NORTH SUMATRA – MERGUI BASIN
CROSS BORDER CASE STUDY
EPPM-CCOP

PLAY TYPE IN THE CROSS BORDER
NORTH SUMATRA – MERGUI BASIN

Mohd Razali Che Kob
Petroleum Resource Exploration,
PETRONAS
Presentation Outline

- Regional Petroleum Geology
- Play Type & Associated Risk
- Analogues
Regional Geology and Petroleum System
North Sumatra-Mergui Basin
The Mergui – North Sumatera Basin occupies an area of cross-border among 4 Countries: Thailand, Malaysia, Indonesia, Myanmar.

Andreason, et. al., 1997
The Mergui –North Sumatera basin: bounded by convergence of Mergui Ridge with continental crust of Sunda Craton to the north, Asahan Arch to the east, Barisan Mountain to the south, and the Mergui ridge to the west.

The main tectonic elements dominated by relatively N-S and NW-SE trending highs and deeps.

These highs and deeps divide the larger basin into several sub-basins and depocentres.
Regional Tectonic Elements

- Considered as a back-arc basin
- Initially formed in Late Cretaceous by crustal extension of Sundaland
- Collision of India with Asia initiated extrusion of Indochina causing clockwise rotation-oblique subduction-NWSE wrench faults systems and associated transtensional basins
- Continued collision, subduction and extrusion

Extrusion model
Tapponnier et al (1982)

(From Thailand Team Presentation, 2011)
Tectono-stratigraphic development

- Initial deposition in Late Eocene - Early Oligocene as initial syn-rift infill
- Main sedimentation during Late Oligocene to Pleistocene
- Wrench tectonism in Mid Miocene
- Compressional tectonism during Plio-Pleistocene
- Maximum sedimentary rocks thickness is up to 6,000 m in the deepest part of the basin.
Stratigraphy of North Sumatra-Mergui and Melaka Platform
NORTH SUMATRA BASIN

• A prolific hydrocarbon bearing basin producing oil and gas.

• Hydrocarbon Exploration history began in the late 19th century.
  • Telaga Said oilfield (1885)
  • Darat oilfield (1889)
  • Perlak (1900),
  • Serang Jaya (1926),
  • Rantau (1929),
  • Gebang (1936)
  • Palu Tabuhan (1937).
• The most significant field in the basin today is Arun gasfield discovered in 1971. Total initial reserves of this field was estimated to be 17 TCF.

Does this reflects the cross border area?

Generalized physiography and productive HC discoveries of the North Sumatra basin

Netherwood (2000)
## Exploration Well Results in Thailand’s Mergui Basin

<table>
<thead>
<tr>
<th>OPERATOR</th>
<th>WELL NAME</th>
<th>BLOCK</th>
<th>SPUNNED DATE</th>
<th>RELEASED DATE</th>
<th>RESULT</th>
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<tbody>
<tr>
<td>ESSO</td>
<td>W9-A-1</td>
<td>W9</td>
<td>15-Dec-75</td>
<td>01-Mar-76</td>
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<td>GAS &amp; OIL SHOWS</td>
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<td>13-Mar-00</td>
<td>DRY</td>
</tr>
</tbody>
</table>

*(Ministry of Energy, Thailand)*
## SUMMARY OF EXPLORATION WELL RESULTS

<table>
<thead>
<tr>
<th>Well</th>
<th>Operator</th>
<th>Year</th>
<th>TD (m)</th>
<th>Objectives</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSS-XA</td>
<td>Mobil</td>
<td>1972</td>
<td>1294</td>
<td>Calcarenites and sandstones below Baong Shale</td>
<td>Dry</td>
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<tr>
<td>MG-XA</td>
<td>Mobil</td>
<td>1974</td>
<td>1651</td>
<td>Synrift graben fill reservoirs</td>
<td>Dry</td>
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<tr>
<td>Dayang-1</td>
<td>Sun</td>
<td>1989</td>
<td>1142</td>
<td>Melaka carbonate/ Bampo Formation</td>
<td>Dry. Trace Gas/oil shows</td>
</tr>
<tr>
<td>Singa Besar-1</td>
<td>Sun</td>
<td>1989</td>
<td>844</td>
<td><strong>Melaka Carbonate</strong>&lt;br&gt;on top of basement</td>
<td><strong>3.3m NGS,&lt;br&gt;Flowing at 3.7MMSCF/day</strong></td>
</tr>
<tr>
<td>Langgun Timur-1</td>
<td>Sun</td>
<td>1989</td>
<td>2028</td>
<td>Tampur Carbonate and Middle Graben Fill clastics</td>
<td>Minor gas shows TD in Tampur carbonates</td>
</tr>
</tbody>
</table>
Petroleum Systems Model (Doust & Noble, 2007)

Early Synrift (Early Oligocene) – Early graben fill of conglomerate & bioclastics limestone

Late Synrift (Late Oligocene) – Argillacious deep marine of Bampo main sourse rock

Early Postrift (Early-Middle Miocene) - Peutu & Belumai Formations basinal deeper marine shales and marls with extensive reefoid carbonate buildups developed on structural highs. (major resrvoir)

Late Postrift (Middle Miocene to Pliocene): the argillaceous Baong Fm (in which turbidite sands occur) and the overlying paralic shales, silts and sands of the Keutapang and Seurula formations. In the north, deeper marine facies became shallower towards the southeast, With deltaic sands of moderate to good reservoir quality.
The Petroleum System

**The Bampo–Peutu**: This system comprises a late synrift source of early postrift affinity and early postrift reservoir and traps north. sourced from Bampo Formation, and possibly Peutu Formation. The main reservoir/traps are carbonate build-ups of the Peutu (or Arun) Formation, with minor sandy Belumai Formation and basement.

**The Baong–Keutapang**: southeast region, more oil-prone and contains many of the shallow fields that produced the first reserves in Indonesia. Charge from Baong Formation, and possibly re-migration from deeper reservoirs may contribute. Reservoirs - deltaic facies of Keutapang and Seurula formations.

Others – Belumai systems

(Longley, PGSEA Course note, 2012)
Petroleum Potentials In The Cross-border Area (North Sumatra – Mergui Basin-Melaka Platform)

<table>
<thead>
<tr>
<th>Presence of gas accumulation indicative of valid petroleum systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source Rocks</strong></td>
</tr>
<tr>
<td>• Gas Prone</td>
</tr>
<tr>
<td>• Oligocene – Miocene shales marine shales with land derived organic</td>
</tr>
<tr>
<td>• Type II &amp; Type III Kerogen</td>
</tr>
<tr>
<td>• Mature Source rocks in the deep depcentres</td>
</tr>
<tr>
<td>• Expulsion in Middle/Late Miocene-Pliocene</td>
</tr>
<tr>
<td><strong>Reservoir Rocks</strong></td>
</tr>
<tr>
<td>• Oligocene Shallow Marine/Deltaic Sandstone</td>
</tr>
<tr>
<td>• Oligocene Turbidites</td>
</tr>
<tr>
<td>• Lower Miocene Sandstone</td>
</tr>
<tr>
<td>• Lower Miocene Carbonate</td>
</tr>
<tr>
<td><strong>Traps and seals</strong></td>
</tr>
<tr>
<td>• Both structural and stratigraphic traps presence</td>
</tr>
<tr>
<td>• Marine shale seals of Miocene and Pliocene</td>
</tr>
</tbody>
</table>
Play Type In Cross Border Area
North Sumatra-Mergui Basin & Melaka Platform
Play Model for North Sumatra Basin

Modified from Buck & Mc. Culloh (1994)
Play Model for Mergui-North Sumatra Basin
Conceptual Play Types in the MG Basin

**Structural Traps**
1) Drape over Basement High of Lower Oligocene Deltaic sand
2) Roll-over of Upper Oligocene sand
3) Crest of block of Oligocene sand
4) Drag fold of Lower Miocene sand

**Stratigraphic Traps**
5) Oligocene Basin Floor Fan
6) Pinch-out of Lower Oligocene Deltaic sand
7) Lower Miocene Carbonate Buildups
8) Mid-fan Turbidite of Lower Miocene sand
9) Miocene Conglomerate reef
Play Model Graben Fill Play in Melaka Platform
## Play Type Classification For Cross Border Area

<table>
<thead>
<tr>
<th>Play Family (1st Order Play Definition)</th>
<th>Plays in matured and frontier area in the southern North Sumatra Basin and cross border area</th>
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<td>Basement</td>
<td>Prerift Fractured Basement</td>
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</table>
Simplified Play Type Model

(Satyana’s Course on Petroleum Geology of Indonesia)
Tested Play in the Cross Border Area

SIKAO-1
Gelumpang Minyak-1
W9-C-1
Singa Besar-1
Langgun Timur-1
NSBC-1
HYDROCARBON POTENTIAL

HYDROCARBON EXPLORATION

Total: 43,559 Km seismic lines
1031 wells

The seismic sections and well data are available in Patra Nusa Data (PND)

33 Oil & Gas fields. Almost of them are located in onshore areas

Challenge to find oil & gas in offshore area

EXISTING SEISMIC SECTION S& WELLS MAP
(PND, 2008)
The main Play type in North Sumatra Basin - **Miocene Carbonate Play**
Miocene Carbonate Play - 
The success story

**Arun Field** (gas-condensate)  
(North Sumatra Basin)  
UR: 18-20 TCFG; > 700 MMBC  
Early-Middle Miocene reef (Arun Limestone of Peutu Formation),  
Accumulate on Arun High bounded by Lho Sukon deep on both sides  
Source: Bampo (4000, thick in adjacent basin) Baong  
Seal: Baong Shale  

Abdullah & Jordan (1987)
NSO-A and J Field
(North Sumatra Basin)

Lower Miocene Reef developed over basement high
Melaka member, Belumai Formation (Early – Middle Miocene)

(Alexander & Nellia, 1993)
Exploration wells penetrating the Miocene Carbonate in the **Cross Border Area**

![Diagram showing exploration wells](image-url)
• Dry Well
• Miocene Carbonate Reef
• Inadequate local source to charge the reservoir
• No lateral migration from nearby kitchen
Inadequate local source to charge the reservoir
No lateral migration from nearby kitchen
Miocene Biogenic buildup
Melaka Limestone
Shows of gas/condensate
Poor reservoir development
Langgun Timur-1
Tampur Carbonate & Graben fill Play
Trace of oil & gas
Charge?

Malaysia

Indonesia

NSB C-1
Basin Slope Biogenic Carbonate Buildup
Show of gas & condensate
No reservoir

Singa Besar-1

Langgun Timur-1

NSO69-25

NSO69-46

Singa Besar

Langgun Timur

Tampur

Carbonate

&

Graben fill Play

Trace of oil & gas

Charge?

Top Basement

Top Keutapang

Top Baong

NSBC-1

83-MS-09

NSO69-25

NSO69-46

Strike Line

Dip Line

Strike Line

NSB C-1

Basin Slope Biogenic Carbonate Buildup
Show of gas & condensate
No reservoir

NSBC-1
Singa Besar-1 Melaka Carbonate Gas show Charge?

Langgun Timur-1 Tampur Carbonate & Graben fill Play Trace of oil & gas Charge?

Langgun Timur-1 tested the Tampur Carbonate and upper synrift and not a valid test for Graben Fill,
## Play Type Classification For Cross Border Area

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**W9-C-1**  
**LGT-1/P Klang-1**
Water Depth: 3000’
Dry Well
Faulted anticline
Oligo-Miocene Clastics
(Synrift Fan Delta & Postrift Turbidite)
Singa Besar-1

Seismic Attributes:
- Good reflection and low continuity, sub-parallel
- Moderate to low reflection, low continuity, sub-parallel
- Moderate to poor reflection, low continuity, slightly divergent
- Good reflection and continuity, slightly mounded

Melaka Carbonate on top of basement
3.3m NGS, Flowing at 3.7MMSCF/day

Singa Besar-1

Line 83-MS-09
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Untested Stratigraphic Play (onlap pinch-out)
Untested Stratigraphic Play (onlap pinch-out)
Graben Fill Play
Seismic Vertical Sections across the Northern, the Central, and the Southern areas.
Thailand Cenozoic Intermontane basins

Oligocene (Alluvial-Fluvial-Lacustrine)

(Polachan et al., 1989)
RUBY FIELD, VIETNAM
Light Oil
Fractured basement (Cretaceous)
Trap: Basement Horst with drape of cover sediments
Trap formed in Late Miocene
Source: Fluvial-lacustrine (Oligocene)
Seals: Intraformational shale (Oligo-Miocene)

RUBY FIELD – A FRACTURED BASEMENT PLAY
Summary

• Successful Miocene Carbonate Play is associated with proximity to local kitchen area, however variation in depositional facies could deteriorate reservoir development.

• The migration of hydrocarbon seems to be controlled by faults (mostly steep – vertical).

• Younger tectonic posses a threat to trap integrity.

• Untested Play:
  • Graben Fill Play
  • Stratigraphic Pinch-out Play
  • Fractured Basement Play

• .....LOCATION! .....LOCATION! .....LOCATION!