Emerging Shale and Tight-Sand Plays, Perth Basin, Western Australia*

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Abstract

Exploration of shale petroleum in the Perth Basin was driven by the rapid increase in shale gas production in the US after 2005. Since the early 70s, hydrocarbon trapped within the source rocks was known and addressed in many publications, but the production of these hydrocarbons was proved when US gas reserves globally rated the highest in 2009. Production from these reservoirs has changed the position of the US from importer to exporter; it achieved the world’s highest oil and gas production in 2014. In shale reservoir, trapping mechanisms are typically subtle and cover large basinal areas; the timing of charge versus trap formation is not as critical as it is in conventional reservoir systems. The US achieved production from shale reservoirs by using a combination of horizontal drilling and hydraulic fracturing. The geological understanding and petroleum prospectivity of the Perth Basin is gradually growing with regard to tight and conventional reservoirs. The Perth Basin has a well-developed infrastructure to explore and exploit shale petroleum resources.

Reference Cited

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Western Australia

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AAPG GTW “Characterization of Asian Hydrocarbon Reservoirs”
Bangkok, Thailand
Friday 1 April 2016: 1:40 – 2:05 PM
Presentation - Overview

Petroleum Systems Concepts

- Perth Basin
- Tight-Reservoirs
- Shale-play modelling
- Petroleum production
- Conclusions
Perth Basin

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Perth Basin

- Time-stratigraphy
- Source
- Reservoirs
- Petroleum systems
Woodada Deep 1

Gas Flare - 11 August 2012  Triassic Core
Perth Basin
Data Distribution

![Bar chart representing data distribution with categories: Wells, TOC & RE, VR Maturity, Heat Flow. The values are 364, 110, 78, and 162 respectively.]
Source Rock Quality Potential

Facies

Maturity
Triassic
Jurassic
Permian
Cretaceous
Petroleum Systems Distribution
Permian

Data source: AGSO & GeoMark 1996 GA 2005
Presentation  Overview

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Shale-plays  United States

Shale Petroleum

95 basins - 137 Shale Formations - 42 countries

Oil - top ten countries - Gas

Oil
1. Russia
2. U.S.A.
3. China
4. Argentina
5. Libya
6. Australia
7. Venezuela
8. Mexico
9. Pakistan
10. Canada

Gas
1. China
2. Argentina
3. Algeria
4. U.S.A.
5. Canada
6. Mexico
7. Australia
8. South Africa
9. Russia
10. Brazil

Status
Exploring
Developing
Exploring
Developing
Exploring
Exploring

Data: EIA 2013

Technically recoverable shale oil resources (billion barrels)

Technically recoverable shale gas resources (trillion cubic feet)
Self-sourcing

Petroleum System

Effective source rocks: 2–20% TOC
Organic-rich shale, carbonate, and coal

- Expelled to conventional reservoirs
- Retained in self-sourcing reservoirs

Total organic carbon

Conventional

Kerogen

Self-sourcing Petroleum Systems

Convertible carbon

Residual carbon
Shale Petroleum Australia

Oil - Australian basin - Gas

Canning Basin
- Ordovician Goldwyer Formation: 9.75
- Triassic Kockatea Shale

Perth Basin
- Western Australia: 0.54
- Permian lacustrine shales: 1.56

Cooper Basin
- Eastern Australia: 4.65
- Cambrian Arthur Shale
- Precambrian Velkerri and Kyalla shales

Georgina Basin
- Central Australia: 0.99

Beetaloo Basin
- Central Australia: 4.65

Canning Basin
- Ordovician Goldwyer Formation: 234.8
- Permian Caygina Formation: 12.8

Perth Basin
- Triassic Kockatea Shale: 7.9
- Permian lacustrine shales: 9.29

Cooper Basin
- Cetaceous Goodwood/Cherwell: 19.2

Maryborough Basin
- Eastern Australia: 24.8

Georgina Basin
- Cambrian Arthur Shale: 12.8
- Precambrian Velkerri and Kyalla shales: 43.7

Beetaloo Basin
- Central Australia: 43.7

Data: EIA/ARI May 2013
Fracturing Quality - Petrography

Permian Carynginia Formation
Redback 1: 3762.00 m
TOC = 2.38%
Ro = 1.40%
Brittleness: 0.38

Triassic Kockatea Shale
Redback 2: 3788.52 m
TOC = 2.29%
Ro = 1.32%
Brittleness: 0.29
- Perth Basin
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Shale-plays Modelling – Arrowsmith 2

- Petroleum generation modelling plays a critical role in assessing richness of self-contained (source-reservoir-seal) petroleum systems:
  - Organic-richness and maturity
  - Source-rock trapped hydrocarbon-richness
  - Source-rock fracturing quality (clay-richness)
Arrowsmith 2

- Kockatea Shale
- Hovea Member
- Carynginia Formation
- Cattamarra Coal Measures
Arrowsmith 2 – Maturity Modelling

Maturity VR LLNL (%Ro)

Temperature

Depth Subsurface (m)

Government of Western Australia  Department of Mines and Petroleum
Arrowsmith 2
Kockatea Sh

Initial TOC [5.00]
Transformation Ratio [1.00]
Production Index [1.00]
Thickness for Rock Unit [500.00]
Maturity VR LLNL [3.00]
Presenter’s notes: Perth Basin heat flow distribution on the left and subsurface temperatures distribution on the right. Heat flow values range from a low of about 46 to a high of about 114 milliwatts per square metre. The temperature distribution in centigrade to a depth of 5 kilometre range from a low temperature of about 110 degree centigrade in the south to high temperatures of about 250 degree centigrade in the north. These figures indicate that northern parts of the Perth Basin are comparatively more prospective for developing geothermal energy.
Apatite Fission Track Analysis

- Regional paleothermal event of the Perth Basin
- Identified from analysis of 15 samples representing 26 tracks of the Permian to Jurassic rocks from three wells:
  - Arranoo South 1
  - Cataby 1
  - West Erregulla 1
Presentation Overview

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Western Australia
2014

- **Perth**
  - Oil (bbl): 7,334,711,19
  - Condensate (bbl): 1,16
  - Gas (cubic feet): 6,720,35

- **Canning**
  - Oil (bbl): 128,02
  - Condensate (bbl): 14,01
  - Gas (cubic feet): 2,228,18

- **Carnarvon**
  - Oil (bbl): 8,033,893,01
  - Condensate (bbl): 104,32
  - Gas (cubic feet): 325,50
Most Australian gas markets are based on bilateral arrangements between producers, major users and retailers linked together through pipeline hubs connecting gas fields to gas consumers.
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Total Gross: + 700 Bcf
Waitsia gasfield 2014
largest on shore discovery
Reserves: 89 Bcf (2P)
Resources: 153 Bcf (2C)
Source: AWE 2015

Permian Carynginia
Formation: Gas 24.8 Tcf
Triassic Kockatea
Shale: Gas 7.9 Tcf
Oil: 0.54 billion bbl

Source: EIA/ARI
2013

Gas Reserves: 0.05 Tcf (2P)
Gas Resources: 0.33 Tcf (2C)

Gas Reserves: 12 Tcf (GIIP)
Source: Department of Mines & Petroleum
Presenter’s notes: Another outlook for shale-gas for many countries including Australia. Up to 25% will be contributed by shale gas by 2040, hopefully correct.
Thanks

Questions