Western Flank of the Papuan Basin, Indonesia

Agu Kantsler & Ian Longley
Outline

1. Intro/Why The Papuan Basin?
2. Geology & Exploration History of the Papuan Basin
3. The Toro/Base regional seal play
   Reservoir
   Seal
   Charge
   Trap
4. Future Plays and Opportunities in the Papuan Basin
5. Summary
Oil/Gas Fields and Wells in the Papuan Basin

SE Papua PSC

P’nyang

Muruk

Hides

Moran

Kutubu

Antelope
Why the Papuan Basin in Indonesia?

- The Papuan Basin has delivered material exploration discoveries and is clearly not mature for exploration opportunities.
- The Western extension of the basin into Indonesia is overlooked and very poorly explored and is well located to receive charge from source kitchens in PNG.
Country and Basin Rankings by YTF

SE Papua PSC is in the foreland basin of the Papuan Basin in Indonesia. Indonesia has the region’s largest yet-to-find volumes and the Papuan Basin has 3 sub basins in the top 20 Basins (#4 & #11 #15)
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Papuan Basin Chronostratigraphy

- Mesozoic Rift/Sag passive margin
- End Cretaceous Uplift then sag
- Late Miocene to present day compression
Regional Top Toro Depth Map
Papuan Basin Regional Cross-section
~31 tcf 2P gas reserves discovered + 680mmb oil and 520mmb condensate
Drilling Activity and Success Rates/Average Discovery sizes

Basin delivering consistent ~100mmboe average discovery sizes and has an increasing success rate approaching 60%

Not Creamed
Kutubu Crestal Cross Section and summary stats

- Papua New Guinea’s largest oil field
- Discovered 1986
- First production 1992
- Main formations Toro A, B, C sands
- STOOIP about 600 MMstb
- EUR about 350 MMstb
Hides Field Top Toro Depth Map (after ExxonMobil)

1987 Discovery Anticline with Surface Relief 9tcf ~200mmbc
P’nyang

- Discovered 1990 by Chevron
- Surface Expression
- 3.7 tcf & 60mmbc
- Oil Leg under gas found in P’nyang South
- Got bigger with appraisal drilling
Moran

- Discovered 1996
- Surface Expression
- 110mmbo 200bcf rec
- Post Discovery 4 sidetracks followed immediately with Moran 2 + 2 sidetracks
- Up to 1200m oil column in Digimu
- First Second Trend Discovery back from the frontal thrust play
Moran

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Antelope

- Discovered 2006 InterOil
- No Surface Expression (on a large gas seep)
- Seismic defined Antelope after initial Elk platform limestone discovery
- ~7tcf and 60mmbc rec
- Combination structural stratigraphic trap on back of a thrust sheet
- Has been deeply buried and uplifted – good secondary porosity developed
Muruk

- 2016 Foldbelt discovery Oil Search
- First significant highlands discovery with NO surface expression
- ?1-2 tcf – close to Hides so hopefully easy to develop
- Largest operated exploration discovery ever by Oil Search in PNG

Muruk 1 (PPL 402): High potential NW Highlands exploration

- Muruk 1 targeting multi-tcf exploration prospect on-trend with Hides
- Located north-east of Juha and Juha North pools
- Operated by OSH in co-venture with ExxonMobil
- High-impact well and potential new source of gas for PNG LNG expansion, if successful
- Expected to spud in 1Q16, subject to pad readiness and rig mobilisation
- Part of coordinated OSH 2016 Highlands drilling campaign to source gas for expansion

<table>
<thead>
<tr>
<th>PPL 402</th>
<th>WI %</th>
</tr>
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<tbody>
<tr>
<td>Oil Search</td>
<td>50.0</td>
</tr>
<tr>
<td>Esso PNG Wren Ltd (ExxonMobil affiliate)</td>
<td>50.0</td>
</tr>
</tbody>
</table>
Summary

- All large discoveries are in the Foldbelt
- We are currently finding something big every 10 years…
- Why has the foreland not delivered a large discovery?
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We over complicate the nomenclature of the targets beneath the regional seal. The first sand beneath the thick Ieru shale is normally the one with the HC’s…

The base Ieru Play we call the base regional seal play. It hosts ~75% of the reserves…
Extensive well and Seismic control of regional sands

Seismic Next Slide

Shale out/Sand depositional limit

Subcrop edge associated with Coral Sea uplift in the Gulf
Composite Section A-B-C-D (1982 Vintage)

- Stanley-1 well tied interpretation extended westward across northern boundary of SE West Papua block.
- Stanley-1 intersected ~35m net reservoir (Toro and Alene Sst), 260 Bcf gas, 8 mmbls condensate.
- Alene sands interpreted across basement high (red star).
- Thick section of Ieru Shale providing top seal.
- Structural highs indicated by yellow and red stars on seismic line correspond to gravity highs on gravity map.
- Seismic section validating gravity map as indicator of (basement) structure and lead identification.

Bouguer gravity
Density 2.2

Sesnuk Oil Seep

Stanley-1 intersected 35m reservoir

Ieru Shale (seal)

Top Alene Sst

Base Darai

Sedikit Raksasa
Reservoir Distribution – Biostratigraphy

Reservoir “Younging” onto older basement structures and flank of basin

Lake Murray-1  Lake Murray-2

2.7km

Back-stepping, shallow marine reservoir system, retrograding southward onto the Gondwana craton
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Base Regional Seal Reservoir Notes

Extensive well and Seismic control of thick marine shale sequence

INDONESIA  PNG
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Main source rock is W Spectabilis Upper Jurassic Type II (Type D/E) oily source rock. Distribution is in Graben – published map below.

Seeps in FB also shown

Jurassic Seep here

Mapped and drilled Jurassic Section in the Strickland foreland – typed to Oils in the foreland

Thick Rift section under Hides
Source Rock Maturity Notes

Foreland basin area easy to evaluate – Foldbelt more complex. Many wells in the foldbelt have probably failed due to lack of access to charge...

Hides/P’nyang areas charge from underneath

Kutubu Area Fields charged from backlimbs loaded by overriding thrust sheets

Strickland Oil Kitchen- extension of same kitchen that charges foldbelt fields (?130degC) today

Antelope and eastern FB seeps charged from Cretaceous Kitchen NOT the W Spec Kimmeridgian - hence drier gas
What is a practical approach to prospect phase prediction?

- Firstly, acknowledge the irreducible uncertainties and not over-sell our ability to predict HC phase at the prospect level using a purely “bottom-up” approach.

- Even if we only know the dominant source type and target trap depth:

  - Wet gas with light oil
  - Dry gas with heavy oil
  - Under-saturated oil: Source A/B/C or low maturity DE
  - Volatile oil/Rich Gas condensate: Source A/B/C/DE
  - Gas condensate: Source DE
  - Under-saturated Dry Gas: Source F or low HI DE

  - 50 – 55° API liquids
  - 45 – 50° API liquids
Main source rock is W Spectabilis Upper Jurassic Type II (Type D/E) oily source rock. Distribution is in Graben – published map below.

Hides/P’nyang areas charge from underneath.

Kutubu Area Fields charged from backlimbs.

Kau is oil.

Approximate 70deg Isotherm at base regional seal reservoir.

Dry gas fields with some oil legs – oil has been biodegraded to gas because of reservoir temperatures (and meteoric waters).
West Papua Surface Seep Sampling – Bukit Site

- Sample site was covered by dirt path some years ago
- Minor excavation
- Seep collected off water surface
- Projected SR Type – Marine/Paralic-Deltaic
- Maturity – 0.7-0.75 VRE
- API – 35.1 (non-degraded)
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The few lines in Irian show that there are likely traps present and these are associated with a large N-S ridge that provides larger trap size potential. PNG has a reasonable grid of 2D data to define the low relief traps.
SE Papua Aero Gravity & Magnetic Survey

N-S lineation on extension of the Tasman-line. Faulted E margin of the Arafura High

NE-SW trend – parallel to direction of Triassic/Jurassic rifting

Morehead Graben Extensions

Kau-Strickland Trough

Raksasa Lead & others
Raksasa lead

Old lines help define a feature well identified on FT gravity data

Raksasa ~50km x 20km anitiform
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Seismic Line X-Y (1970’s River Seismic)

- Seismic line (A-B) acquired along river
- Structural rollover observed on seismic line (extent of yellow arrow) lies on flank of gravity high (Lead Grav_A)
- Seismic section validating gravity map as indicator of basement structure and lead identification
- Alene Sst interpreted to extend across flank structural high — pinchout updip, prior to Aripoe-1 where sands were absent
- Toro Sst interpreted to onlap flank of Grav_A lead

Aripoe-1

Top Alene Sst

Basement

Raksasa Lead
Structural rollover on seismic line lies on flank of gravity high

Top Toro Sst

Sesnukt Oil Seep

Bouguer gravity
Density 2.2
### Exploration & Resource Potential (Unconstrained; Unrisked)

<table>
<thead>
<tr>
<th>Lead (Target Depth)</th>
<th>Comment</th>
<th>Gross Reservoir Thickness (m)</th>
<th>N:G (%)</th>
<th>Porosity (%)</th>
<th>Shc (%)</th>
<th>GEF/FVF</th>
<th>RF Gas/Oil (%)</th>
<th>Mean rec. gas (bcf)</th>
<th>Mean rec. oil (mmbbls)</th>
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</thead>
<tbody>
<tr>
<td>Raksasa (1600m)</td>
<td>Mostly gravity defined, one poor quality river-line across northern flank</td>
<td>20</td>
<td>60</td>
<td>14</td>
<td>65</td>
<td>150/1.1</td>
<td>70/35</td>
<td>3384</td>
<td>1731</td>
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<tr>
<td>Sedikit Raksasa (1750m)</td>
<td>2 loosely spaced (+30km) 2D dip-lines</td>
<td>20</td>
<td>60</td>
<td>14</td>
<td>65</td>
<td>150/1.1</td>
<td>70/35</td>
<td>752</td>
<td>385</td>
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<tr>
<td>EPJ1 (2100m)</td>
<td>1 poor quality 2D dip-line</td>
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<td>14</td>
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<td>150/1.1</td>
<td>70/35</td>
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<td>Lead C (1800m)</td>
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<td>150/1.1</td>
<td>70/35</td>
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<td>Lead D</td>
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<td>150/1.1</td>
<td>70/35</td>
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**Total:** 7021 3701
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Total Malu Prospect DW Gulf of Papua PPL576 ~2000m WD

Deep water potential remains untested..
Undrilled PNG shallow offshore opportunity in The Gulf (Papua not Mexico!)

Undrilled & 5-10tcf simple Miocene build up exploration potential...

~5km to top target

Like in Luconia – the deep carbonates can be filled and this feature could have a 1km HV column
Alene Pressure Cell Play

In this region the Toro is connected to the uplifted Toro outcrops in the foldbelt and is overpressured... where as the Alene above does not see this overpressure. Means the Alene is regionally isolated and a large fault trap may be present somewhere - ?Multi-tcf.?
The prospect with the MOAST…

The Mother Of All Sub Thrust Prospects

This should be charged… analog is P’nyang South Footwall
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Summary

- The Papuan Basin is underexplored and has significant remaining exploration potential

- There are many different opportunities available beyond the simple structures that the industry has focussed on to date

- The SE Papua PSC opportunity can be summarised below

<table>
<thead>
<tr>
<th>Status</th>
<th>Reservoir</th>
<th>Seal</th>
<th>Source</th>
<th>Migration/Phase</th>
<th>Trap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Likely Present</td>
<td>Very Likely Present</td>
<td>Proven – not an issue</td>
<td>Shares the same oily mature kitchen as the large foldbelt fields</td>
<td>Simple migration path – Raksasa in oil goldilocks depth range</td>
<td>Potentially large – needs more seismic (or a brave driller!)</td>
</tr>
</tbody>
</table>

- If you don’t want to enter into PNG but want a slice of the action from the Indonesian side of the fence then this is the opportunity for you!

- Visit us at our farmout booth Contact Agu Kantsler [agu.kantslaer@transform.com.au](mailto:agu.kantslaer@transform.com.au) or +61(0)419937917 for more information - we have evacuation routes down the Digul river and solid economic evaluations…
The field geology is always fun…
PNG is full of surprises… some of them are good..
Thank You...