Lebanon 2nd Round
Evidence for Oil Generation
South Levant Discoveries > Biogenic Gas

**Tanin**
2011 Gas Discovery, 130ft net pay
Lower Miocene ‘Tamar’ sands
Reserves: Mean 1.1 TCF

**Aphrodite**
2011 Gas Discovery
310ft net pay
Miocene sands
Reserves: Mean 7 TCF

**Leviathan**
2010 Gas Discovery
220ft net pay
Lower Miocene sands
Reserves: Mean 17 TCF.
*Reported deeper thermogenic gas zone at 21,000ft

**Shimsom**
2012 Gas Discovery
Reserves: Mean 1 TCF.

**Dalit**
2009 Gas Discovery
220ft net pay
Lower Miocene sands
Reserves: Mean 0.5 TCF

**Dolphin**
2011 Gas discovery
‘Tamar’ sands
Reserves: Mean ca 0.5 TCF

**Tamar**
2009 Gas Discovery 2012 onstream
460ft net Mid- Lower Miocene sands
Reserves Mean 9 TCF

**Karish**
2013 Gas Discovery
180ft net Lower Miocene sands
Reserves mean 2-3 TCF
*Producing thermogenic light oil

Q: Where is the thermogenic light oil in Karish coming from?
Stratigraphy of the Levant Basin

Source Rocks
1. Oligocene
2. Paleocene – Eocene
3. Cenomanian-Turonian
4. Jurassic
Basin Modelling
Evidence for Oil Generation
Basin Modelling: South to North Levant

- Evaluate the hydrocarbon potential of defined source rocks
- Investigate the likely pathways of hydrocarbon migration and accumulation
- Evaluate the petroleum system(s) considering timing of generation, expulsion, and migration of hydrocarbons related to the basin’s tectonic history

Flowchart for the input geochemical data to the basin modeling

<table>
<thead>
<tr>
<th>Oligocene</th>
<th>Paleocene</th>
<th>U. Cretaceous (SEONIAN &amp; CEN-TUR)</th>
<th>M-U. Jurassic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinetics: Type II</td>
<td>Kinetics: Type II</td>
<td>Kinetics: Type II</td>
<td>Kinetics: Type 50H/50H</td>
</tr>
<tr>
<td>Estimated TOC: 3.0%</td>
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<td>Estimated TOC: 3.0%</td>
<td>Estimated TOC: 3.0%</td>
</tr>
<tr>
<td>Estimated Thickness: 100 m</td>
<td>Estimated Thickness: 30 m</td>
<td>Estimated Thickness: 60 m</td>
<td>Estimated Thickness: 60 m</td>
</tr>
</tbody>
</table>
Oligocene-sourced oil

Offshore West Mediterranean Oligocene-Sourced Oil

Modified after Halim et al., 1996

Pristane
Phytane

$Pr/Ph = 1.01$

Whole oil gas chromatogram

Oligocene source rock encountered at Amathusa and Onasagoras ENI wells
Burial History & Thermal Maturity for Example Well

Present Day

- U. Cretaceous to Oligocene source rocks modelled as Early Mature.
- Jurassic source rock modelled as Late Mature
3D Basin Modelling: North Levant

- Oligocene Source Expelling oil from Messinian times to Recent

- Oligocene and Paleocene-Eocene source rocks are currently in the “Mid-Mature” stage (0.7-1.0% Ro)
Karish Oil from Oligocene Source Kitchen?

- Long distance oil migration from Oligocene source kitchen in North Levant Basin explains light oil in Karish
- Karish is the South Levant Field nearest to the North Levant oil kitchen
HC Indications - Seeps

High Potential for Oil

Levant Basin
15 to 20ºC/km
Meaning of Seeps and Fluid Pipes

Cantarell 2nd largest 35 BBOIP

Scarborough, NW Carnarvon Basin, Australia (Jablonski et al., 2013)
Multi-Episode Focused Fluid Escape

- Syrian arc related inversion structure associated with fluid pipe and pockmark at the seabed
- Reservoir has been recharged 20 times due to continued hydrocarbon generation over the last 1.7 Ma
- Indicates a working petroleum system
- Oil generation supported by nearby oil seep

HC Indications
Early Miocene Reservoir Provenance

Nile: Prograding Deltaic Packages

Southern Levant: Deep Marine Clastic Transport systems

Northern Levant: Basin Floor Depocenter Basin Floor Fan Complex

1 km sand

Reservoir

Levant Ramp

260Km

50Km

290 km 2D line

Levant Ramp

Tamar
Trap 3D Cube View
Meaning of Layer Bound Faults

Lebanon 3D – Mature source rock = Ductile

Canyonlands, Utah (Tari et al, 2012)
Lower Miocene Structures Map from 3D

Phoebe

Trap
Structures North and South Levant Basin

Phoebe
Far less complex than compressional structures in South Levant

Leviathan

Ref: Noble Website
As the Early Miocene seaway through to the Persian Gulf closed, so no eastward sediment drift from the Nile.

The northward collision of the Arabian plate caused the Palmyride Inversion, which may have created a local source for the Late Miocene.
Base Messinian Evaporites depth

Lannister

Baratheon

Stark

Phoebe

Greyjoy

Targaryen

Upper Miocene Play
“AVO” quick-look ; (Far-Near)*Far angle stacks

Very positive AVO responses at Late Miocene level.
Base Messinian Structures and DHIs?

- Hard reflection that is discordant with the geometry of the anticlines reflections.
- The discordant reflection terminates against the inner side of the anticline.
Block 5: Resource Potential

1) 25 + structures Lower Miocene
    30-50 TCF or 5 to 8.3 BBOE

2) 2 large low relief structures Upper Miocene Level (three plays)
    8 -15 TCF or 1.3 to 2.5 BBOE potential resources
Block 3: Resource Potential

1) 17 + structures Lower Miocene 15-35 TCF or **2.5 to 6 BBOE** potential resources.

2) 2-3 large low relief structures at Upper Miocene 8 -15 TCF or **1.3 to 2.5 BBOE** potential resources

3) Block 1 Pinch-out play in north unquantified.
Lebanon 2019 License Round Opportunity

Blocks 3 & 5
>100 TCF or
>16 BBBO

Blocks announced Nov ‘18

Pre qualification Q1 ‘19

Bidding from May to Oct ‘19

Awards 4Q ‘19