UNCONVENTIONAL PROSPECT IN MYANMAR

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MYANMA OIL AND GAS ENTERPRISE
MINISTRY OF ELECTRICITY AND ENERGY

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GENERAL GEOLOGY
Fore-arc/Back-arc System

Heat flow increases towards volcanic front

Frisch et al., Plate Tectonics, Springer, p.211, 2011

Pivnik et al., AAPG Bulletin, v. 82, no. 10, 1998
Stratigraphic column for the Salin basin based on measured section at Mann Chaung

<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cretaceous</td>
<td>- Kabaw</td>
</tr>
<tr>
<td>Paleocene</td>
<td>- Kabaw</td>
</tr>
<tr>
<td>Eocene</td>
<td>- Laungshe</td>
</tr>
<tr>
<td>Oligocene</td>
<td>- Tabyin</td>
</tr>
<tr>
<td>Miocene</td>
<td>- Paunggyi</td>
</tr>
<tr>
<td>Plio-Pleist</td>
<td>- Irrawaddy</td>
</tr>
</tbody>
</table>

Unconformities:
- ~~~ Unconformity ~~~
- ~~~ Unconformity ~~~
- ~~~ Conformity ~~~

Metamorphic basement

- Obogon (650 m)
- Kyaukkok (1250 m)
- Pyawbwe (500-1500 m)
- Okhminthaung (2250 m)
- Padaung (Tiyo) (680 m)
- Shwezetaw (1000 m)
- Yaw (500 m)
- Pondaung (1325 m)
- Tabyin (1415 m)
- Tilin (615 m)
- Laungshe (2125 m)
- Kabaw (1230 m)
- Irrawaddy (100-4900 m)

Legend:
- conglomerate
- sandstone
- limestone
- shale
Structural Cross Section

Fault-propagation fold eroded

MOGE-8 borders

Pivnik et al., AAPG Bulletin, v. 82, no. 10, 1998

UNOCAL seismic
Present Depth to Ro = 0.90

This indicates approximate depths where peak oil generation has occurred. It is shallower on the flank of the basin due to Tertiary uplift and erosion.

These would be approximate target drilling depth for an insitu unconventional play assuming a strong source and brittle reservoir could be found.

The low temperature gradient causes the depths to oil generation to be very deep in the basin center (~6000 meters).
YAW – SOURCE ROCK MAP (MOGE INHOUSE STUDY)
• 21 samples selected for rock eval
• Analysis included TOC and carbonate %, Ro (19 samples), pyrolysis (6 samples)
• Analysis provided by Geomark (Rock Eval) and Charlie Landis (VKA)
• Most samples of low quality (TOC < 1%, low $S_1$)
• Pyrolysis only reliable for two coal samples
## VKA Data

### Myanmar Central Basin
#### Shale Samples Ro List

<table>
<thead>
<tr>
<th>Block</th>
<th>Sample ID</th>
<th>% Kerogen Facies Assemblage</th>
<th>Vitrinite Refl.</th>
<th>Measured Vitrinite Ro (%)</th>
<th>No. of Readings</th>
<th>Comments</th>
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<tbody>
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<td>RSF-7</td>
<td>1-3</td>
<td>nd 86 5 tr nd tr 9</td>
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</table>
PETROLOGY ANALYSES

• Outcrop samples from the Central basin of Myanmar consist dominantly of very fine to medium and coarse-grained volcanic litharenite sandstone
• Compaction of volcanic rock fragments and other ductile grains has largely destroyed intergranular porosity
• Porosity has survived in samples with more abundant quartz and feldspar, even if restricted to more quartzose patches within lithic sandstone
• Cementation by ferroan calcite cement has also destroyed intergranular porosity
PETROLOGY

• Dissolution of plagioclase and potassium feldspar, and locally volcanic rock ash and volcanic rock fragments has created moldic porosity
• Remaining intergranular pores are typically lined by clay mineral and quartz cement
• Clay mineral cement causes reduced permeability and elevated irreducible water saturation
• Much of the porosity detected during core analysis consists of microporosity within altered volcanic rock fragments
• Outcrop weathering and sample drying have induced microfractures that may cause elevated porosity and permeability
OIL SAMPLES ANALYSES

- Six Oils have been provided by Daewoo International
- Sample were obtained for various field sites in the Salin Basin, Myanmar.
- All oils have undergone standard bulk and biomarker analysis to determine source depositional environment, biodegradation and maturity at which the oil was generated.
- The #662 Mann Field production oil was chosen for additional analysis using GCxGC TOFMS. The preliminary results are reported here.
- Technical literature provides a meaningful framework for interpretation.
• Oils exhibit various indications of biodegradation and maturity but share a similar source rock depositional environment.
  – There may be more than one type of source rock facies due to various lines of Source rock depositional and oil maturity evidence.
  – Curiale points out some very useful biodegradation, correlation and maturity parameters.
• The six oils provide to dig can be characterized as coaly source, high wax oils that have undergone variable processes of biodegradation.
• We now have useful geochemical parameters to predict fluid quality in shallow reservoirs.
The Central Myanmar (Burma) Oil Family – Composition and Implications for Source (1994, Organic Geochemistry)
Joseph A. Curiale, Pe Kyi, Ian D. Collins, Aung Din, Kyaw, Nyein, Maung Nyunt, and Charles Stuart

• Work was completed with cooperation between MOGE and Unocal in the early 1990s.
• Major conclusion is that, of the 31 oils studied, the major source is an Eocene age, resinous shale/coal source for the oils.
  – Oldest (Eocene) reservoirs fill (or charge) first
  – Younger (Miocene) reservoirs fill later.
  – Surface seepage and near surface oils charging reservoirs result from deeper reservoir fill to spill migration mechanisms.
• Biodegradation is prevalent in the oil samples used in this study and accounts for the major geochemical differences.
Myanmar Onshore “Unconventional” Resource Potential

- **Limited Data:** No rigorous national-level data gathering and analysis yet.

- **Structural Complexity:** Complex, not easy to perform effective hydraulic fracturing

- **CBM:** Thin and low maturity coal, small reserves, generally low potential.

- **Shale Oil/Gas:**
  - Non-marine shale with low TOC, low maturity and high clay content
  - Wet gas window is too deep to be feasibly economic (over 7,000m)
  - Require further investigation on contract terms and conditions to make shale project economically feasible

- **Tight Oil/Gas:**
  - Presence of low poro and low perm in Eocene or older reservoirs
  - No hydrocarbon indication (=high water saturation)
  - Probably best potential would be near or beneath the existing oil fields
THANK YOU VERY MUCH FOR YOUR ATTENTION.