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

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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

Sales, J.K., 1997, Seal strength vs. trap closure-a fundamental control on the distribution of oil and gas, *in* R.C. Surdam, (ed.), Seals Traps, and the Petroleum System: AAPG Memoir 67, p. 57-83.

Big Oil from "Gas-Prone" Source Rocks and Leaking Traps: NW Borneo

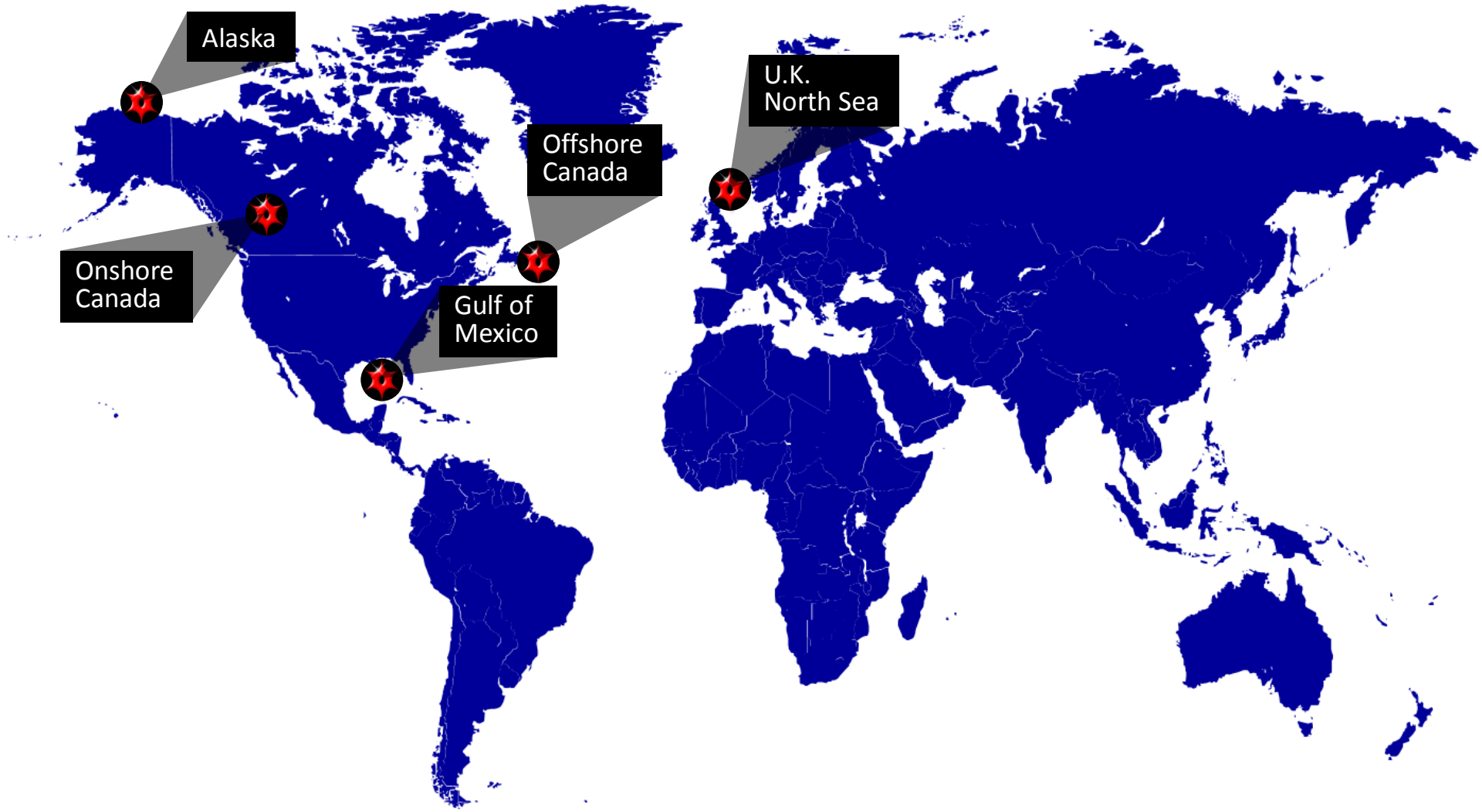
Sam Algar

Murphy Oil

September, 2012

Murphy Oil 1998

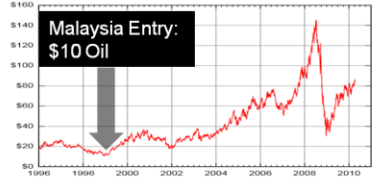
Market Cap ~$2Billion



Murphy Oil 2012

Market Cap ~$10Billion

Murphy's Entry into Malaysia in 1999



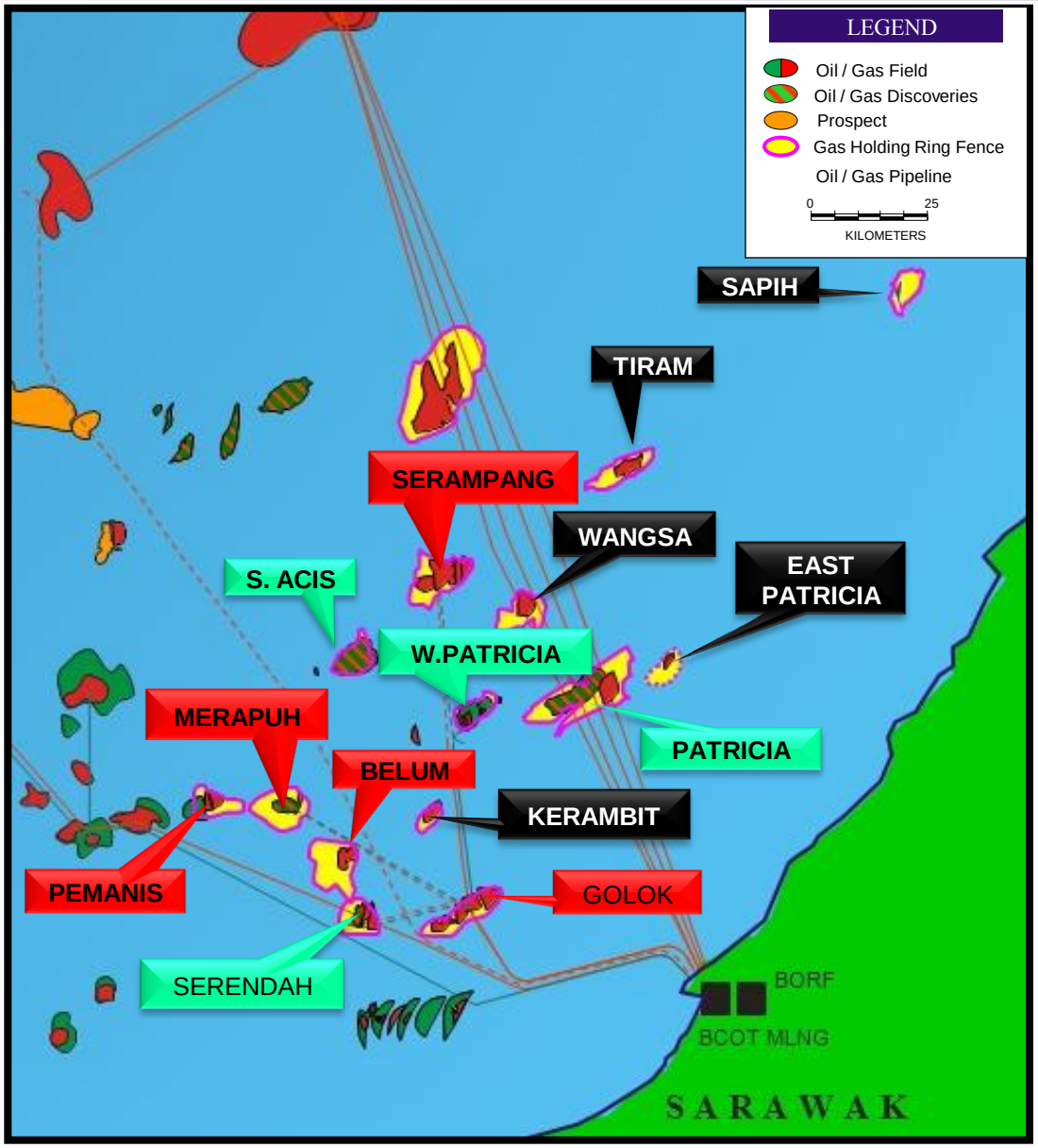
- Contrarian Timing
- Alignment w/ Government
- Balanced Portfolio

- Low Exposure
- High Upside
- Extensive Running Room

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.

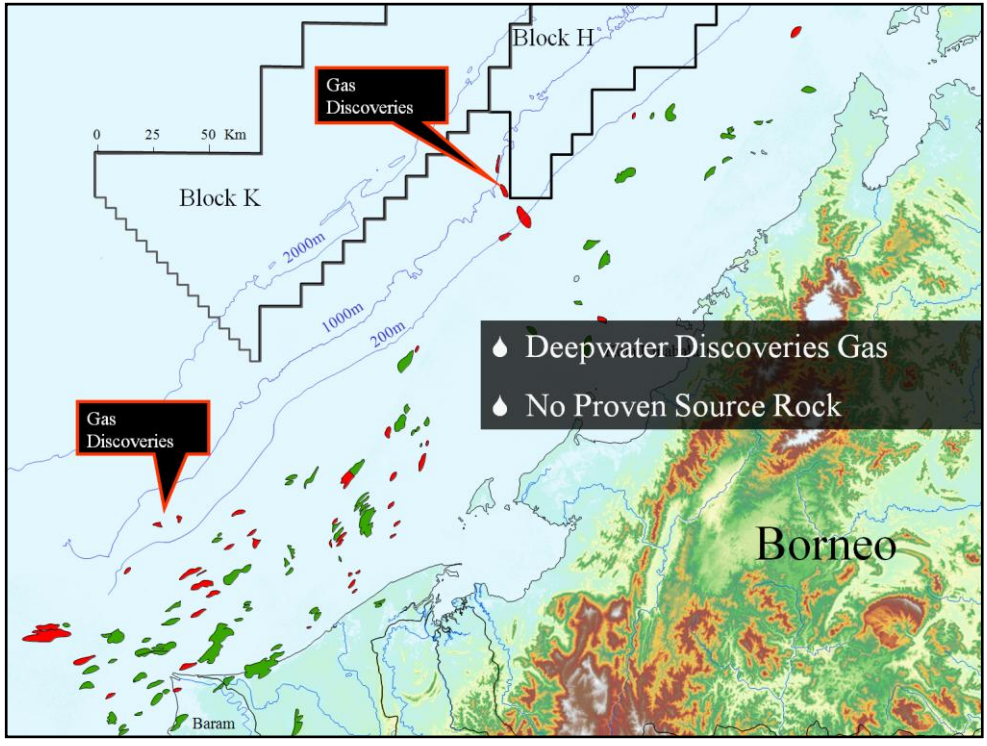
Shallow Water – Early Success

- **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"

	High Perm Reservoir	Large Prospects	Oil-prone Source Rock
Angola	✓	✓	✓
Brazil	✓	✓	✓
Gulf of Mexico	✓	✓	✓
Borneo	✓	✓	✗



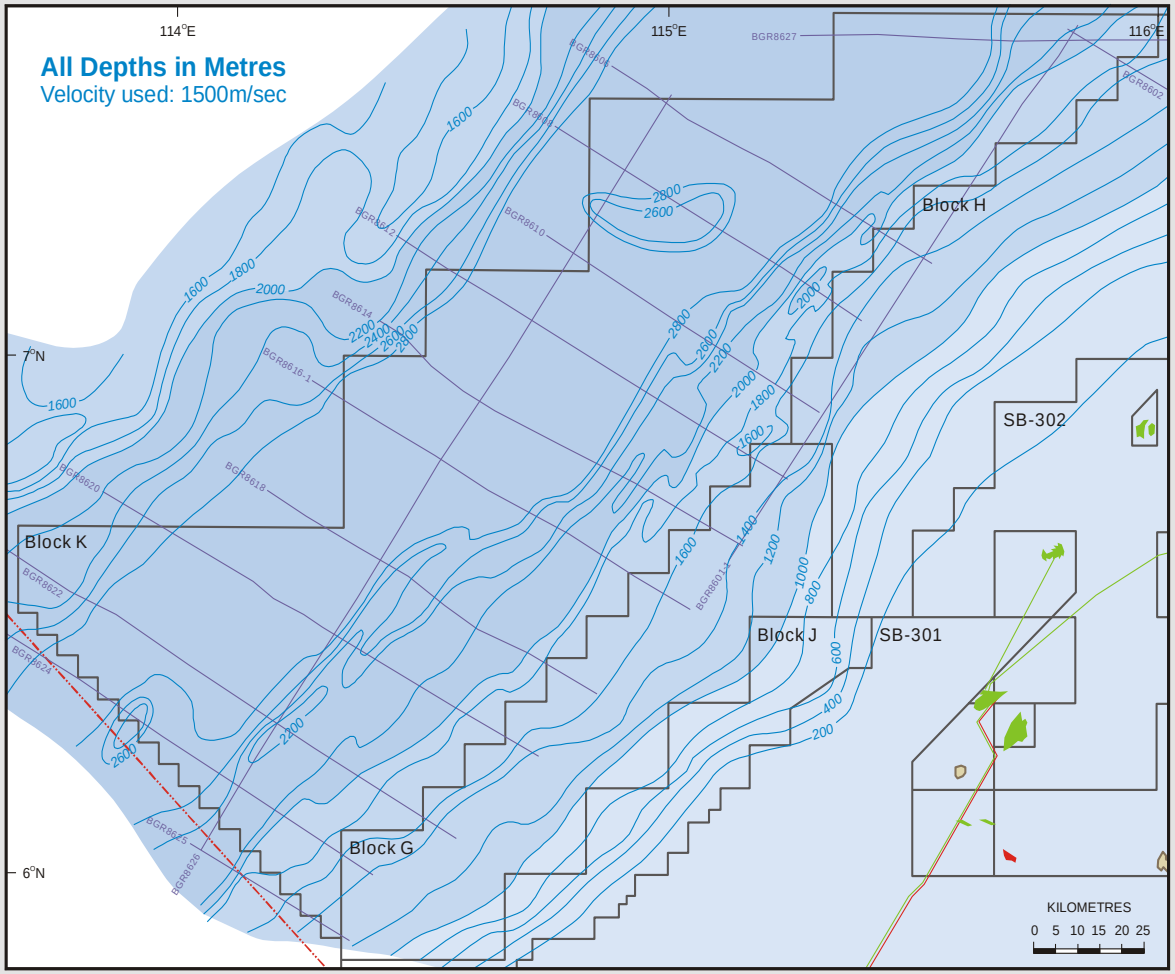
Presenter's notes: Exploration on East Borneo had also found predominantly gas in deepwater; this at least helped the theory that there was a reservoir, but not an oily one.

1999 2D Seismic Grid

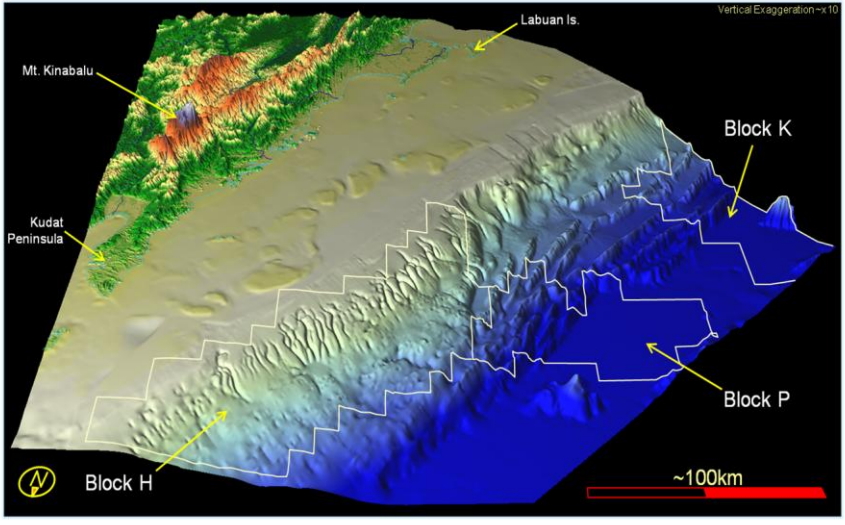
MURPHY SABAH OIL CO., LTD.

Offshore Sabah - Block K

Bathymetry Based on Seismic



1999 Play Concepts



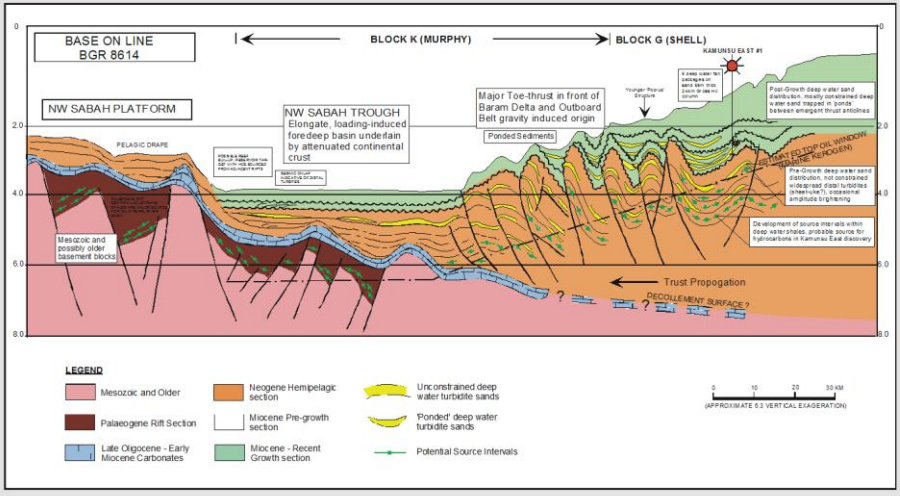
- Present day morphology of Sabah Trough reveals the location of different structural domains

Presenter's notes. Toe thrusts in blocks K and P.

1999 Play Concepts

MURPHY SABAH OIL CO., LTD.

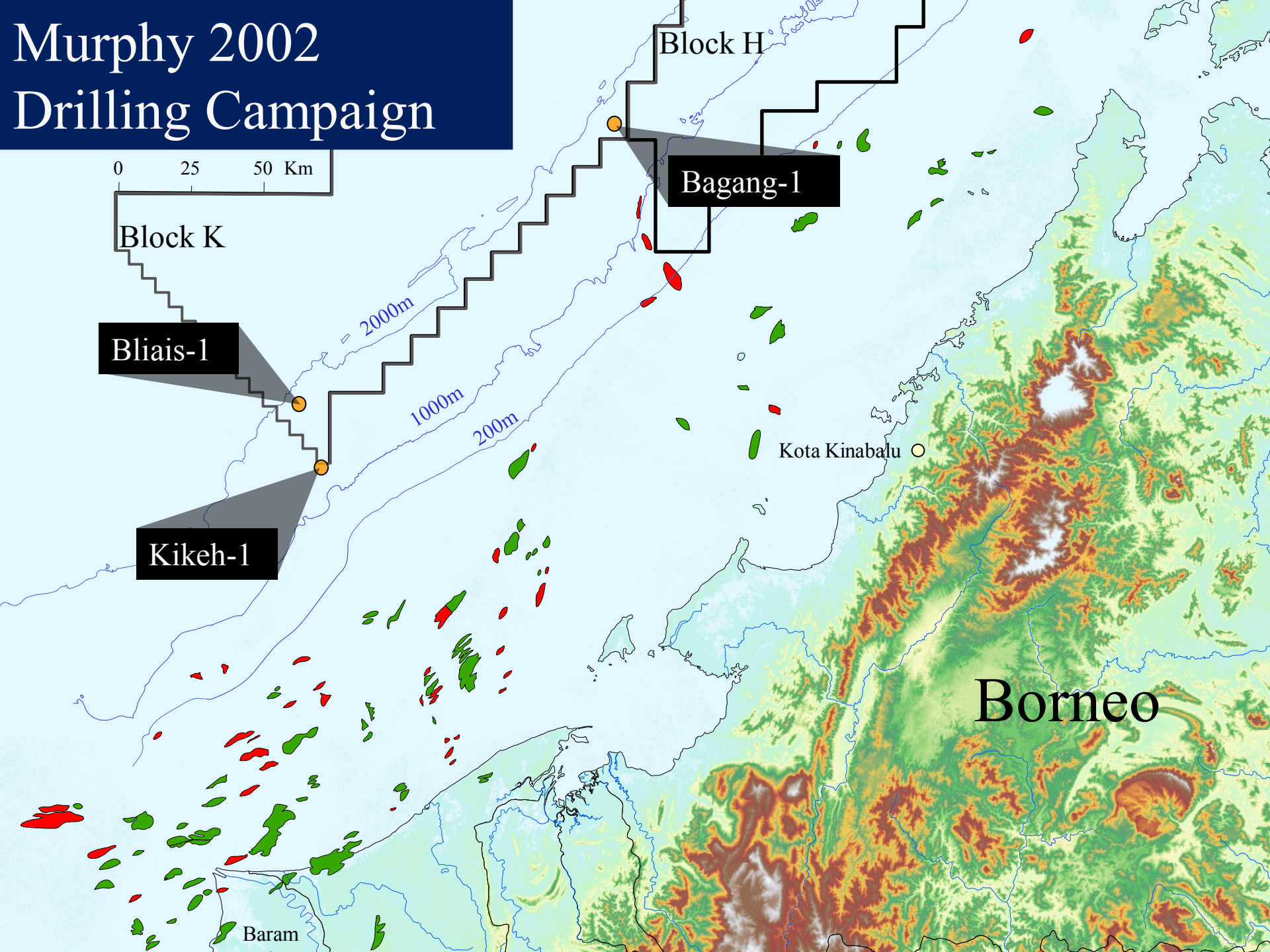
Offshore Sabah - Block K
Play Summary Section



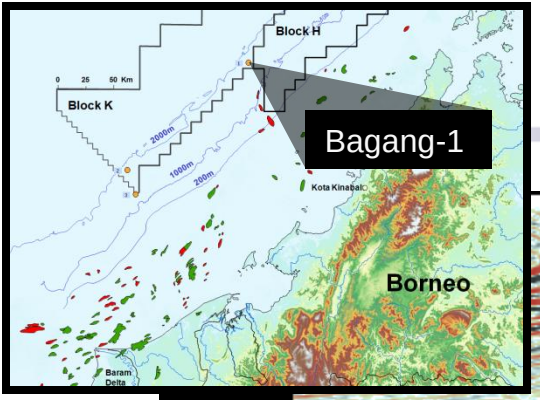
December 1999
j:\malaysia\playsum\

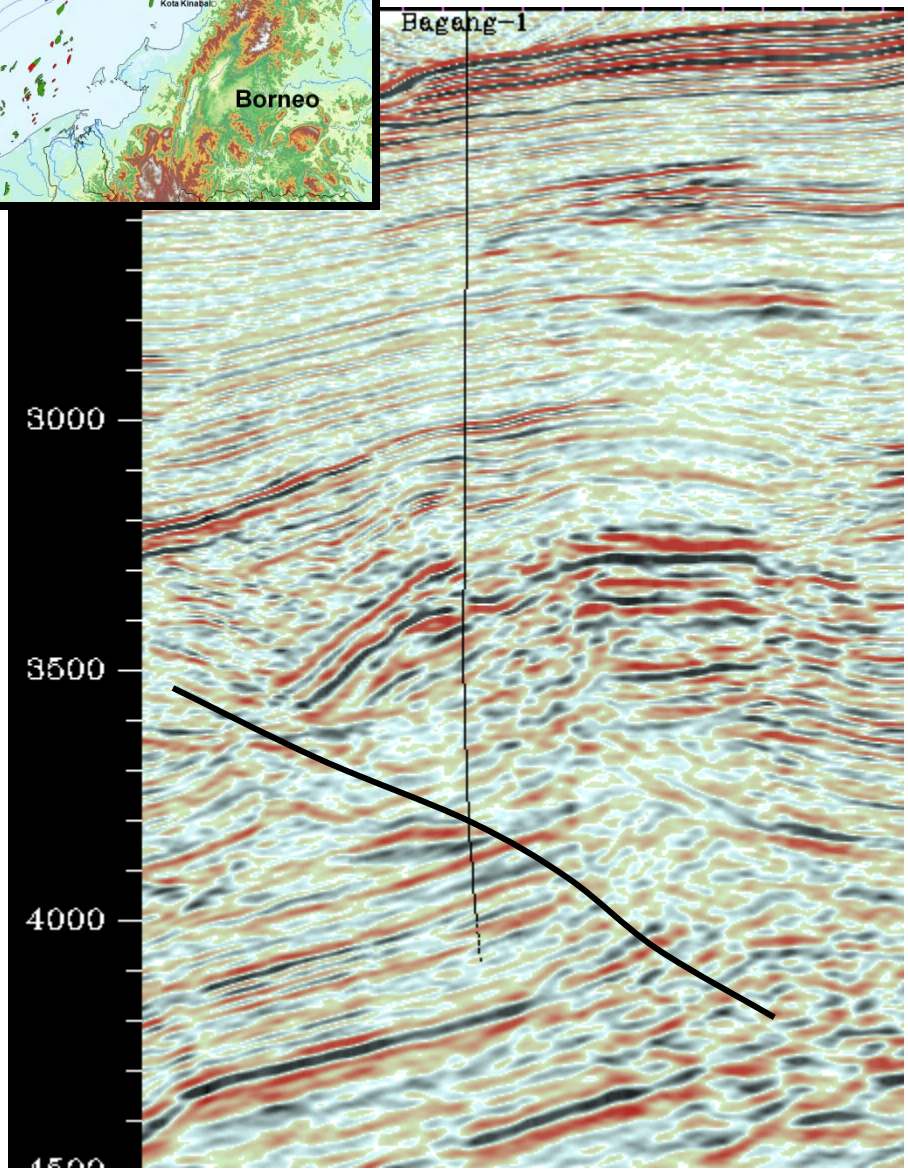
Figure 20

Presenter's notes: Toe-thrusts in blocks K and P.


Murphy 2002
Drilling Campaign
0
25
50 Km
Block K
Block H
Bliais-1
Bagang-1
Kikeh-1
2000m
1000m
200m
Kota Kinabalu
Borneo
Baram

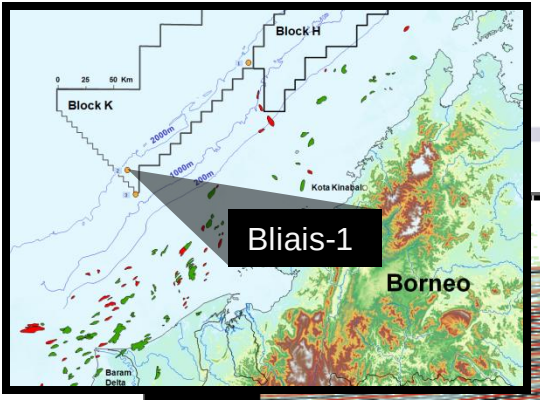
1st Murphy Malaysia DW Well: Bagang-1

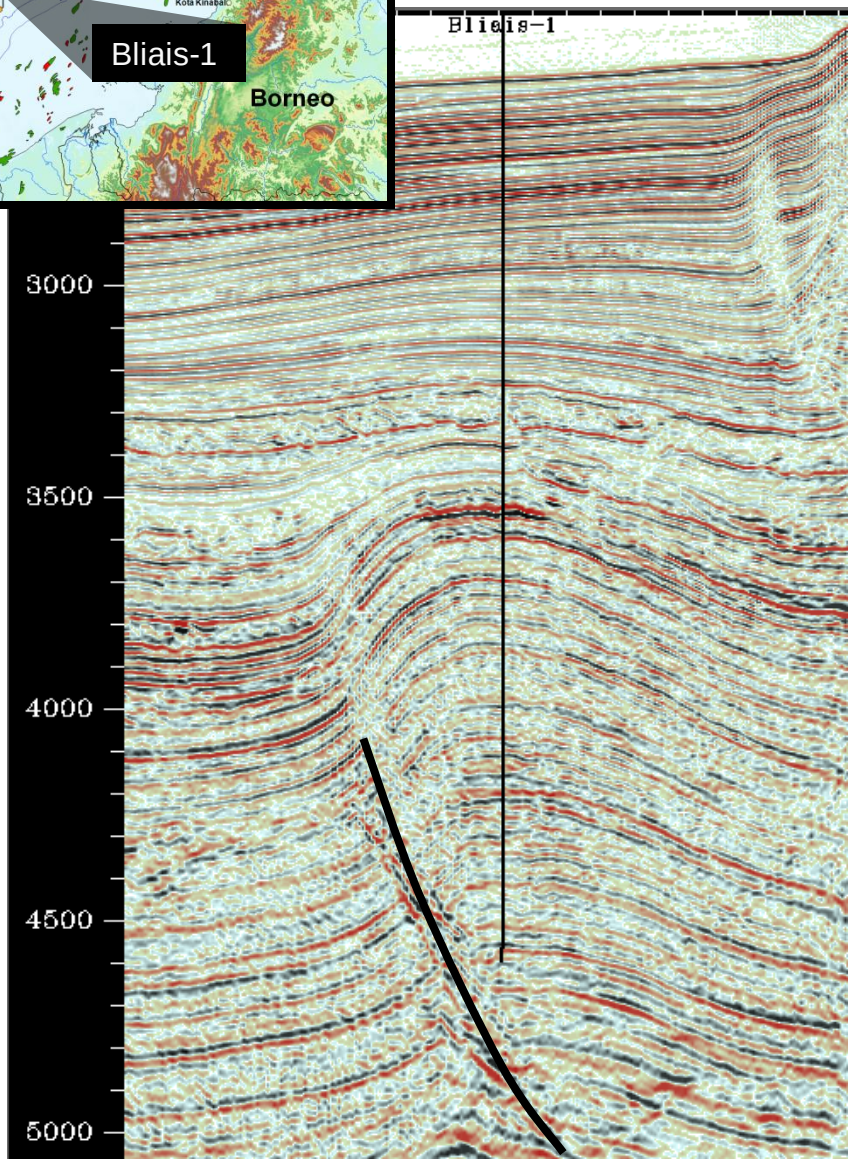




- Supra- & Sub-thrust traps
  - Recent Failure of Supra-thrust trap (Ubah-1)
  - 3D seismic not processed in South
- Spud Mar 2002
- WD 1705m
- Minor ?Gas Discovery
- Oil Shows....
- Proved Significant Reservoir

2nd Murphy Malaysia DW Well: Bliais-1





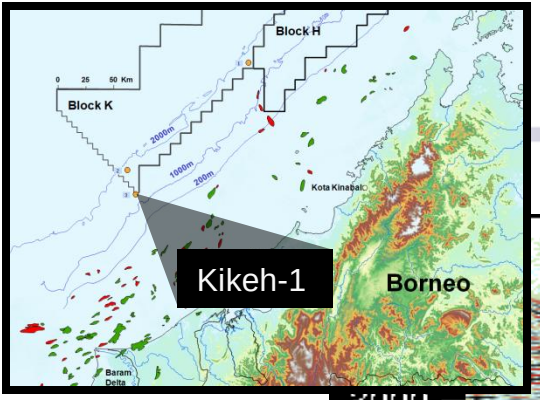
- Outboard – allaying top seal concerns
- Spud May 2002
- WD 1875m - deepest water depth drilled in Malaysia
- TD 4211m
- Gas shows
- Failure due to lack of reservoir and possibly lack of charge

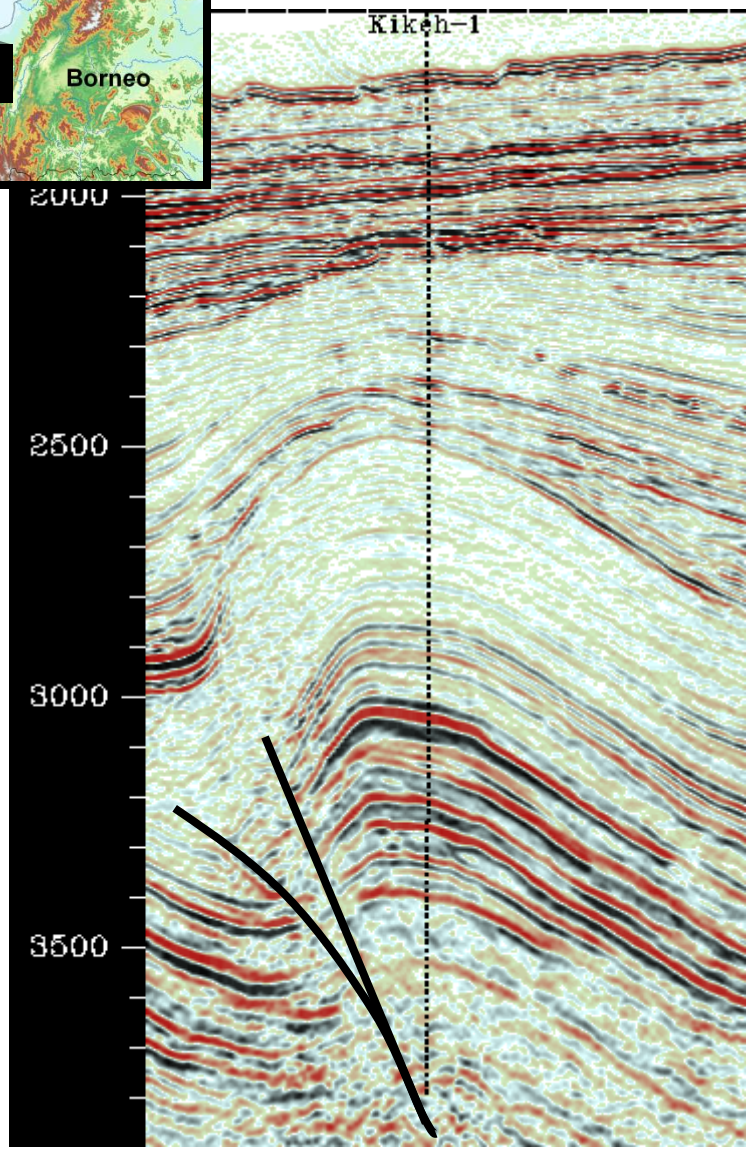
STOP

“2 Dry Holes
Lets Get Out”

But our chances of Success were 1 in 3.....

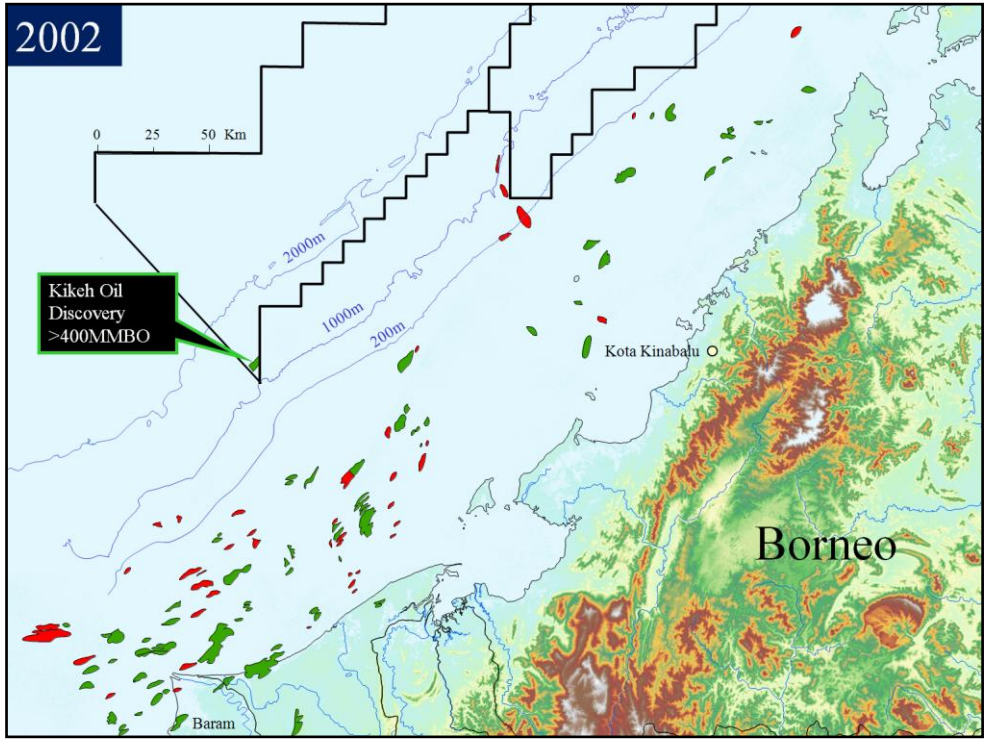
3rd Murphy Malaysia DW Well: Kikeh-1



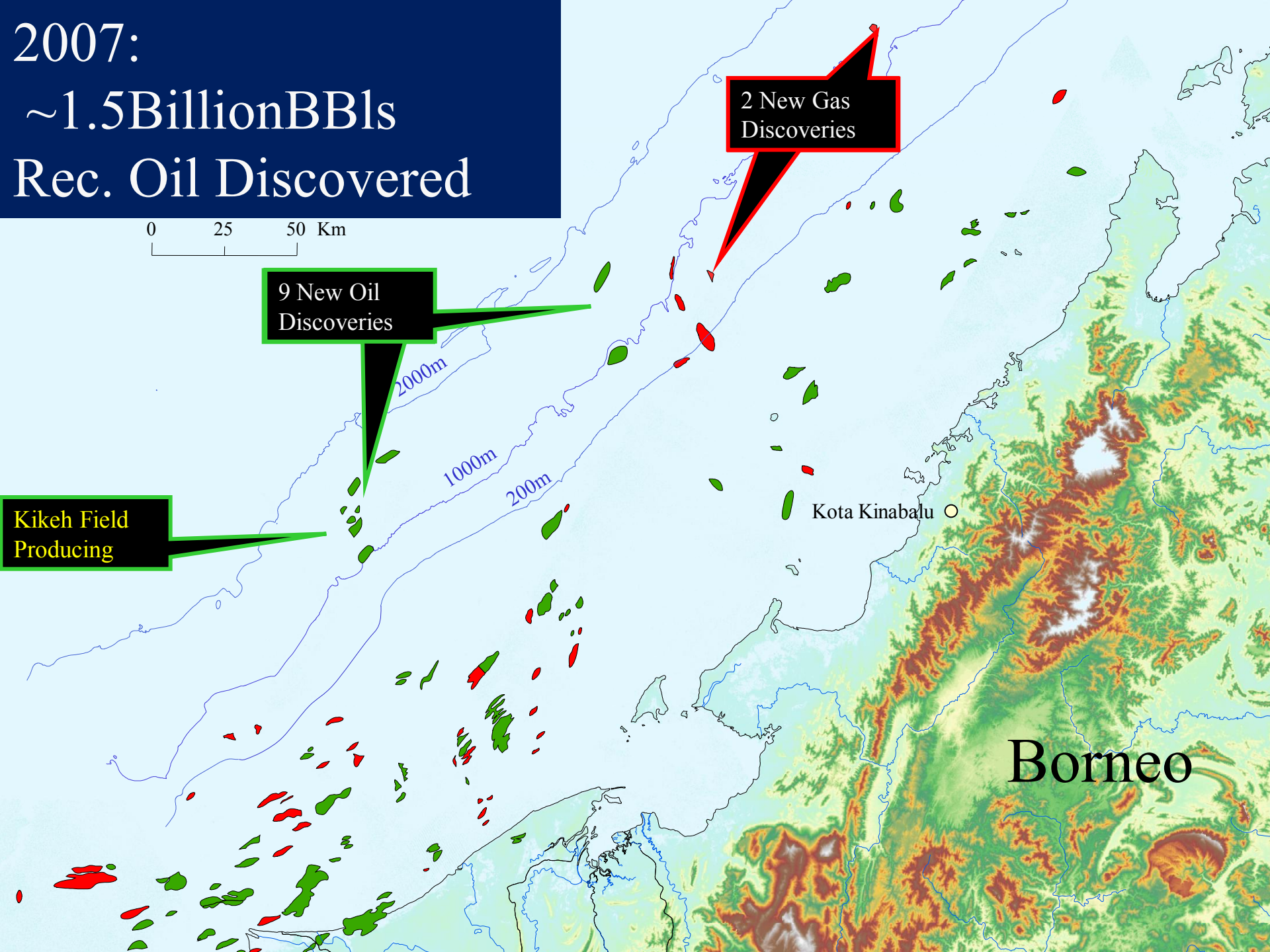


- 3D Seismic ready in South
- More proximal than Bliais
- Spud July 2002
- WD 1313m
- 93.3m Net Oil Pay

~400mmbbl Oil Discovery



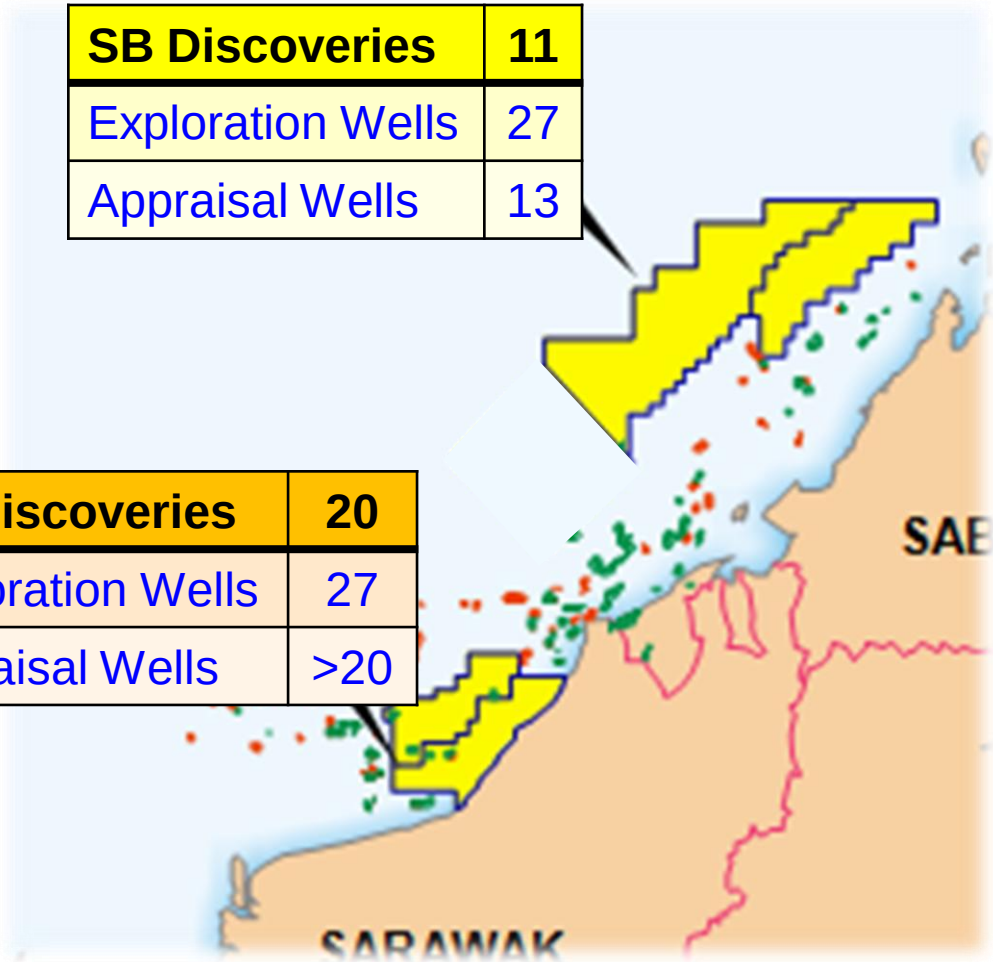
Presenter's notes: In 2002 Murphy discovers Kikeh Field--first commercial deepwater oil field in Sabah. This proved oil potential of deepwater and initiated a period of active exploration. Since that time, a number of potentially commercial oil discoveries have been made in the deepwater. Total potentially 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:
~1.5BillionBBls
Rec. Oil Discovered
0 25 50 Km
2 New Gas Discoveries
9 New Oil Discoveries
2000m
1000m
200m
Kikeh Field Producing
Kota Kinabalu
Borneo

Murphy Malaysia Exploration

SB Discoveries	11
Exploration Wells	27
Appraisal Wells	13

SK Discoveries	20
Exploration Wells	27
Appraisal Wells	>20



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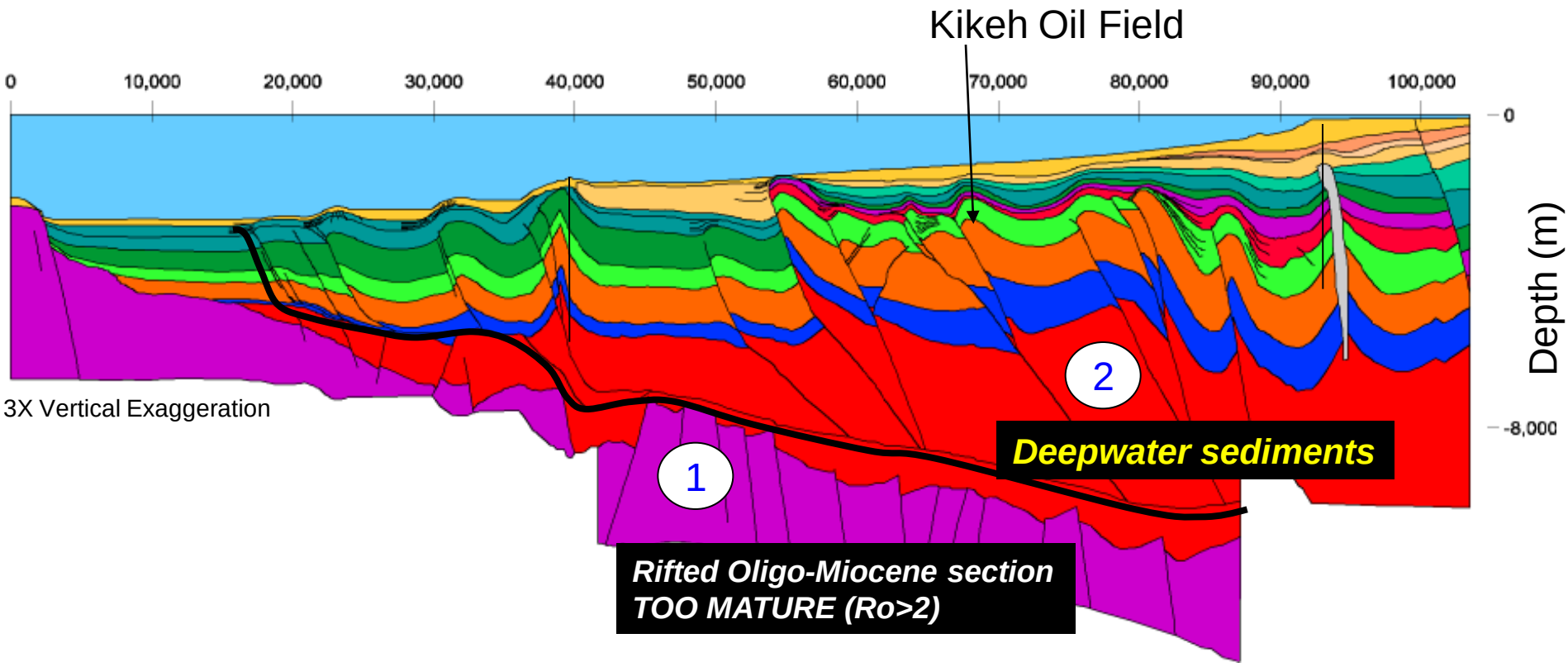
- Shelf Oil & Gas Production
  - Low Cost
  - Complementing existing facilities
- High Local Content
- Top Quartile Safety Performance
- Current Gross Production ~125,000 boepd
- >50% Murphy Global Net Production

BUT WHERE DOES THE OIL COME FROM?

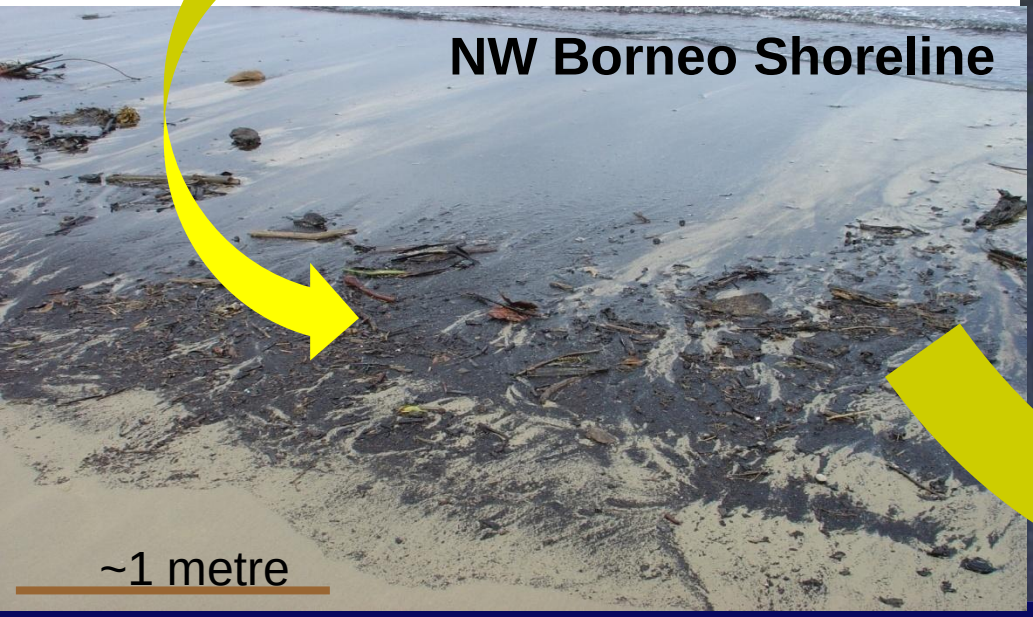
Potential Source Rocks

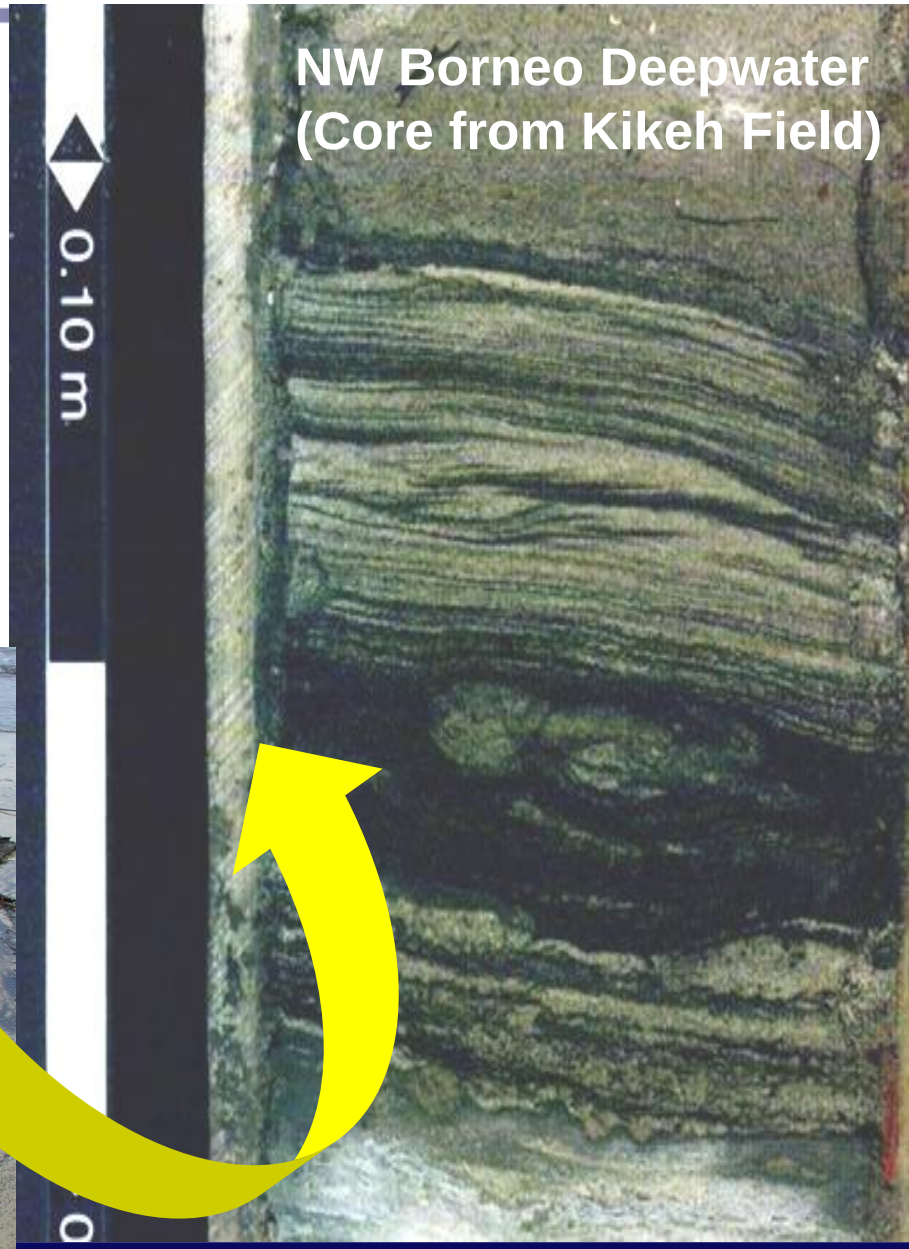


E. Borneo Deltaic Peat Ridge

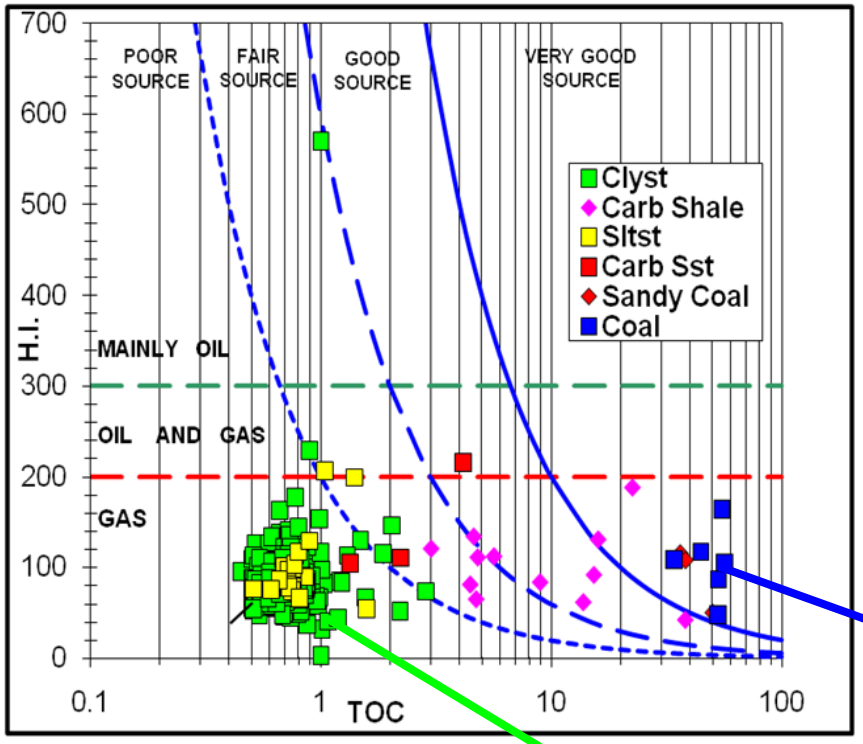
Transportation of organic matter to shelf with sands

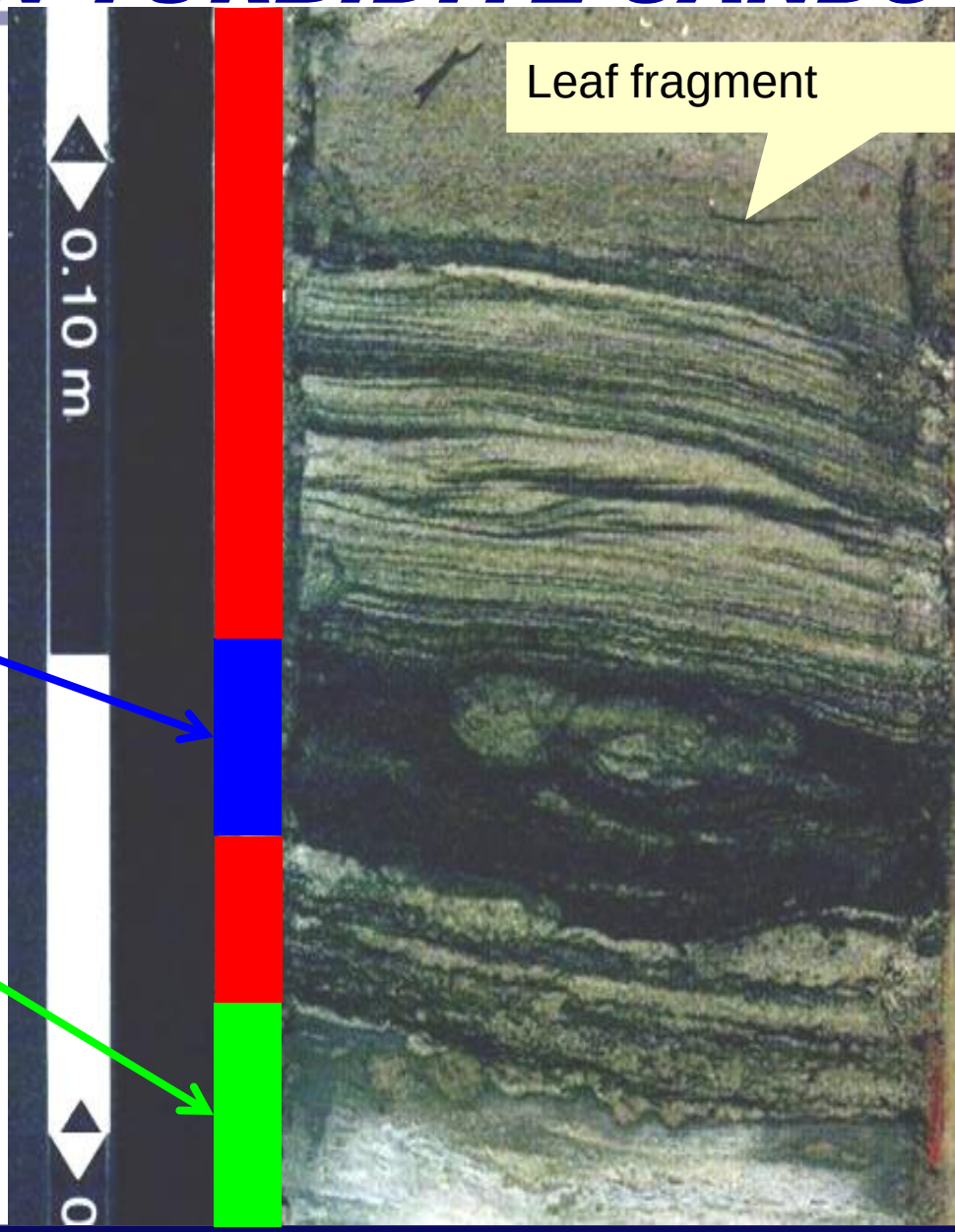
NW Borneo Deepwater Source Rock



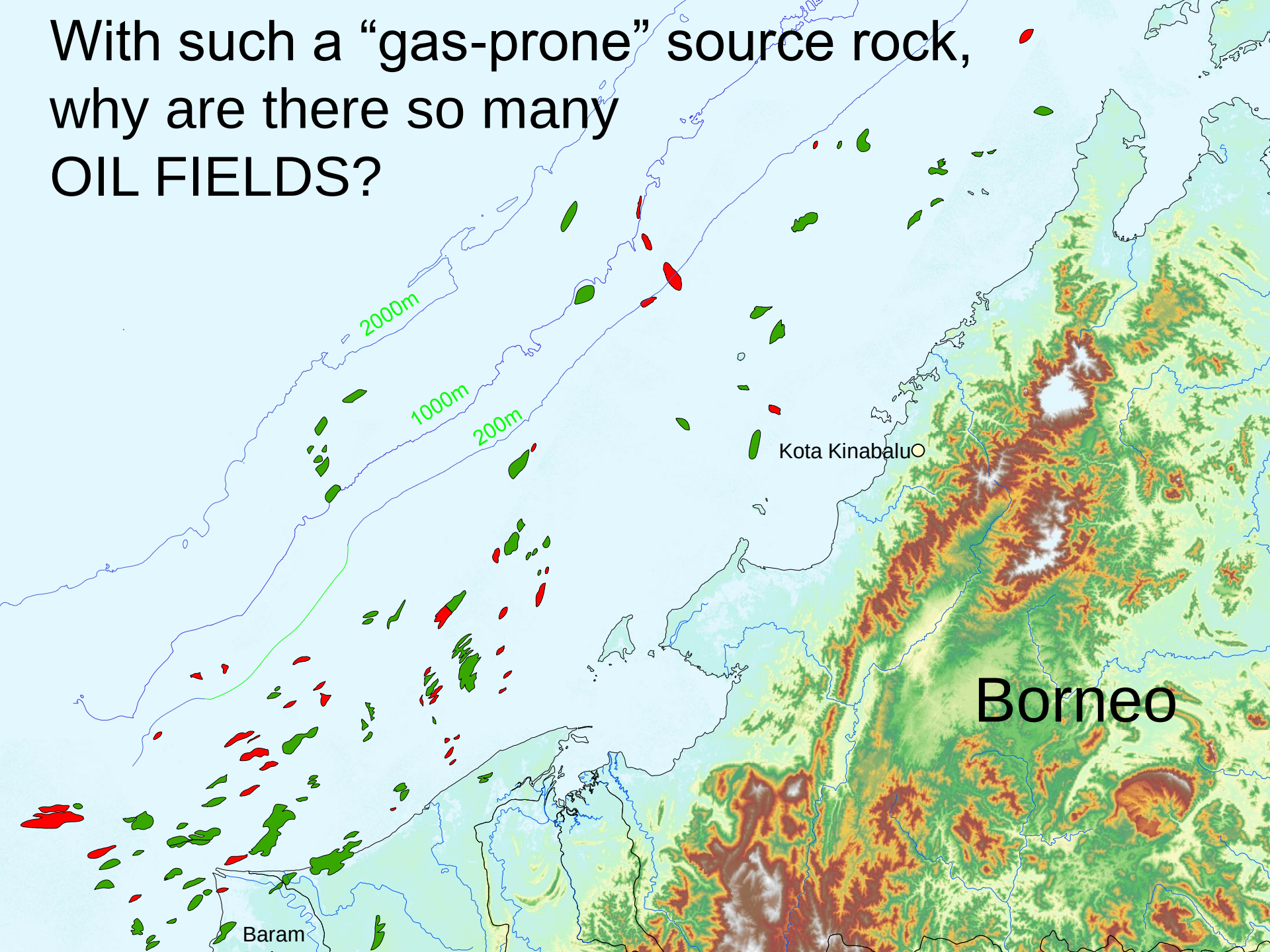


Source – IN TURBIDITE SANDS

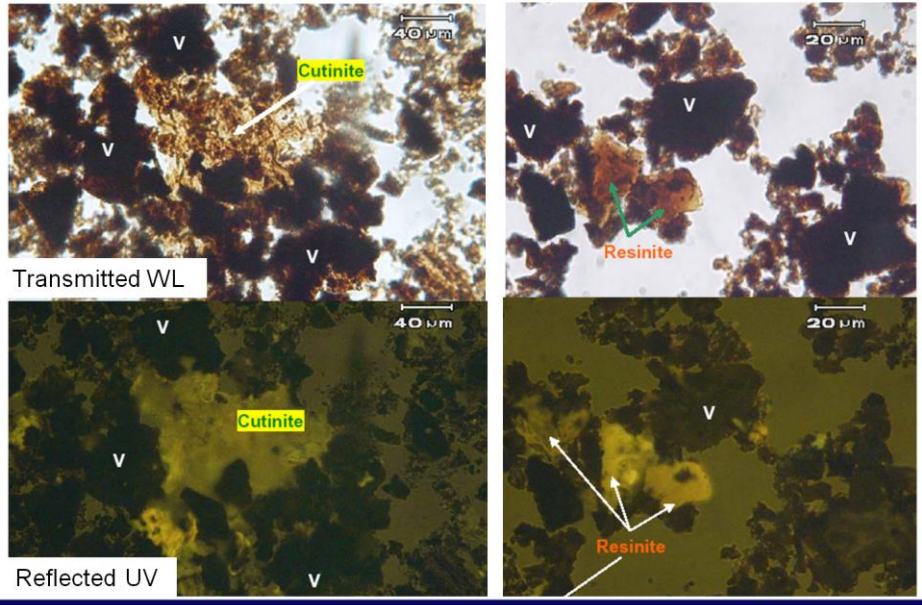




- Organics predominantly in sandstones
- Pyrolysis indicates limited oil potential

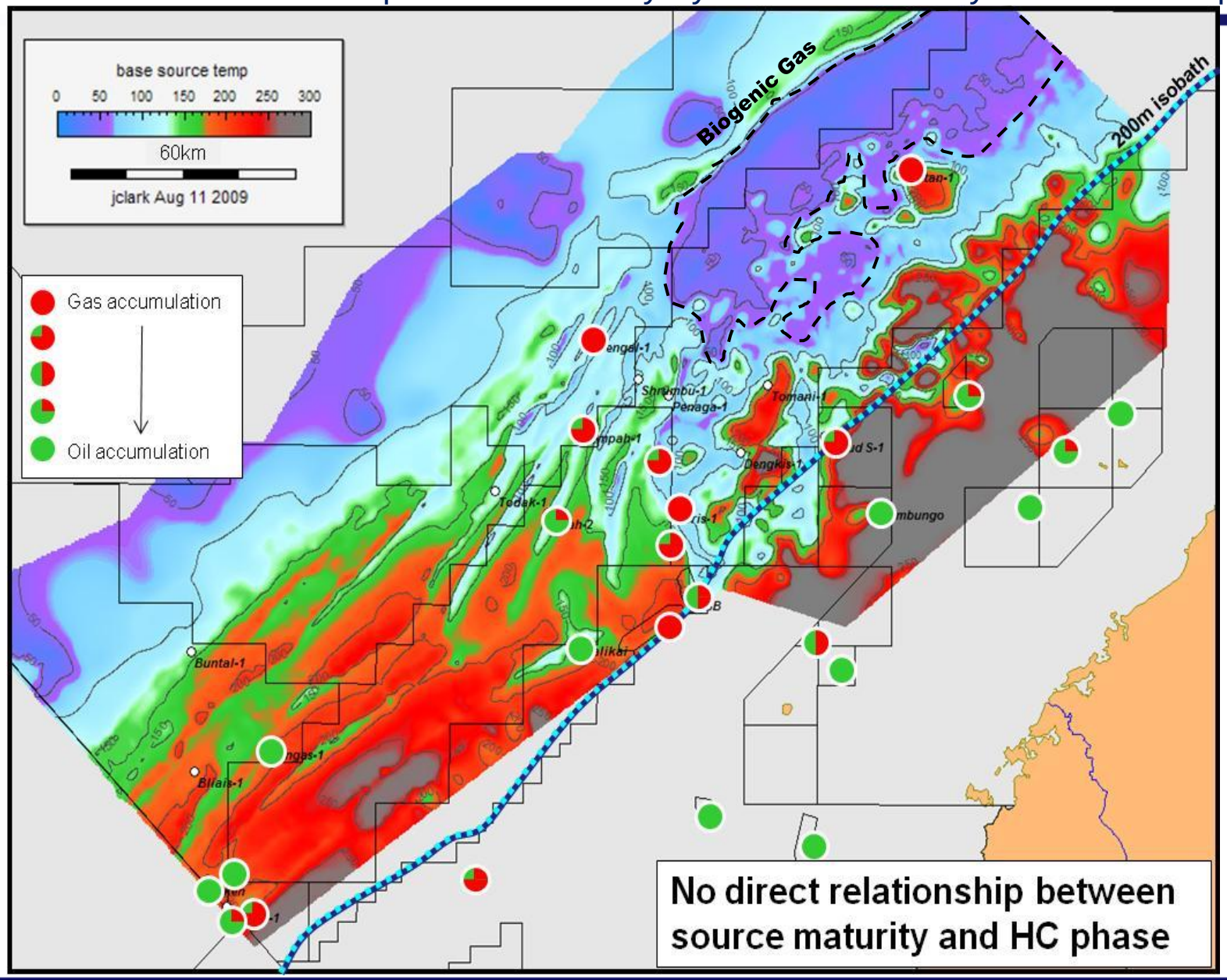

With such a “gas-prone” source rock, why are there so many OIL FIELDS?
2000m
1000m
200m
Kota Kinabalu
Borneo
Baram

Oil-Prone Kerogen Present



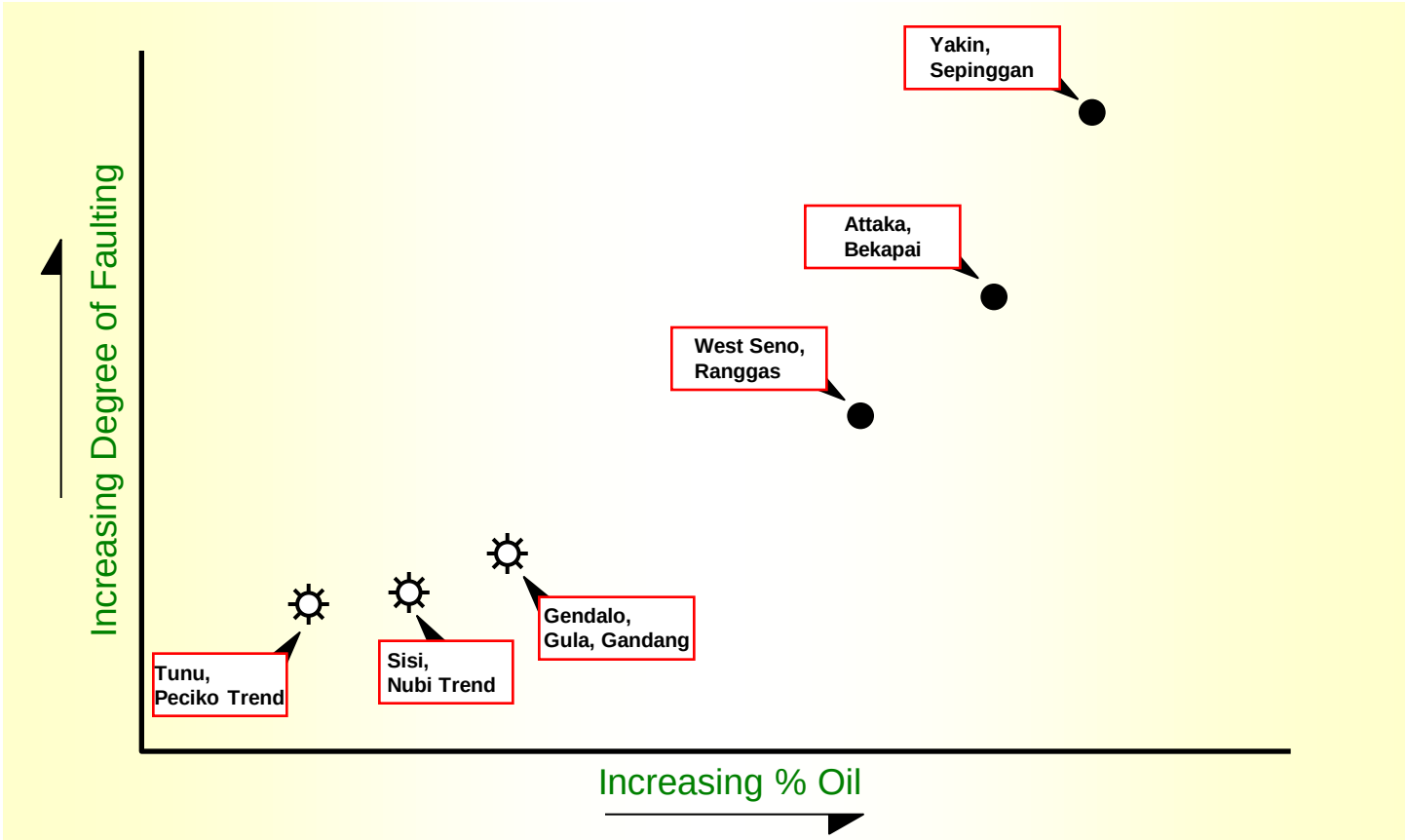
Presenter's notes: The oil-prone kerogen appears to have been washed away during the process of cleaning the oil-based mud.

Sabah Deepwater Preliminary Hydrocarbon Maturity Indicator - Temperature



Gas Leakage via faults

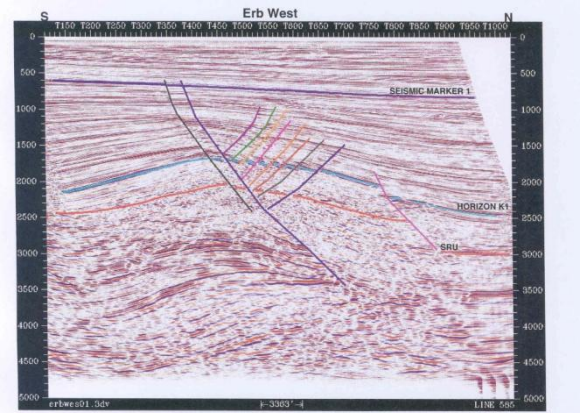
- Proven mechanism worldwide (Sales 1997)
- Primary mechanism in Kutei Basin, E. Borneo:



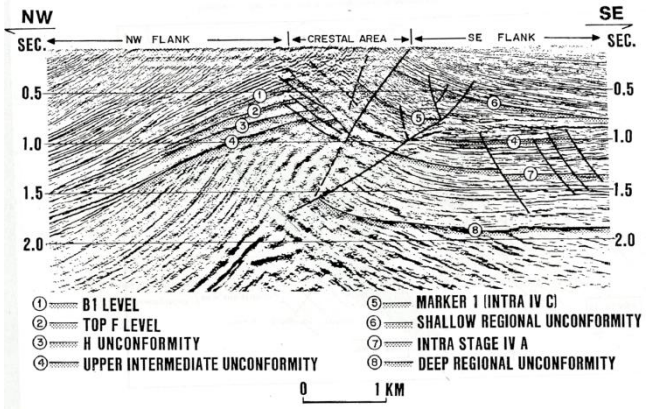
Gas Leakage via faults

- **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**

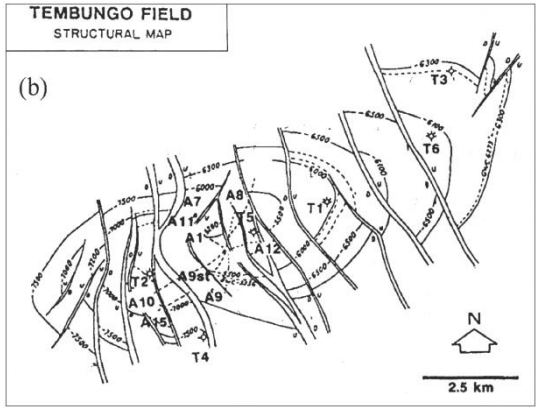
Erb West



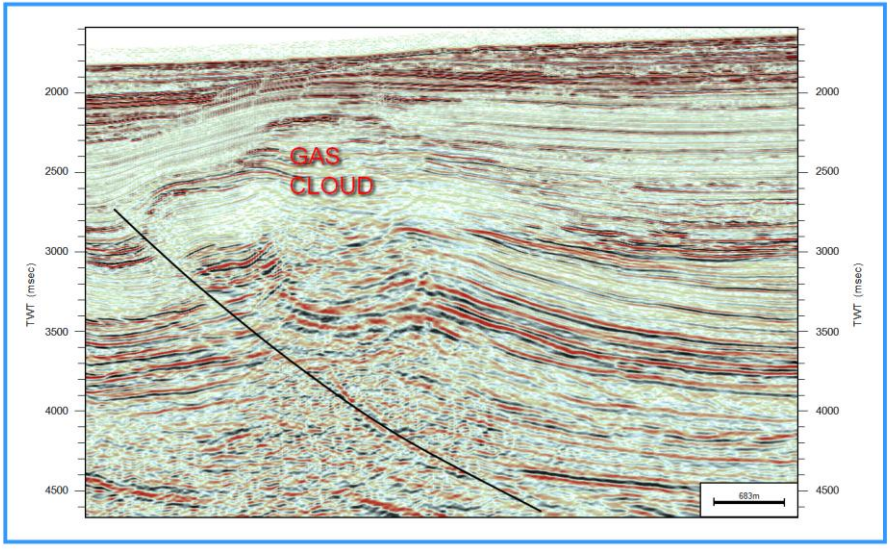
St. Joseph



Tembungo

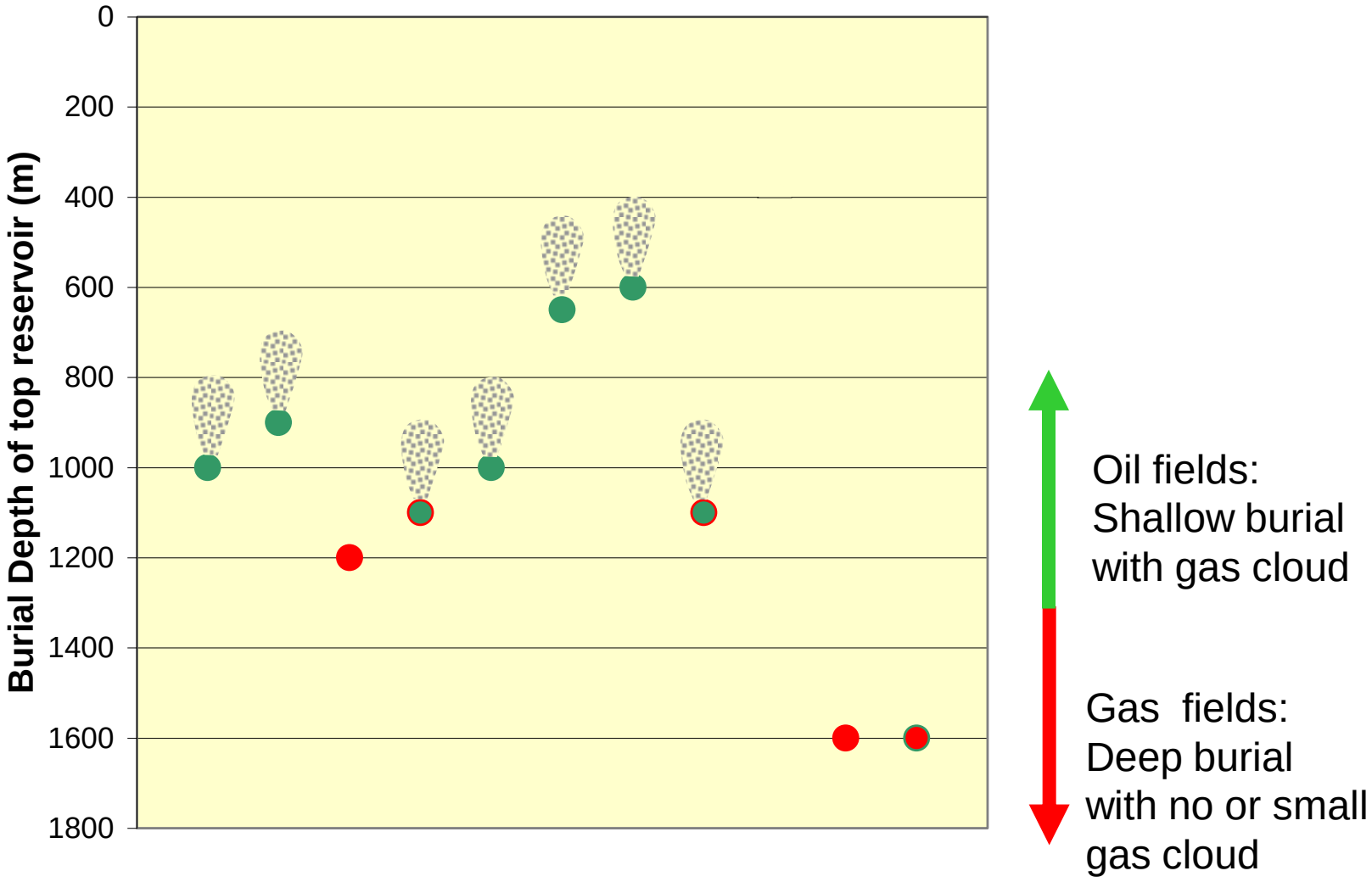


Kikeh Gas Cloud



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.

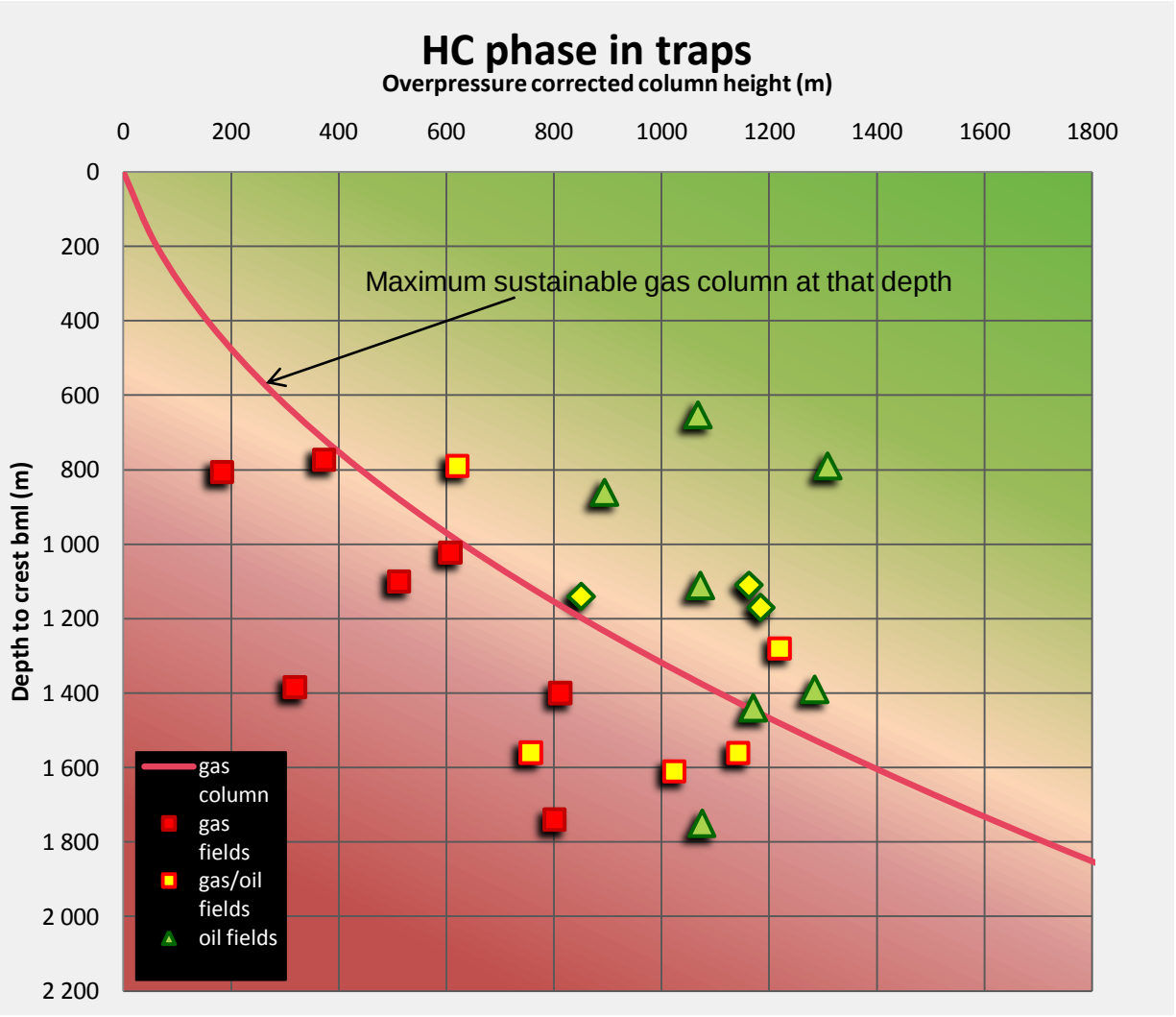
Gas Cloud & Oil Accumulations



Oil fields:
Shallow burial
with gas cloud

Gas fields:
Deep burial
with no or small
gas cloud

Current Model



- **Fluid type/proportion controlled by:**
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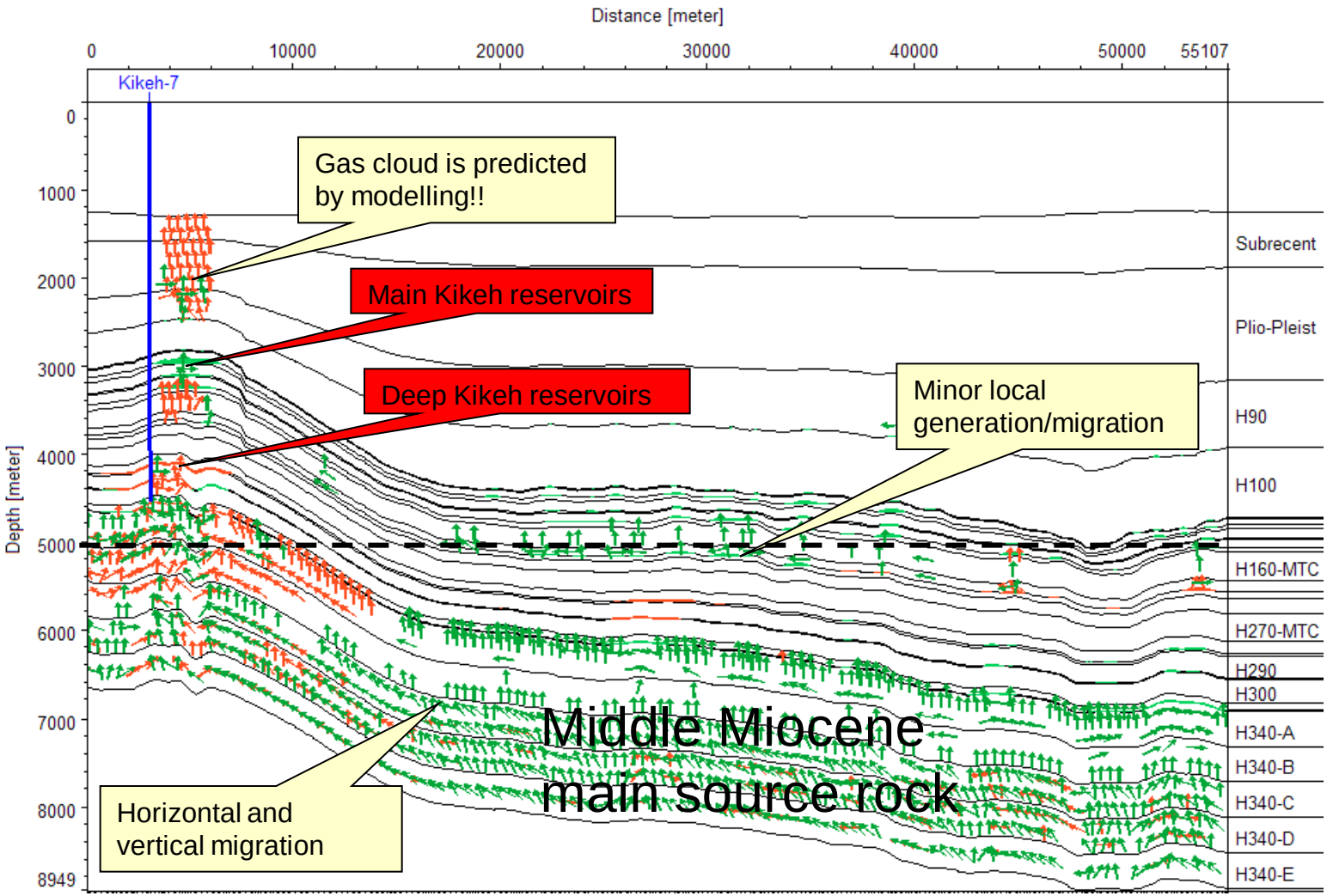
  - **Overpressure**

- **A Leaky Trap required for significant oil accumulation!**

Migration Modelling for NW Sabah



Green:
HCs in liquid phase, liquid migration

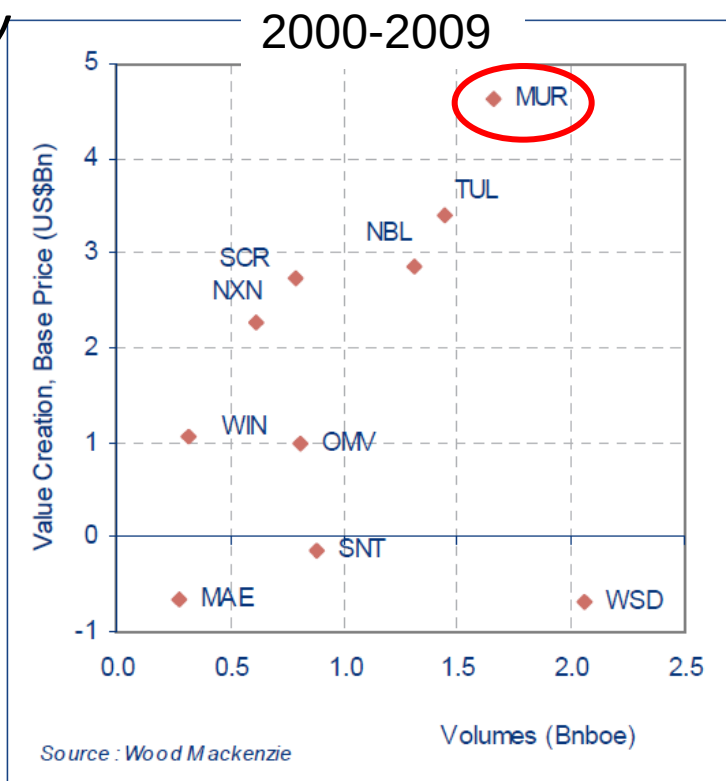
Red:
HCs in vapor phase, vapor migration

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**
- **2011 - Cameroon –** *Atl. Marg. Strat.*
- **2012 - TBA!**



Learnings

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- 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

HAVE FUN ALONG THE WAY

MURPHY SABAH EXPLORATION TEAM 2005