Translating 2D Seismic to New Oil and Gas Resources

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Outline

- Petroleum Geology
- Seismic Data
- Thailand Analogies
- Prospects
- Resource Size and Economics
- Summary
Oil and Gas Concession

- Concession west of Vietnam and east of Thailand
- Area of 12,000 sq./km
- Year 3 of 7 year exploration term
- Exploration began in 1990’s
- Hunt, Enterprise and Salamander
  - Geological field work
  - Seismic acquisition
  - 2 well commitments

CamCan Energy (2014)
Drilling to date

- Three wells have been drilled in the country
- Two near the concession
- 2010 by Salamander Energy called Bang Nouan-1
  - Gas show in Triassic
  - Wet porous Permian
- Hunt Oil Company in 1990’s
  - Jurassic gas charged column over deeper volcanics
Stratigraphy

- Stratigraphic chart of the basin
- Reservoir units in the Permian and Triassic
  - Best reservoir the Permian
- Permian is an early marine to continental clastic and carbonate sequence
- Overlain by a thick clastic sequence of Triassic to Cretaceous age sediments

Racey (2011)
Regional Structure

- Early basin rifting episode
  - Series of horst and graben structures (Pink and Blue) in the center of the basin
- A large scale erosional event
  - Late Triassic time
- Compressional event
  - Cretaceous aged, perpendicular to the horst and graben features
- Sets up a number of different trap types
Post Permian Structural Mechanics

Permian Non-Deposition

Laos Govt. Files
Paleogeography - Permian

- Permian largest producer to date on the west side of the basin
- Map shows
  - Carbonate platforms, in red
  - Basement highs at Permian time, in brown
  - Thickening of sediments away from the platforms, from 3-6 km, in blue
- One set of carbonate platforms trend NW-SE and extend into the Laos concession

Racey (2011)
Source Rock and Oil Seeps

- The source rocks are Permian and Triassic in age
- Gas and condensate being produced within the basin
- Oil seeps and bitumen staining on Laos side of the basin in outcrop
  - Field mapping carried out by Hunt Oil in the 1990’s
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Seismic Data

- A total of 3000+ km of 2D legacy seismic lines
- 1990’s data – Blue
  - Little field data
  - No original survey available
  - Paper copies of seismic
  - Location map
- 2008 data - Orange
  - Good quality data, digital available
Field Survey Regenerated

Field survey for seismic was missing

- Old interpreted maps with line locations
- Vibroseis data on roads
- Regenerated elevations with Google Earth
- Edited survey based on shot by shot visual Q.C.
For field data that hasn’t been found data could be scanned to add information to dataset.

- survey information available on top of some paper sections
Reprocessing from Field Data

- Poor quality in zones of interest
- Basic 1990’s processing:
  - Predictive decon
  - Refraction analysis
  - Post stack migration
  - Fx noise attenuation
Reprocessed Seismic Data

Reprocessing

- crooked line geometry
- advanced noise attenuation
- manual first break picks
- advanced tomography
- pre-stack time migration
- spectral balance
Seismic Processing 1990’s

- Basic 1990’s processing:
  - Predictive decon
  - Refraction analysis
  - Post stack migration
  - Fx noise attenuation
Reprocessed Seismic Data

- 1990’s data reprocessed
  - crooked line geometry
  - advanced noise attenuation
  - manual first break picks
  - advanced tomography
  - pre-stack time migration
  - spectral balance
Value Add

Less new seismic to shoot

- Didn’t have to shoot these seismic lines again because we were able to reprocess the data.
- Time savings as well, able to use existing data without waiting a year to shoot new data.
- Cost savings of about $2 MM to the company.
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Thailand Analogies

- 2 Major Producing Fields
  - Phu Horm
  - Nam Phong

- 1 Field being tied-in
  - Don Mung

- Various other gas tests and shows in the basin
  - Si That-1, as an example
Production: Nam Phong

- Permian section preserved on top of the structure
- On production for 30 years
- Rates up to 60MMcf/d from 5 wells, mainly dry gas
- Partially filled structure
- 1Tcf estimated reserves
Isolated platform high with Permian reservoir preserved

Carbonates 100-200 m thick

Porosity 1-15%

Porosity enhanced by fracturing, dolomitization and hydrothermal alteration

On production since 2006

Producing 90-110Mmcf/day from 4 wells to date

P1 and P2 = 1.4 Tcf reserves + condensate
Future Production: Dong Mung

Dong Mung Field

- Permian reef buildups on the carbonate platform, no significant faulting
- Flow rates on Dong Mung-1 well up to 23 MMcf/d
- Gas shows in the Lower Jurassic sandstones, porosities up to 15%
- Only 3 wells into pool, 1 well was wet and low
Si That-2

- Shut-in gas production in the Permo-Carboniferous
- Well missed the Permian reservoir
- Platform extends for 15 kms
  - carbonate platform buildup on the edge of the platform
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This is a structure map of the Top of the Permian prior to the new data and reprocessing done.
This is a structure map of the Top of the Permian. The prospects are as follows:

- Prospect 1: Savannakhet
- Prospect 2: Non Oudom
- Prospect 3: Non-Chan
- Prospect 4: Dong Phao

Prospects range from 1500-2500 m in depth.
Prospect 1: Savannakhet
Prospect 2: Non Oudom

- Depth structure map of the Permian
  - Prospects trend in a NW-SE direction
  - Bounded by faults in four directions
  - Erosion of the sediments occurring on the other side of the faults in some places
- Key seismic line is outlined in red and shown on next slide
• Savannakhet is defined by the pinchout of the Permian (purple)
  • against the highland on the east side of the concession
• Non Oudom is a Carbonate buildup on a pre-existing carbonate platform
  • Closure independent of faulting
  • Potential for hydrocarbons to be trapped in the Triassic here
Prospect 3: Non-Chan

- Depth structure map of Permian
- Non-Chan is a series of stacked imbricates
  - length of 30 km trending in a NW-SE direction
  - Significant thickness of Permian to be self-sourced for hydrocarbons
  - The complex structural elements lend to fracture and possibly hydrothermal alteration
- 2D seismic dip and strike lines (marked in red) are on the next slide
Non Chan - Dip Line

- Trap an early failed half graben
  - Filled with remnant Triassic and Permian sediments
  - Followed by compressional tectonics
- Potential hydrocarbons in 2 reservoirs
- Liquids may also be encountered here due to proximity of oil shows at surface
Prospect 4: Dong Phao

- Depth structure map of the Permian
- Prospect is a result of Triassic and older sediments being deposited in a failed graben
  - Later erosional event followed by compression providing the structural trap.
- Key N-S seismic line is on next slide
Dong Phao is a stratigraphic pinchout of the Permian against the highland to the south:

- bounded by two major faults trending in an NE-SW direction
- Potential for Triassic (above the purple) hydrocarbons to be trapped in this location as well
Value Add

4 New Prospects and New Geological Models

- Able to add 4 new prospects to the company inventory
- Two new geological models for the area
  - Failed half graben
  - Reef development within half graben
Permian high encountered as a result of late compressional structuring
- Not a result of an early stage platform high
- No opportunity for a carbonate platform to develop
- Well missed the structural closure, wet as a result
Value Add

Explanation why initial drill didn’t work

- Explains why the previous well didn’t find significant hydrocarbons or reservoir
- Provides opportunities for re-evaluation and $$ investment in the area
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Energy Independence and Economic Growth

- World's poorest and least-developed nations
- More than 60% of the population is rural, living in some 9,000 villages.
- Import all oil and natural gas at high prices
- Laos' growth amongst the fastest in Asia nearly 8% per year for the last decade.
- Economy drivers of late have been mining, logging, and construction
- If the exploration program is successful in Lao, it will be the first hydrocarbon production in the country ever.
Resource and Economics Highlights

• $P_{50}$ Gross-In-Place 36 Tcf

• NPV@10% $847$ MM US
  • Risked number
  • $6-8$ MM per well/ D&A
  • Gas price $11/mcf
  • Includes gas plant and tie-in to Thailand

• Commercial terms exceptional
  • PSA: 55% Oil, 60% Gas
  • Full cost recovery
  • No royalties
  • No corporate tax on petroleum profits
• Significant value added by the additional seismic data, reprocessing and re-interpretation = $849 MM U.S.

• Energy independence and economic growth for Laos = $$$$$$....
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