Big Oil from “Gas-Prone” Source Rocks and Leaking Traps: Northwest Borneo*

Sam Algar

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Key Comments

Murphy’s Record
- Malaysia from 1999– Deep and shallow water
  ✰ 31 discoveries in 8 years
  ✰ 57% exploration success rate
  ✰ 1st deepwater oil discovery in NW Borneo
  ✰ World’s fastest first oil for deepwater field
  ✰ Shelf oil and gas production
    ✰ Low cost
    ✰ Complementing existing facilities
  ✰ High local content
  ✰ Top quartile safety performance
  ✰ Current gross production ~125,000 boepd
  ✰ >50% Murphy global net production
- 2003 - Brunei – Extending Deepwater Malaysia

Current Model
- Fluid type/proportion controlled by:
  ✰ Burial depth
  ✰ Column height
  ✰ Overpressure
- Leaky trap required for significant oil accumulation!

Conclusions
- NW Borneo deepwater oil play opened up by contrarian thinking
“New” source rock for deepwater
“Leaky” traps required for significant oil fields

Learnings
- Look for alternative ideas – challenge dogma.
- Talk to others – learn from one another.
- Apply learning from one area to another.
- Be prepared to champion your controversial new idea.
- Secure running room in a new play.
- Be prepared to fail.
- Persevere.

Reference
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Sam Algar
Murphy Oil

September, 2012
Murphy Oil 1998

Market Cap ~$2Billion

Locations:
- Alaska
- Offshore Canada
- Onshore Canada
- Gulf of Mexico
- U.K. North Sea

Map showing Murphy Oil's operations in various locations.
Murphy Oil 2012

Market Cap ~$10Billion

- Alaska
- Eagle Ford Shale
- Offshore Canada
- Gulf of Mexico
- U.K. North Sea
- Iraq
- Suriname
- Brunei
- Malaysia
- Indonesia
- Australia
- Onshore Canada
- Cameroon
- Congo
- Congo
- Cameroon
- CONGO
Presenter’s notes: Timing and relationships: Malaysia realised it needed to incentivise exploration; Improved fiscal terms; Looking to Independents to revitalise exploration; Limited competition at a time of low oil prices; Balanced risk profile—low-risk shelf exploration/development, high-risk deepwater – unproven.
West Patricia Oil Field
- Discovered 2001
- On Production 2003

2011 Production
- Gas = 260 MMCFPD
- Condensate = 3,700 BOPD
- W. Patricia = ~5,000 BOPD
# Deepwater Exploration “Must-Haves”

<table>
<thead>
<tr>
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<th>High Perm Reservoir</th>
<th>Large Prospects</th>
<th>Oil-Prone Source Rock</th>
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<tbody>
<tr>
<td>Angola</td>
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Presenter’s notes: Exploration on East Borneo had also found predominantly gas in deepwater; this at least helped the theory that there was a reservoir, but not an oily one.
1999 2D Seismic Grid

Offshore Sabah - Block K
Bathymetry Based on Seismic

MURPHY SABAH OIL CO., LTD.

All Depths in Metres
Velocity used: 1500m/sec

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Presenter’s notes. Toe thrusts in blocks K and P.
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1st Murphy Malaysia DW Well: Bagang-1

- Supra- & Sub-thrust traps
  - Recent Failure of Supra-thrust trap (Ubah-1)
  - 3D seismic not processed in South

- Spud Mar 2002
- WD 1705m
- Minor ?Gas Discovery
- Oil Shows....
- Proved Significant Reservoir
2nd Murphy Malaysia DW Well: Bliais-1

- Outboard – allaying top seal concerns
- Spud May 2002
- WD 1875m - deepest water depth drilled in Malaysia
- TD 4211m
- Gas shows
- Failure due to lack of reservoir and possibly lack of charge
STOP

“2 Dry Holes
Let's Get Out”
But our chances of Success were 1 in 3.....
3rd Murphy Malaysia DW Well: Kikeh-1

- 3D Seismic ready in South
- More proximal than Bliais
- Spud July 2002
- WD 1313m
- 93.3m Net Oil Pay
- ~400mmbbl Oil Discovery
Presenter’s notes: In 2002 Murphy discovers Kikeh Field—first commercial deepwater oil field in Sabah. This proved oil potential of deepwater and initiated a period of active exploration. Since that time, a number of potentially commercial oil discoveries have been made in the deepwater. Total potentially recoverable reserves will be in the billions of barrels – not bad for a petroleum system unproven until 4 years ago!! So what is the source rock for all of this oil?
2007:
~1.5 Billion BBls Rec. Oil Discovered

- 9 New Oil Discoveries
- 2 New Gas Discoveries

Kikeh Field Producing

Kota Kinabalu

Borneo
Murphy Malaysia Exploration

- 31 Discoveries in 8 years
- 57% Exploration Success Rate
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- World’s Fastest First Oil for Deepwater field
- Shelf Oil & Gas Production
  - Low Cost
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**SB Discoveries**

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BUT WHERE DOES THE OIL COME FROM?
Potential Source Rocks

Deepwater sediments

Rifted Oligo-Miocene section
TOO MATURE (Ro>2)

Kikeh Oil Field

3X Vertical Exaggeration
Transportation of organic matter to shelf with sands
NW Borneo Deepwater Source Rock

NW Borneo Mangrove Forest

NW Borneo Shoreline

NW Borneo Deepwater (Core from Kikeh Field)
Source - IN TURBIDITE SANDS

- Organics predominantly in sandstones
- Pyrolysis indicates limited oil potential
With such a “gas-prone” source rock, why are there so many OIL FIELDS?
Presenter’s notes: The oil-prone kerogen appears to have been washed away during the process of cleaning the oil-based mud.
No direct relationship between source maturity and HC phase
Gas Leakage via faults

- Proven mechanism worldwide (Sales 1997)
- Primary mechanism in Kutei Basin, E. Borneo:

Increasing Degree of Faulting

Increasing % Oil

- Tunu, Peciko Trend
- Sisi, Nubi Trend
- Gendalo, Gula, Gandang
- West Seno, Ranggas
- Yakin, Sepinggan
- Attaka, Bekapai
Could this be the explanation for the abundance of oil relative to gas in Sabah shelf fields?

Most oil fields on Sabah shelf have abundant crestal faulting; e.g., South Furious, Barton, Semarang, Erb West, St. Joseph, Tembungo.
Presenter’s notes: This is a representative seismic line through a deepwater oil field. As can be seen, it is obscured by a poor data zone. We have drilled through this poor data zone and measured sonic velocities in it – which are significantly reduced. We interpret this zone to be a GAS CLOUD. Gas cloud is product of seals leaking by capillary seal failure. Gas is lost preferentially over oil because the molecules are smaller, and there is less surface tension to overcome to move the molecule through the narrow and tortuous pores. End result is that reservoir is enriched in OIL.
Burial depth vs. Fluid Phase

Gas Cloud & Oil Accumulations

Oil fields:
- Shallow burial with gas cloud

Gas fields:
- Deep burial with no or small gas cloud
Current Model

- Fluid type/proportion controlled by:
  - Burial Depth
  - Column Height
  - Overpressure

- A Leaky Trap required for significant oil accumulation!
Green: HCs in liquid phase, liquid migration
Red: HCs in vapor phase, vapor migration

Gas cloud is predicted by modelling!!

Main Kikeh reservoirs
Deep Kikeh reservoirs
Minor local generation/migration

Middle Miocene main source rock

Horizontal and vertical migration
Conclusions

- NW Borneo Deepwater Oil Play opened up by contrarian thinking
- "New" Source Rock for Deepwater
- "Leaky" Traps required for significant oil fields
Discovery Thinking – Track Record

- 1999 - Malaysia – *Deep and Shallow water*
- 2003 - Brunei – *Extending Deepwater Malaysia*
- 2005 - Congo – *Tertiary Oil, Cretaceous Rafts & Pre-Salt*
- 2007 - Suriname – *Atlantic margin strat play*
- 2007 - Canadian Tight Gas - *Montney*
- 2008 - E. Indonesia - *Jurassic Strucs.*
- 2009 – Eagle Ford Shale
- 2010 - Iraq – Kurdistan
- 2012 - TBA!

*Source: Wood Mackenzie*
- Look for Alternative Ideas – Challenge Dogma
- Talk to Others – Learn from One Another
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