executive Director
INVEST IN ROBUST GAS MARKETS

KEEP CALM AND INVEST IN ROBUST GAS MARKETS
MONTNEY TIGHT LIQUIDS PLAY
BRITISH COLUMBIA, CANADA

MONTNEY LIQUIDS
NE BRITISH COLUMBIA
>33,000 net acres

DUVERNAY LIQUIDS
10,000 net acres

MANNVILLE LIQUIDS
27,000 net acres

THE MOST COMMERCIAL ROBUST
UNCONVENTIONAL OIL PLAY IN NORTH AMERICA

UNLOCKING TIGHT GAS
PERTH BASIN, W. AUSTRALIA

EXPLORATION PERMIT 321
100,500 net acres

RETENTION LEASES 6 and 7
67,000 net acres

DANDARAGAN DEEP LEAD

SUSTAINED HIGH GAS
PRICES AND DEMAND

EDMONTON

50km

50km
• Giant gas accumulation (four existing wells) with Gas-In-Place estimates ranging up to 10 TCF

• 30km from major natural gas infrastructure in Western Australia’s robust domestic gas market

• Australia now provides more availability of expertise and equipment for Unconventional Exploration – but it still is a challenge!

• Further appraisal drilling at Warro expected to start mid-August 2015
The Onshore Industry in Australia

- Onshore Unconventional Potential
- Unconventional Investment
- Challenges

North Perth Basin

- Geology
- Warro Field Appraisal
- Dandaragan Deep Exploration

Summary

- Warro Business
- Onshore Australia Business
## Australian Onshore Potential

### Technically Recoverable Shale Gas Resource (Tcf)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>US</td>
<td>1,161 Tcf</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>1,115 Tcf</td>
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<tr>
<td>3</td>
<td>Argentina</td>
<td>802 Tcf</td>
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<tr>
<td>4</td>
<td>Algeria</td>
<td>707 Tcf</td>
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<tr>
<td>5</td>
<td>Canada</td>
<td>573 Tcf</td>
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<tr>
<td>6</td>
<td>Mexico</td>
<td>545 Tcf</td>
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<td>7</td>
<td>Australia</td>
<td>437 Tcf</td>
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<tr>
<td>8</td>
<td>South Africa</td>
<td>390 Tcf</td>
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<tr>
<td>9</td>
<td>Russia</td>
<td>285 Tcf</td>
</tr>
<tr>
<td>10</td>
<td>Brazil</td>
<td>245 Tcf</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>1,535 Tcf</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>7,795 Tcf</strong></td>
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</table>
Australian Basins and Estimated Shale Gas Reserves

- CANNING: 235 TCF
- COOPER: 95 TCF
- MARYBOROUGH: 19 TCF
- PERTH: 35 TCF
- GALILEE: 56 TCF

Prepared for:
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U.S. Department of Energy

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EIA/ARI World Shale Gas and Shale Oil Resource Assessment

Technically Recoverable Shale Gas and Shale Oil Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States
Australian Shale Gas Investment

- **2010 - $150MM**
  Conoco/ New Standard

- **2011 $120MM**
  Buru/Mitsubishi

- **2012 $55MM**
  Hess

- **2012 $55MM**
  Hess

- **2012 - $14MM**
  Fortescue

- **2011 - $55M**
  Hess

- **2012 - $210MM**
  Statoil

- **2011 - $50MM**
  CNOOC/Exoma

- **2011 - $130MM**
  BG-Drillsearch

- **2012 - $200MM**
  Transerv
  AWE
  NorWest
  Waarego

- **2012 - $150MM**
  Total/Central

- **2012 - $190MM**
  Santos/Central

- **2012 - $190MM**
  Total/Central

- **2012 - $150MM**
  Santos/Central

- **Ongoing - $1B>**
  Santos, Beach, Strike, Senex, Chevron
Australian Industry Challenges

- Long distances and lack of infrastructure
- Lack of equipment
  - 15 rigs (4 currently operating)
  - 5 frack spreads (Total HP 188,000)
    \((US = 530 \text{ spreads} / 15 \text{ million HP})\)
- Costs
  - Onshore Spread-rate - $100k-$120k/day (drilling)
  - $80k/day (fracking)
  - Warro 5&6 = 4000m well with 6 stage frack (1 million pounds) = $14MM
  - Seismic approval costs = $1MM
  - Well approval costs = $0.5MM
- Land access
  - Lock the Gate “Get off my Land”
  - Native title
  - Activists and Government lethargy
The Onshore Industry in Australia

• Onshore Potential
• Investment
• Challenges

North Perth Basin

• Geology
• Warro Field Appraisal
• Dandaragan Deep Exploration

Summary

• Warro Business
• Onshore Australia Business
North Perth Basin Regional Structure

INDIAN OCEAN

Warro Field

Exploration Permit 321
100,500 net acres

Dandaragan Deep Lead

Retention Leases 6 and 7
67,000 net acres

100km
North Perth Basin Regional Structure

INDIAN OCEAN

NORTH PERTH BASIN

BASIN BOUNDING FAULT

YILGARN CRATON

RETENTION LEASES 6 and 7
67,000 net acres
WARRO FIELD

EXPLORATION PERMIT 321
100,500 net acres
DANDARAGAN DEEP LEAD

Mory and Iasky, 1996, Stratigraphy and structure of the onshore northern Perth Basin, Western Australia
North Perth Basin Exploration History

**Gingin Discovery (1964)**  
Cattamarra Coal Measures  
<5 MMBOE Gas / Condensate

**Cattamarra Coal Measures**

**Walyering Discovery (1971)**  
Cattamarra Coal Measures  
<1 MMBOE Gas / Condensate

**Warro Discovery (1977)**  
500m Gross Column in Lower Yarragadee Formation Tight Sands

**Woodada Discovery (1980)**  
Cargynginia Limestone  
<10 MMBOE Gas / Condensate

**Ocean Hill Discovery (1991)**  
Cattamarra Coal Measures  
Gas flow at 822m³/day

**Cypress Hills-1 (1988)**  
Cretaceous aged meteorite impact structure

**Yallallie-1 (1990)**  
Cretaceous aged meteorite impact structure

**Dandaragan-1 (1995)**  
Upper Yarragadee target. Oil shows in Otorowiri Member

**Barberton-1 (1990)**  
Wagina Sandstone test – failed to intersect primary objective

**Mory and Iasky, 1996, Stratigraphy and structure of the onshore northern Perth Basin, Western Australia**
Perth Basin Regional Cross Sections

WEST

EAST

YARRAGADEE FM

WARRO FIELD

R6 / 7

DANDARAGAN DEEP LEAD

EP 321

Mory and Iasky, 1996, Stratigraphy and structure of the onshore northern Perth Basin, Western Australia
Perth Basin Field Size Distribution

- **WARRO RESERVE**
  - ESTIMATE 2.8 TCF

- **DANDARAGAN DEEP**
  - LEAD RESERVE
  - ESTIMATE 1.6 TCF

- **ORIGIN/AWE 2014**
  - WAITSIA DISCOVERY
  - ESTIMATES 70 BCF

- **Permian-Triassic wrench-induced anticlines**

- **Large regional anticlines set-up by the basin bounding fault – Jurassic target**

**FIELD**
Warro Structure – 2D Seismic

Warro-2/1

Intra-Yarragadee

Top Yarragadee

Top Reservoir

Cadda

Cattamarra Coal Measures

Warro Structure Map at Cattamarra Coal Measures (from Warro-1 Well Completion Report)
Warro Exploration History

Chevron (1976) 2D Seismic Survey

Warro-1 (1977) Chevron - TD 4495m
Exploration well to test large anticline
Lost well due to high pressure in Cattamarra Coal Measures

Warro-2 (1977) Chevron - TD 4854m
Redrill of Warro-1
Confirmed tight gas column, cored, tested – poor flows due to low permeability

Warro 1 and 2 intersected a 500m gross gas bearing section of low permeability fluvial-lacustrine sandstones
Warro Exploration History

**Warro asset acquired (2007)**
- Emergence and success of North American fracking technology
- Potential for significant gas price increases in Western Australia

**Warro-3 (2009)**
- To confirm presence of moveable gas
- Fracked in 4” with Gel, flowed gas 1 - 3 mmcf/d with water
- Hole problems, limited horse-power and poor frack emplacement

**Warro-4 (2011)**
- Better well design and impact of ‘slick-water frack’
- Excellent hole and frack placement – engineering success
- Gas and water production

**Warro 3D Seismic (2011)**
- Post-drilling due to prolonged process for seismic approvals
Warro Exploration History

Watheroo National Park (1978)

Warro 3D area

EP 321

20km
Warro Structure – 2D Seismic

Warro Prospect

SECTION COVERED BY WARRO 3D

Warro Structure Map at Cattamarra Coal Measures (from Warro-1 Well Completion Report)
Warro Structure – 3D Seismic

3D ONLY COVERS WESTERN FLANK OF THE WARRO ANTICLINE

Warro 3D – Top Gas Structure Map

5km

LINE

2.5km

TOP GAS

BASE GAS

INTRA YARRAGADEE

LWR YARRAGADEE
WARRO-3 (2009)
Fracked in 4” casing with gel
Limited frac capacity and poor frac penetration
Flowed 1-3mmcf/d Gas with water

WARRO-4 (2011)
Fracked in 7” casing with Slick-water
Excellent hole and frac placement
Flowed 0.6mmcf/d Gas with water
Warro 3D – Structure and Fault Image Analysis

Base Reservoir (Top Cadda) TWT Structure Map

Area of field currently tested

Base Reservoir (Top Cadda) Incoherence

INSET
Warro Reservoir Properties

A Zone
- Porosity = 8-12%
- 0.01 – 0.1 mD
- Sw = 60%

B Zone
- Porosity = 8-10%
- 0.005 – 0.1 mD
- Sw = 40%

C Zone
- Porosity = 6-10%
- 0.001 – 0.1 mD
- Sw = 30%

Sg = gas saturation
Sw = water saturation
<table>
<thead>
<tr>
<th>Field Name &amp; Basin</th>
<th>Reservoir</th>
<th>Structure</th>
<th>Water Production</th>
<th>Conformance – Water &amp; Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frenchie Draw Wind River Basin, WY</td>
<td>Lance, Fort Union Lenticular alluvial sands, low overall N/G</td>
<td>Plunging anticline with subtle relief</td>
<td>&gt;500 bbl water/mmcfg</td>
<td>none</td>
</tr>
<tr>
<td>Canyon Creek Greater Green River Basin, WY</td>
<td>Ericson Sandstone, high N/G</td>
<td>High relief anticline</td>
<td>2-6 bbl water/mmcfg</td>
<td>none</td>
</tr>
<tr>
<td>Trail Unit Greater Green River Basin, WY</td>
<td>Ericson Sandstone, high N/G</td>
<td>High relief anticline</td>
<td>2-6 bbl water / mmcfg</td>
<td>none</td>
</tr>
<tr>
<td>Pinedale, Greater Green River Basin, WY</td>
<td>Ericson Sandstone, high N/G. Because of water issues the Ericson is not an economic reservoir</td>
<td>High relief anticline</td>
<td>Produces large volumes of water with some gas on local culminations</td>
<td>none</td>
</tr>
<tr>
<td>East Texas Gas</td>
<td>Travis Peak, Cotton Valley, lenticular alluvial sands and shoreface sands</td>
<td>Broad structures with low relief</td>
<td>10’s – 100’s bbl water / mmcfg</td>
<td>none</td>
</tr>
<tr>
<td>Granite Wash Play, Anadarko Basin, OK</td>
<td>Stacked alluvial sandstones, variable N/G</td>
<td>Strong stratigraphic component</td>
<td>25-100 bbl water / mmcfg</td>
<td>Unaware</td>
</tr>
</tbody>
</table>
Test history matching results suggest faulting and associated natural fracturing of the rock matrix are the most likely conduit for water at the observed rates at Warro 3 & 4.

Warro 5 & 6 are located away from major faults and areas of higher potential natural fracturing.
Dandaragan Deep

- Dandaragan Deep is an un-tested 4-way dip structural closure (currently mapped on 2D Seismic)
- 1.6 Tcf Mean Estimated Ultimate Recoverable Reserves
- Structurally and stratigraphically analogous to the proven Warro accumulation
- Currently planning 3D Seismic acquisition program
Potential for increased reservoir quality in Yarragadee due to proximal location and basin geometry / sediment input points.
Regional Structure and Dandaragan Deep

Total Magnetic Intensity

Yallalie-1

Cypress Hill-1

Bevan et al, 2012
Dandaragan-1 (1995)

Upper Yarragadee
Intra-Yarragadee
Lower Yarragadee
Cadda

TD 1103m
Otorowiri 819m-834m
10° API biodegraded Oil

Otorowiwi

Upper Yarragadee
Intra-Yarragadee
Lower Yarragadee
Cadda

62km Closure
1.6 Tcf Mean EUR

Intra-Yarragadee Time Structure
### Proposed Dandaragan 3D Acquisition

**Years:**
- **2015:**
  - **J:** LANDOWNER CONTACT AND AGREEMENTS
  - **J:** SPRING SURVEY

- **2016:**
  - **J:** PRELIMINARY ENVIRONMENT PLAN LODGED
  - **J:** ASCERTAIN CREW AVAILABILITY
  - **A:** SPRING SURVEY

- **2017:**
  - **J:** ENVIRONMENT PLAN APPROVAL (AT EARLIEST)
  - **A:** EARLIEST POTENTIAL ACQUISITION!

**Proposed Dandaragan Deep Prospect**
- Structural Closure: 62 km²
- 1.6 Tcf Mean EUR

**Warro 3D (2011)**

**Dandaragan 3D (Proposed)**

**Proposed 3D:**
- 170 km²
Western Australia Market

WA gas consumption has historically been driven by the mining/mineral processing sector

ALCOA (TSV JV Partner at Warro) is the largest gas user (85+ PJ per year)

Current WA gas prices in the range $5 to $9/mcf...

...WA gas prices are forecast to increase to an average $8-$10/mcf by 2020

Sources: Gas Bulletin Board, IMO, Gas Statement of Opportunities, December 2014, NIEIR
Australian Unconventional Sweet Spots

POTENTIAL
SUPPORTING JURISDICTION
INFRASTRUCTURE AND REMOTENESS
CHALLENGING
GOOD
FAIR
SUPPORTING JURISDICTION
POTENTIAL
Australian Unconventional Sweet Spots

- **CANNING**
  - Drilling ongoing
  - Minimal land access issues
  - Good infrastructure
  - Strong market demand
  - Industry well equipped
  - Critical mass

- **COOPER**
  - Drilling ongoing
  - Limited activity
  - Substantial land issues
  - No infrastructure
  - No nearby market
  - Remote and inaccessible
  - Lacks critical mass

- **PERTH**
  - Drilling ongoing
  - Some land access issues
  - Good infrastructure
  - Strong market demand
  - Industry well equipped
  - Lacks critical mass

- **WA**
  - Green

- **SA**
  - Pink

- **NSW**
  - Orange

- **VIC**
  - Yellow

- **TAS**
  - Red

- **NT**
  - Light red

- ** QLD**
  - Dark red

- **Macro’ Sweet spot mapping**
The Challenges and Opportunities

• Warro is the largest undeveloped onshore gas field in Australia

• Tight gas exploration in Australia is still in its infancy

• Working onshore Australia has improved but there are still significant challenges

• The Cooper Basin and Perth Basin offer the most practical opportunities