

# **Breakthrough Concept: Turning Hazards Into Resources, the Forgotten Play\***

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## **Abstract**

Over the last three decades, the Malaysian exploration industry has matured significantly. Despite its maturity, new plays continue to evolve and enable PETRONAS to play a role in supporting government policies of reducing dependency on oil as the main energy source. Recent discovery of a shallow gas accumulation in what was once considered a shallow drilling hazard to be avoided, has now become a new play promising substantial commercial gas resources. DS-1 has proven to be the largest shallow gas field, producing gas at a depth as shallow as 512 m MDDB. In addition, several untested reservoirs, some of which yielded gas on MDTs, were encountered. The shallowest interpreted gas reservoir occurred at a depth of 404 m MDDB. The discovery at DS-1 has given impetus and forced a relook at a forgotten play in Malaysian gas exploration history. The success changed the overall exploration strategy in PETRONAS and enhances PETRONAS' resources in meeting the demand for gas in Peninsular Malaysia.

DS-1 tested an east-west trending 4-way dip closure with high amplitude response on seismic, and several have DHI's which appear flat and conformable with the structural closure. The flat events were interpreted as possible gas-water contacts (PGWC). In the past these high amplitudes were thought to be associated with low saturation gas diffused within the rocks as a result seal failure from the underlying field and as a result there was not much data acquired over the zone in conventional wells. However, the appearance of DHI's which were interpreted by the team to be PGWC led the team to convince its management that they represent actual gas accumulation and warrant a well to test the concept.

DS-1 was specifically drilled to evaluate possible commercially viable gas accumulation in several untested shallow reservoirs at depths ranging from about 350 m to 900 m below seabed. The well was located to target several of the brightest amplitude events mapped, which are channels or other sandstone bodies. Cutting samples and sidewall cores of DS-1 indicate the Lower Pliocene section consists of slightly laminated very fine-grained sandstones with dark streaks of carbonaceous material. The section was interpreted to be deposited in a tidal

influenced coastal environment. Gas was discovered in seven reservoirs. Two production tests were conducted in the Lower Pliocene and Upper Miocene reservoirs respectively. The DS-1 was subsequently P&A as a commercial discovery.

# **Breakthrough Concept “Turning Hazards Into Resources, The Forgotten Play”**


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# Presentation Outline

- ❑ **Shallow Gas... Hazards or New Play?**
- ❑ **DS-1 Success story**
  - ❖ **Introduction**
  - ❖ **Geophysical Overview**
  - ❖ **Geological Overview**
  - ❖ **Amplitude Extractions**
  - ❖ **Petrophysical Evaluation**
  - ❖ **Side Wall Cores**
  - ❖ **Well Testing**
  - ❖ **Conclusion & Acknowledgement**

# Shallow Gas... Hazard or New Play?

**OLD DAYS**



**Drillers**

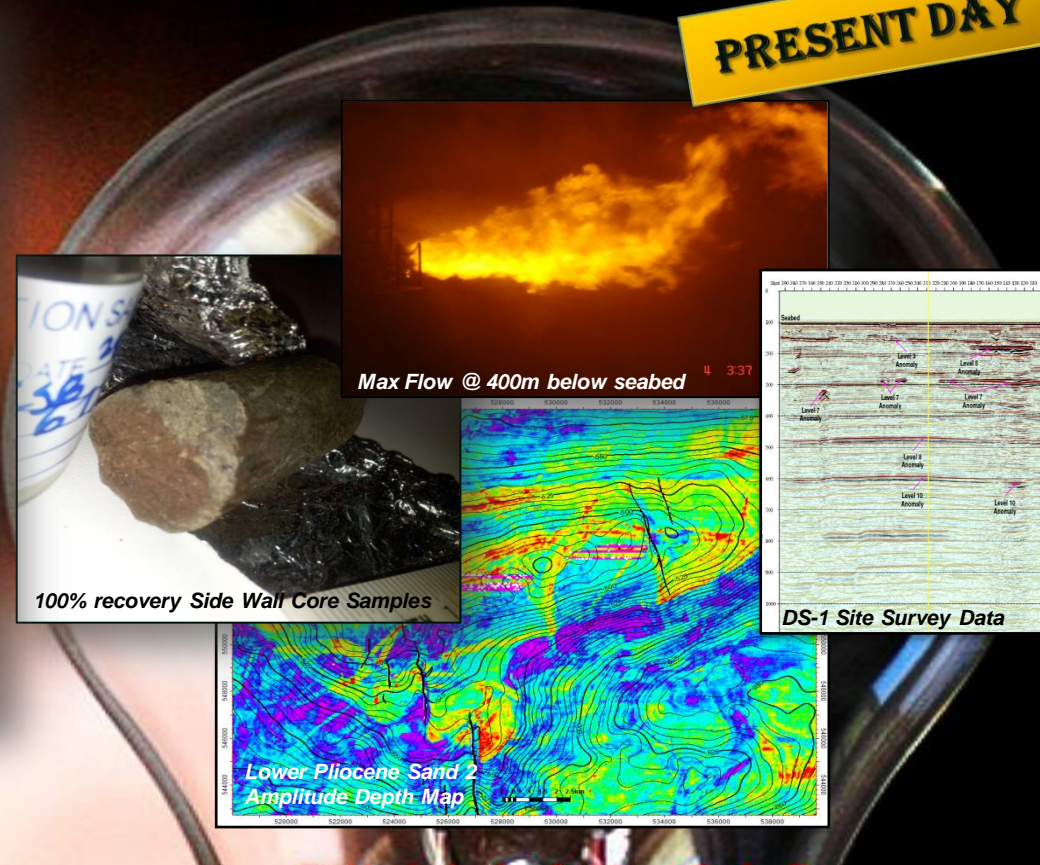
Blowout, Rig  
Punch-through,  
Overbalances,  
Well  
Uncontrolled

**G & G**

Non-commercial,  
Low Pressure  
Reservoir, Biogenic  
Gas, Loose Sand,  
Non-production

**SHALLOW GAS  
HAZARDS**

**PRESENT DAY**



**Max Flow @ 400m below seabed** 4 3:37

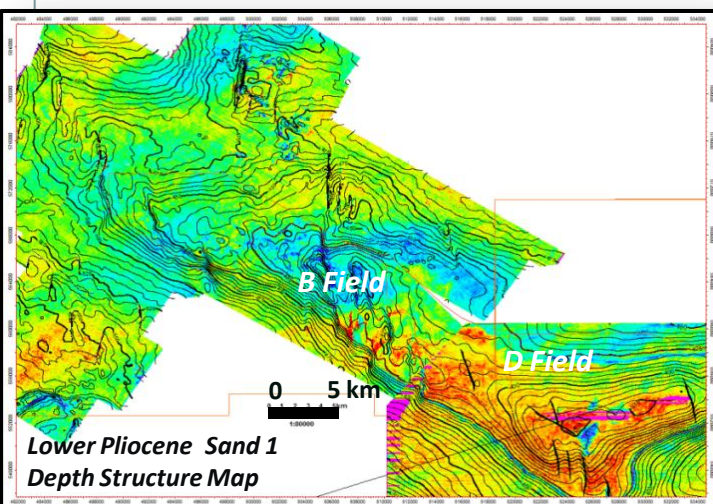
**100% recovery Side Wall Core Samples**

**Lower Pliocene Sand 2  
Amplitude Depth Map**

**DS-1 Site Survey Data**

**SHALLOW GAS  
HAZARDS NEW PLAY**

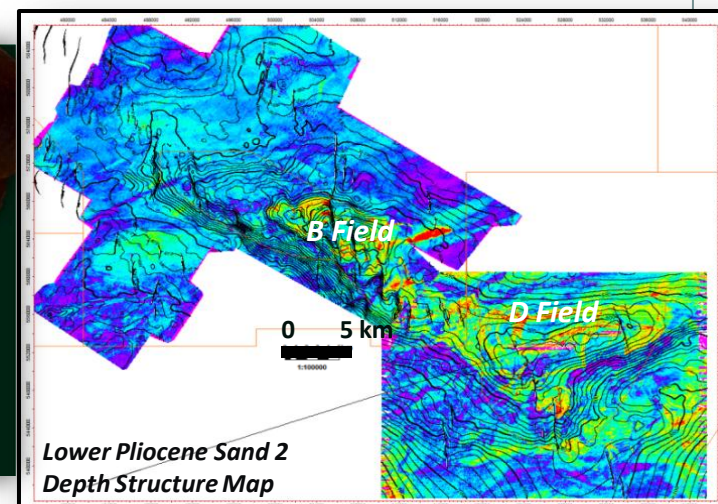
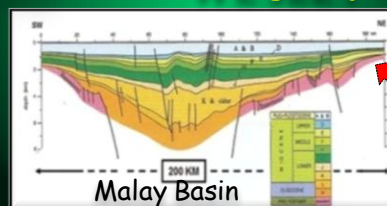
# Introduction



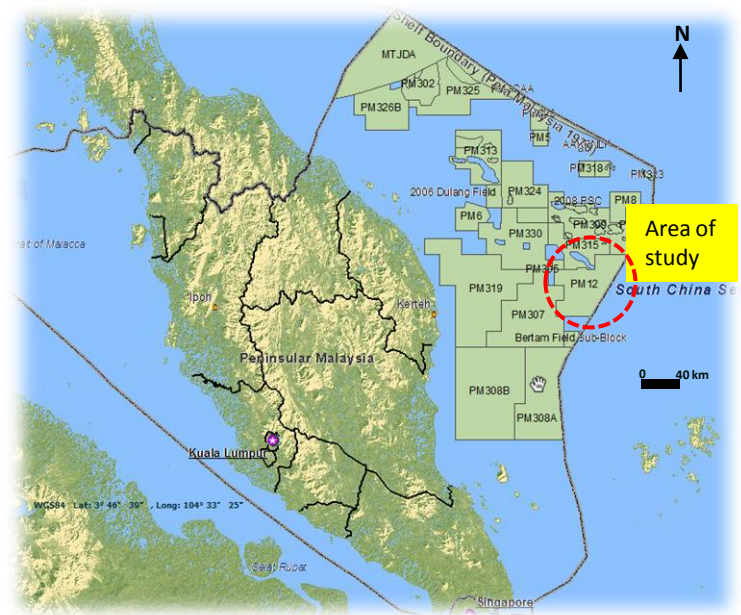
**IMAGINE!**

*'With all the meat taken away, leaving the top and bottom bread'*

**WE SEE!**



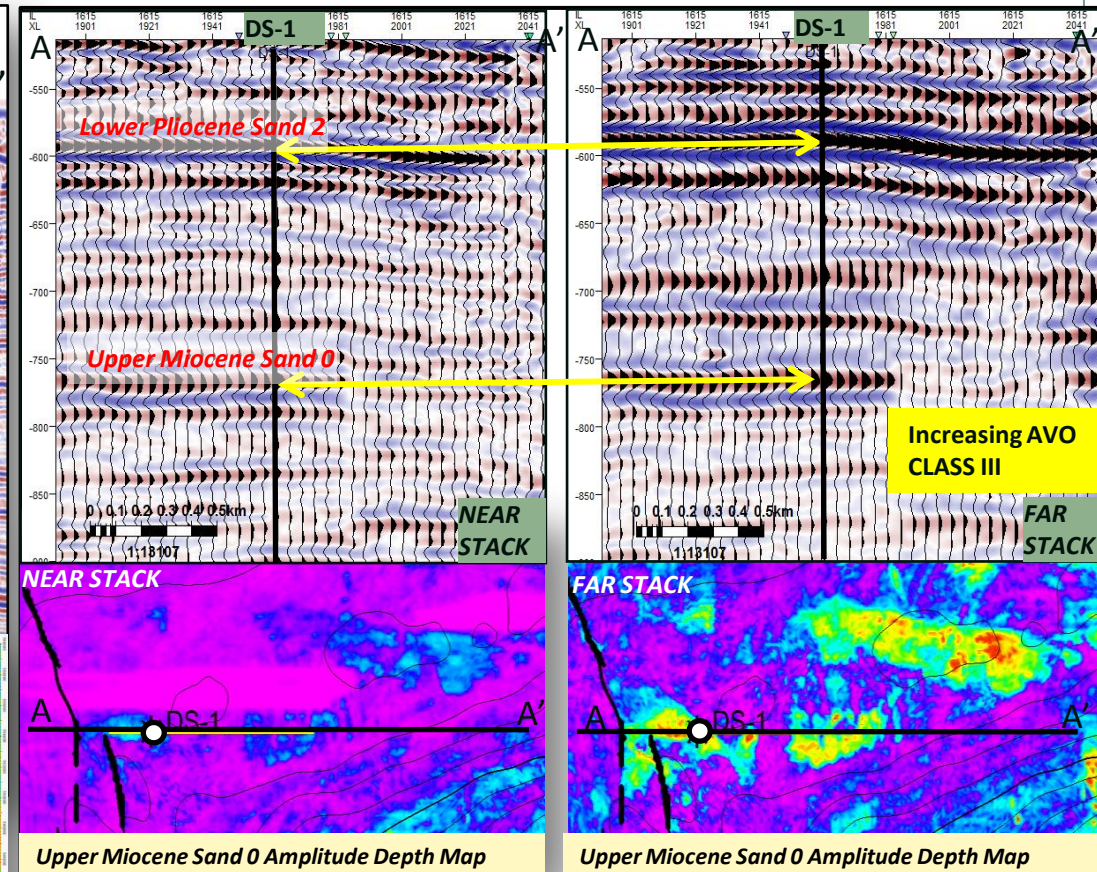
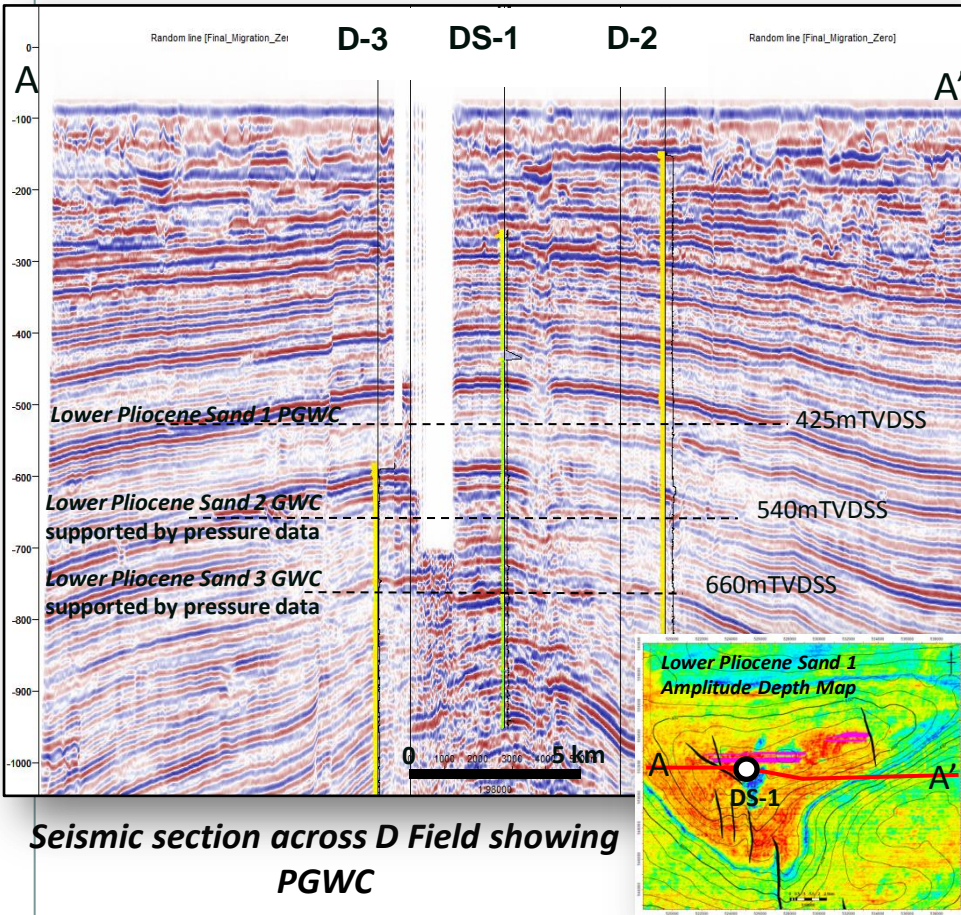
*Distribution of massive shallow gas above D and B Fields which was categorised as "Hazard" during the old days.*



- DS-1 located approximately 236 km northeast of Kemaman Supply Base in 75m water depth in Block PM12, offshore Peninsular Malaysia.
- Objective was to evaluate the HC potential in the untested play of the Lower Pliocene/Upper Miocene sandstones above the existing D Field.
- Result is the discovery of gas in the shallow reservoirs, with the shallowest HC bearing sandstone at 372m TVDss.

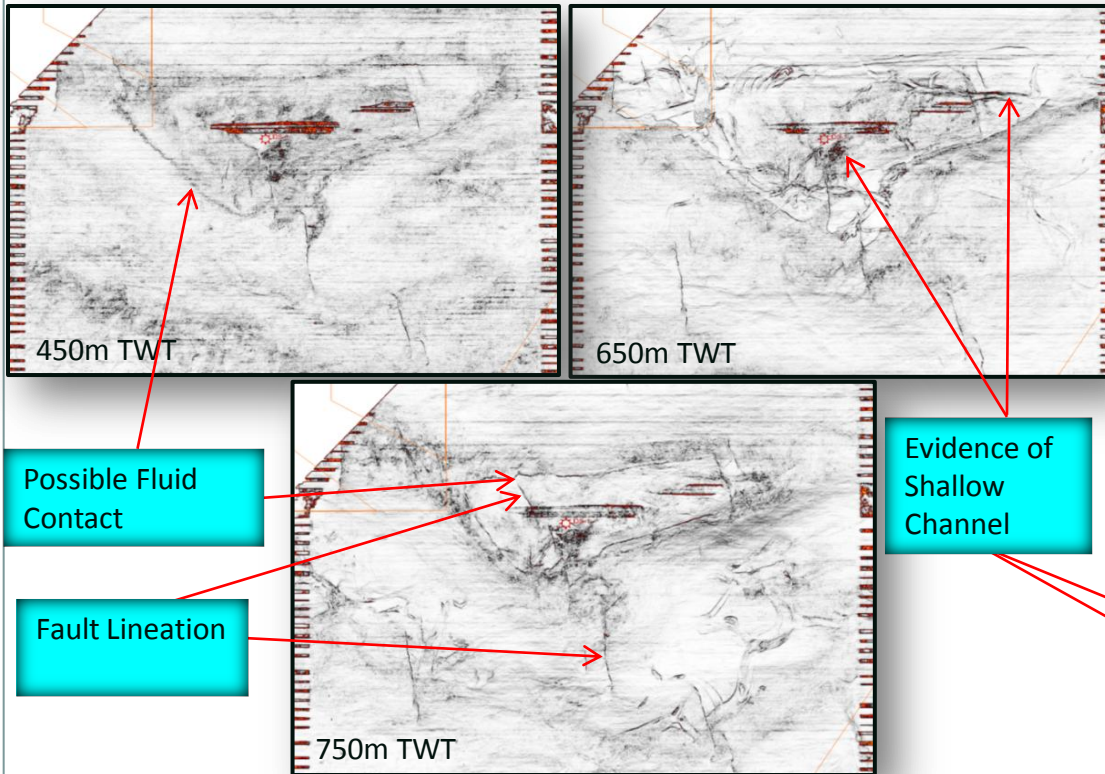


# Geophysical Overview



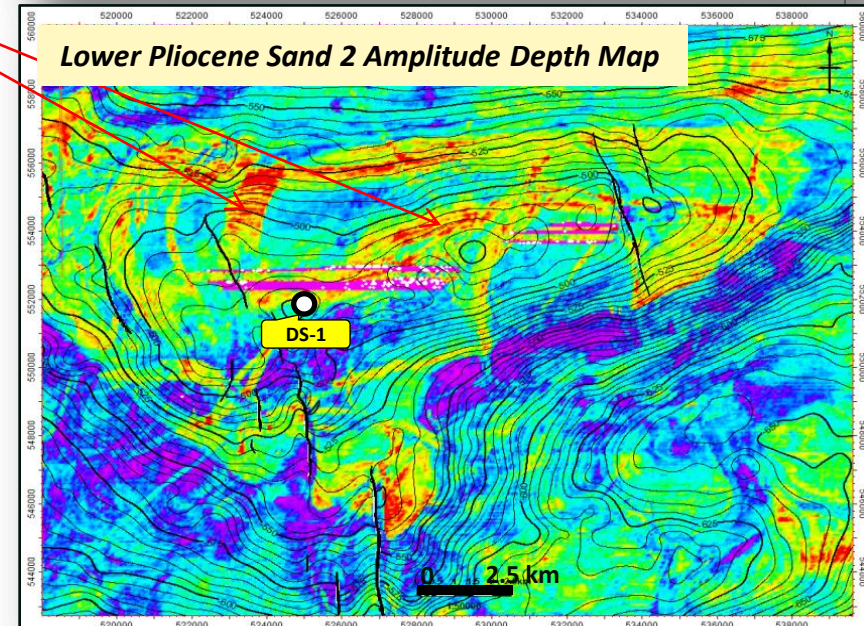
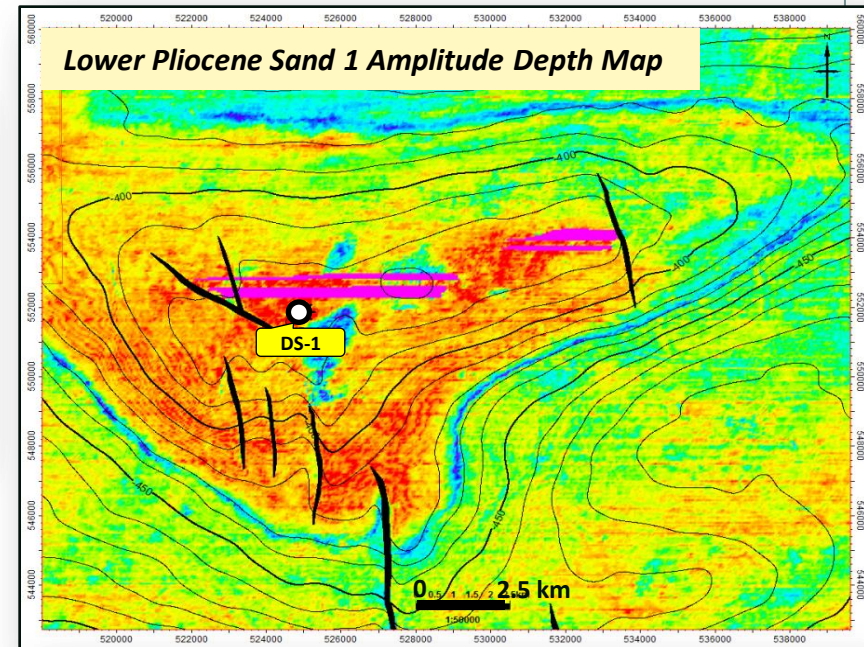
- Upper Miocene Sand 0 showed a positive AVO response with increasing amplitude in the FAR offset.
- The result suggests a CLASS III AVO response as expected from a gas bearing sandstone at this level.

# Geological Overview

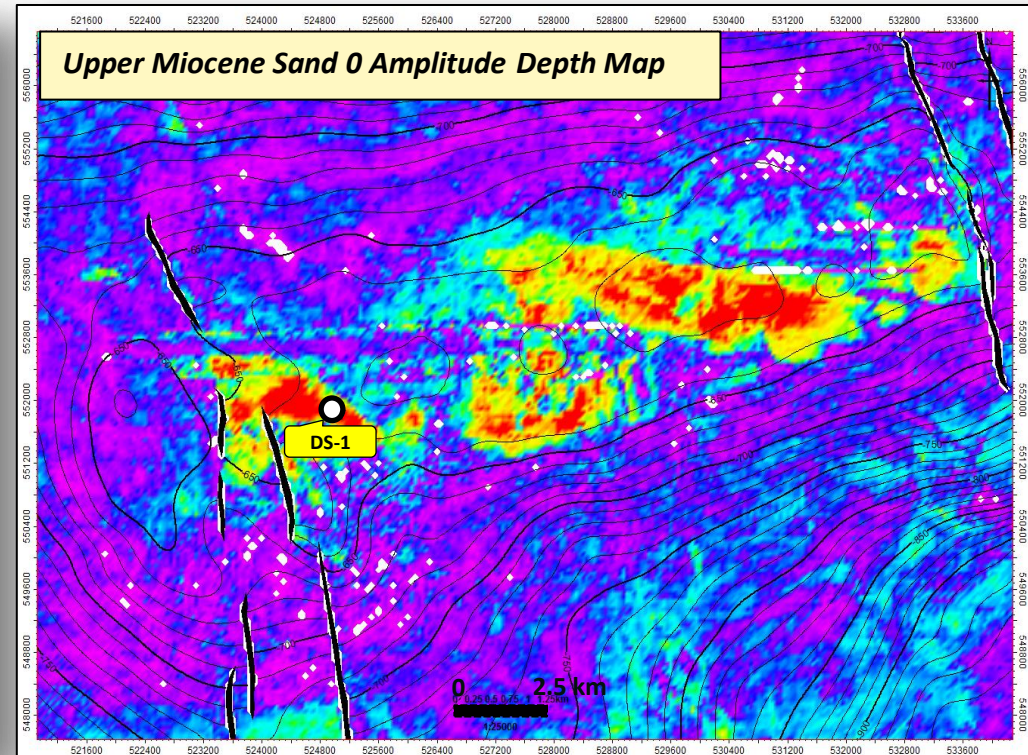
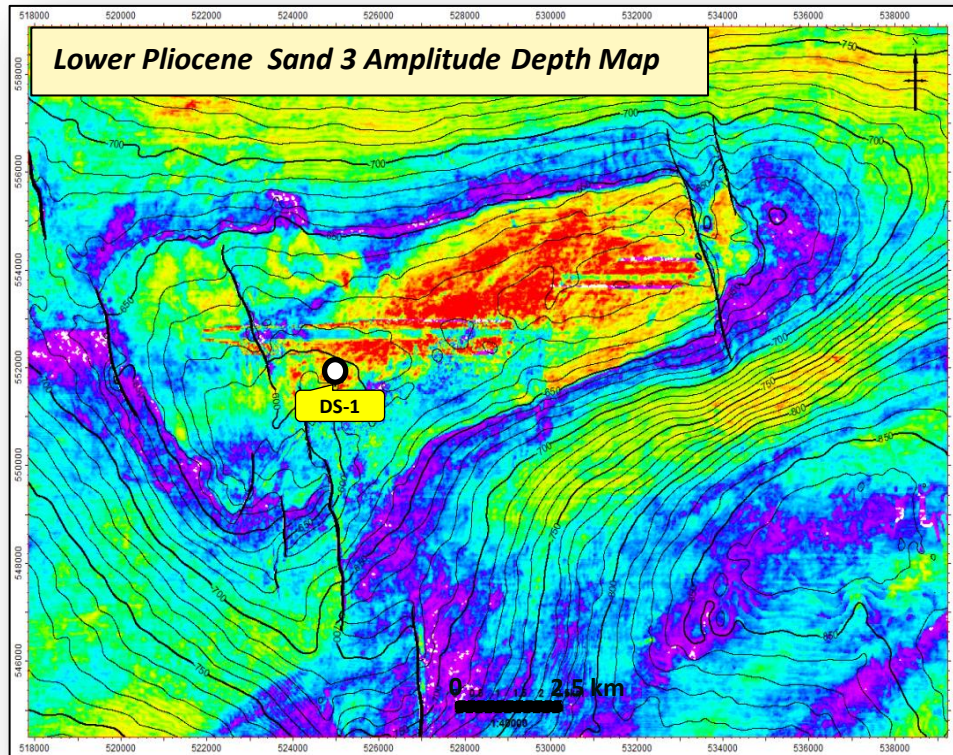


## *Fault interpretation on variance cube*

- DS-1 was located to target several of the brightest amplitude events mapped.
- Clear geomorphological expression indicative of channels or other sandstone bodies.
- Amplitude mapping shows a clearly defined possible gas water contact (PGWC).
- Brighter amplitude is expected to have thicker and better reservoir properties.

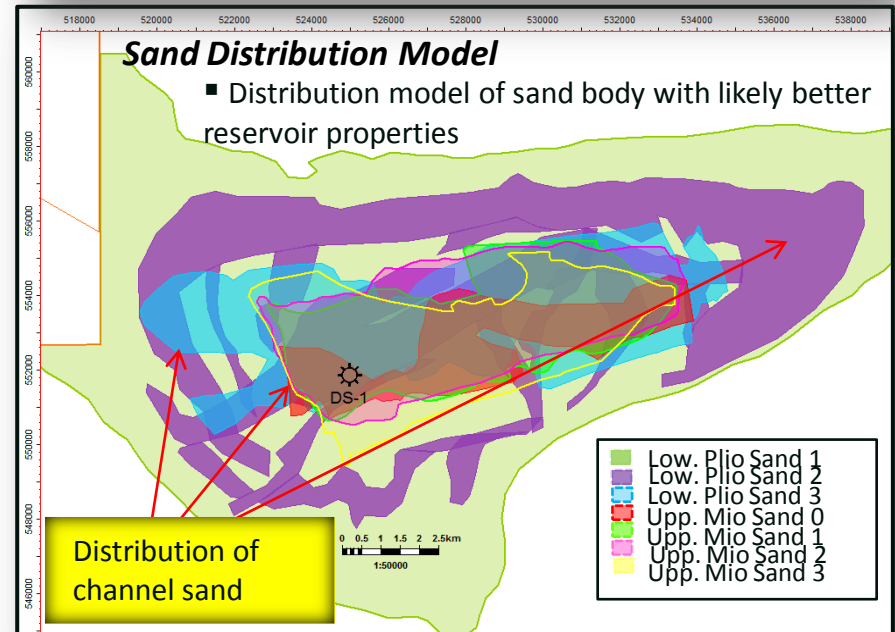
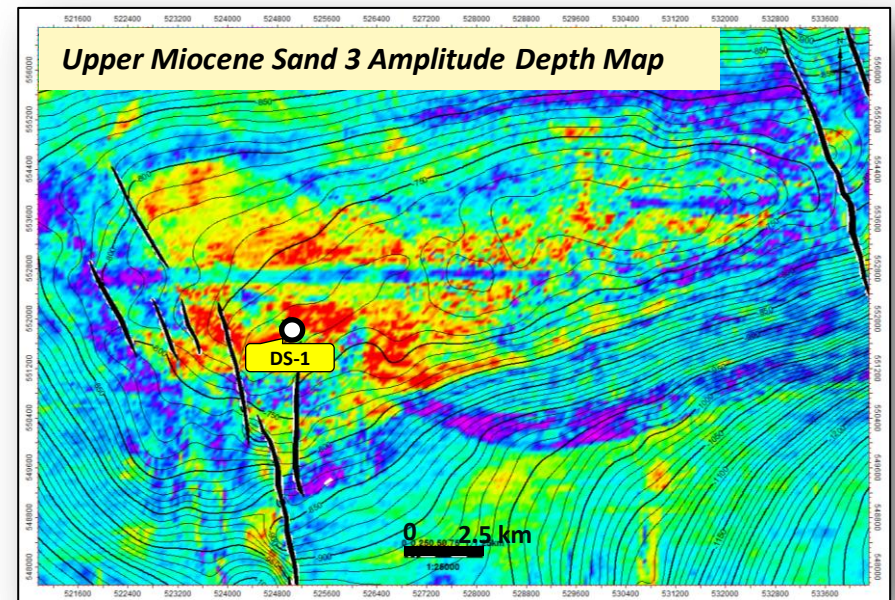
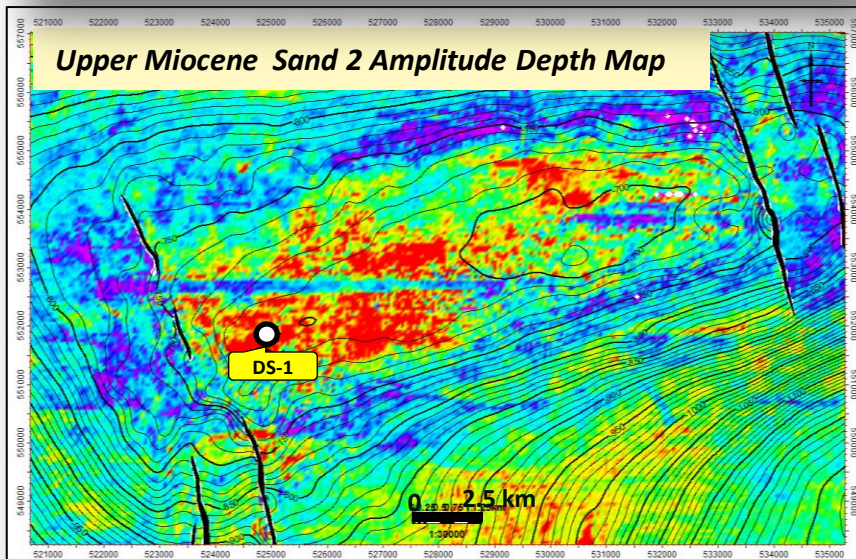
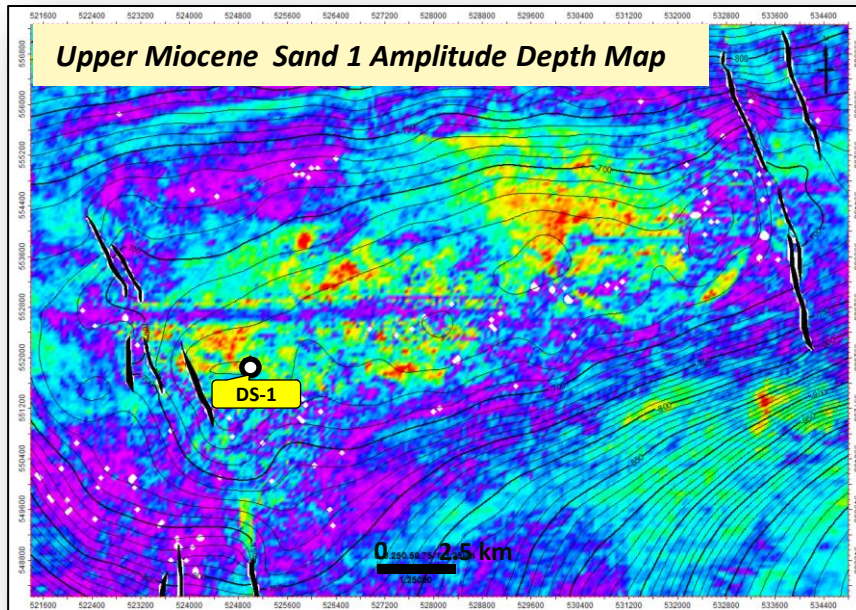


# Amplitude Extractions



- 3D dataset used is reverse polarity according to SEG convention for zero phase data.
- An increase in acoustic impedance or positive reflection coefficient is represented by trough on the workstation.
- RMS amplitude extractions window 15ms above and 15ms below were conducted using the workstation best enhance the features of the target zones and the extracted data overlayed onto the structure maps.
- The high amplitude shown by the extractions indicated presence of sand body while the conformity of amplitude shut-off to the structure closure is interpreted as possible gas water contact (PGWC).
- Pressure plots taken confirmed the contacts at Lower Pliocene Sand 1, Lower Pliocene Sand 2, Lower Pliocene Sand 3 and Upper Miocene Sand 0.

# Amplitude Extractions & Sand Model



# Petrophysical Evaluation

## Petrophysical Log

## Mud Log

Top of Lower Pliocene Sand 2 @ 507m MDDF

DST Interval

512m -

536m MDDF

Pressure (psia):

1) 782.10 @ 515m MDDF

2) 782.74 @ 527m MDDF

Gross Interval: 118m

Net Sand: 47m

PGWC: 572m MDDF

Gas Column: 53m

PGDT @ 565m MDDF

PGWC @ 572m MDDF

Base of Lower Pliocene Sand 2 @ 625m MDDF

Petrophysical evaluation at Lower Pliocene Sand 2 level

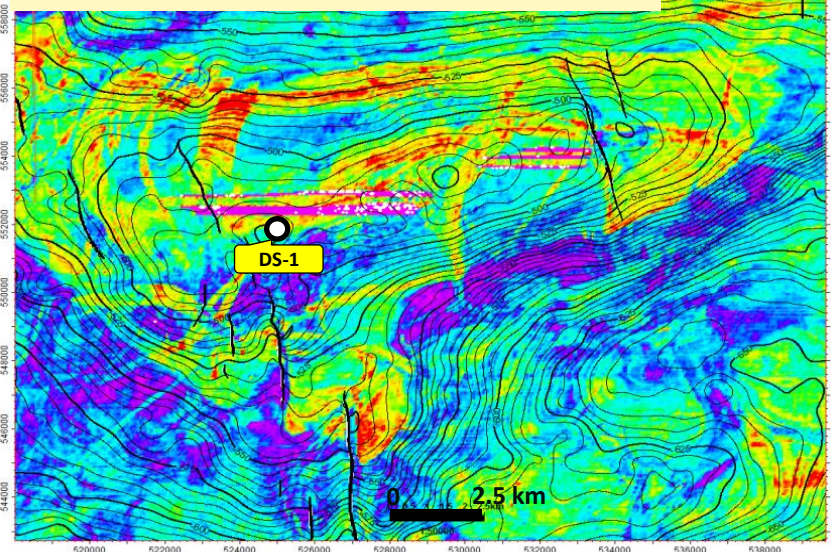
❖ DS-1 proved the presence of Lower Pliocene to Upper Miocene sheet sand and stacked channel sand reservoirs.

❖ From log character and regional correlation, the DS-1 encountered is interpreted to be deposited in a coastal fluvial to shallow marine environment

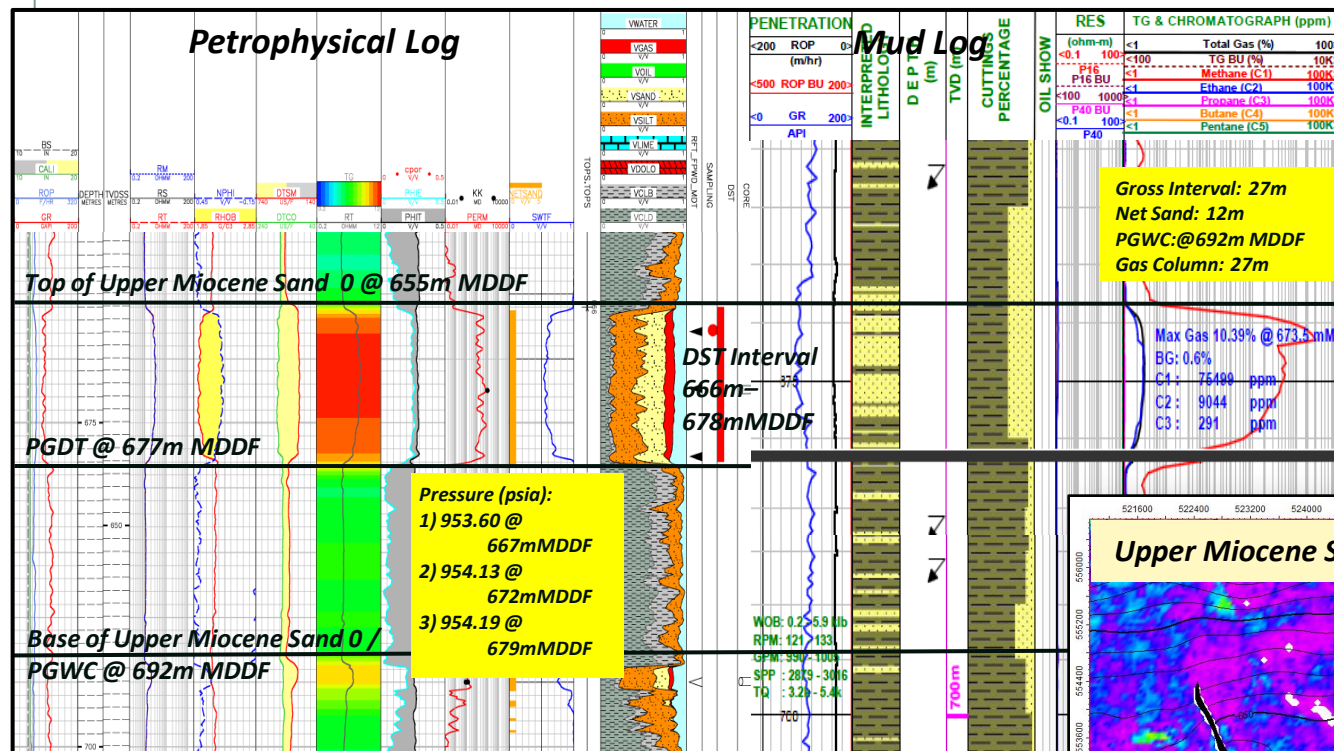
## Lower Pliocene Sand 2

- gross interval 118m
- net sand 47m
- average porosity 31%
- average gas saturation interpreted 35%
- high total gas reading 5%

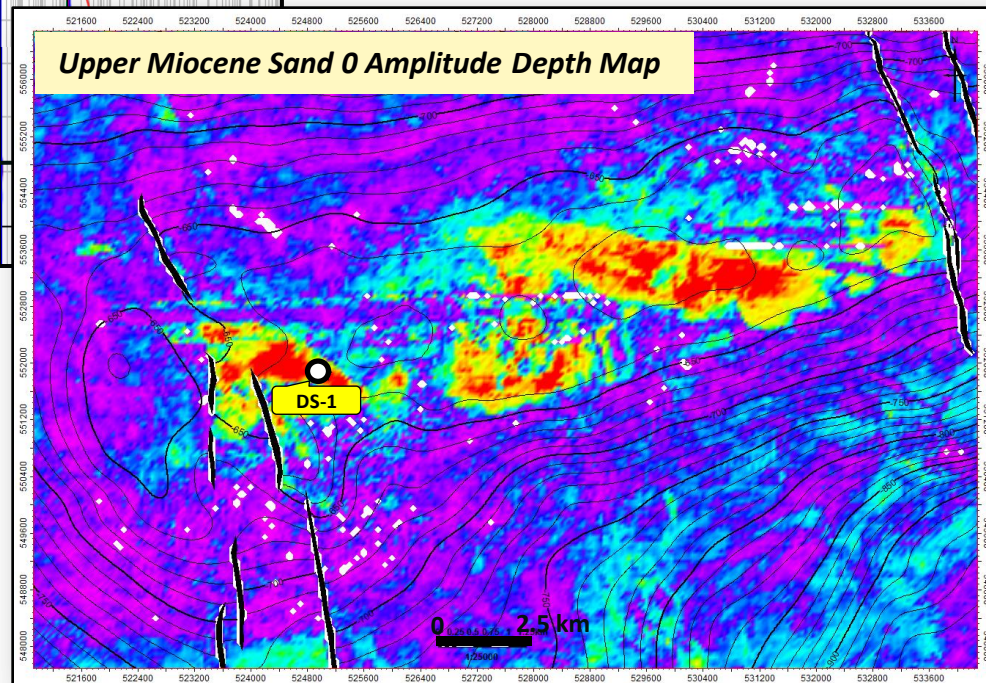
## Lower Pliocene Sand 2 Amplitude Depth Map



# Petrophysical Evaluation



- gross interval 27m
- net sand 12m
- average porosity 30%
- average gas saturation interpreted 40%
- high total gas reading 10.4%



### ***Petrophysical evaluation at Upper Miocene Sand 0 level***

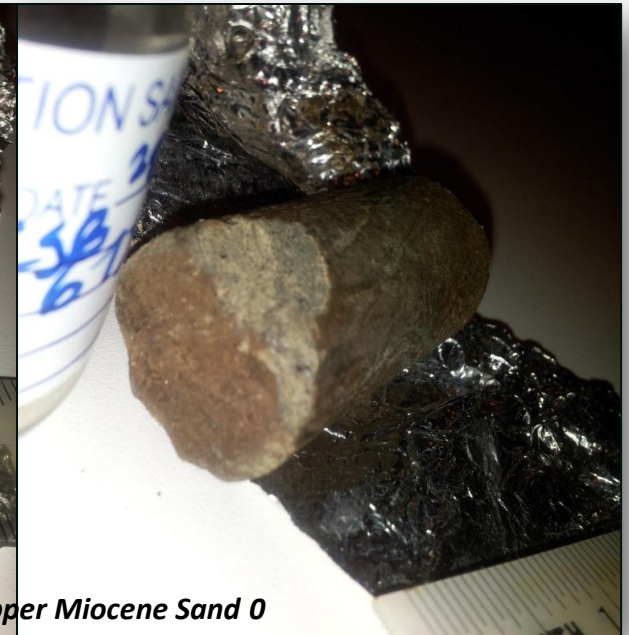
## Side Wall Cores



*Side Wall Core Sample at Lower Pliocene Sand 2*



*Side Wall Core Sample at Upper Miocene Sand 0*



### ***Core description at Lower Pliocene Sand 2***

**Siltstone:** Transparent-translucent, very light to light gray, occasionally loose quartz grains, argillaceous matrix, very fine to fine grained, occasionally medium grained, poorly sorted, subangular to subrounded, occasionally rounded, generally consolidated, moderately cemented, slightly friable, non calcareous, poor visual porosity, N/S.

\*sidewall core is slightly laminated with dark streaks, possibly carbonaceous material.

### ***Core description at Upper Miocene Sand 0***

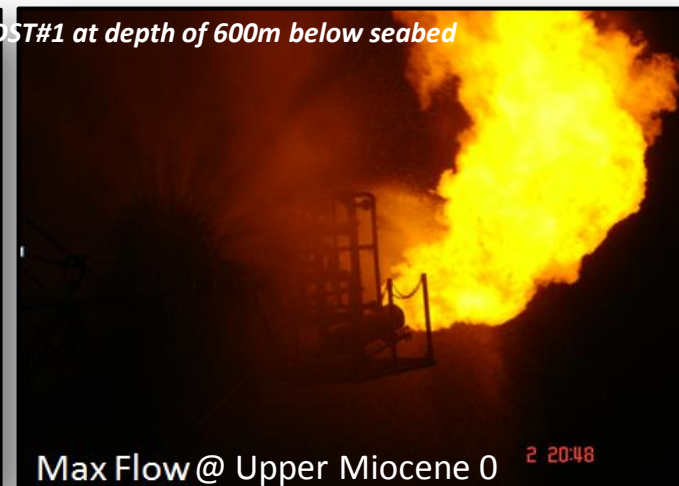
**Sandstone:** Transparent-translucent, medium gray, occasionally dark brownish gray, occasionally loose quartz grains, fine to medium grained, moderately sorted, subangular to subrounded, generally consolidated, slight argillaceous matrix, moderately cemented, friable, non calcareous, poor visual porosity, N/S.

\*sidewall core is moderately hard to hard

# Well Testing

## DST #1 at Upper Miocene Sand 0

- Reservoir pressure is 953psi with temperature 71°C at 672m MDDF.
- DST interval is 12m with perforations from 666-678m MDDF.
- The gas produced a very dry gas with SG of 0.60, zero CGR and no CO<sub>2</sub>, no H<sub>2</sub>S, no water.
- Sand production observed at the surface and highest flow rate recorded is 542g/hr, due to unconsolidated sand in the shallow reservoir.



## DST #2 at Lower Pliocene Sand 2

- Reservoir pressure is 782psi with temperature is 69°C at 515m MDDF.
- DST interval is 24m with perforations from 512-536m MDDF.
- The gas produced a very dry gas with SG of 0.56, zero CGR and no CO<sub>2</sub>, no H<sub>2</sub>S, no water.
- Due to the unconsolidated nature in the shallow reservoir, some sand was produced and the sand production rate is 63g/hr.



▪ DS-1 was subsequently P&A as a commercial discovery. The well proved that what was previously a hazard is a promising new play in the Malay Basin.



## Conclusion

- A breakthrough and is a first discovery on the shallow reservoir.
- Opens up a new play concept in Malaysia gas exploration history.
- In term of operation, the well was successfully drilled with final cost of USD 8 mil, 3 times cheaper than conventional well USD 25mil.
- Compared to conventional reservoir, time duration to complete the drilling was reduced from 1 month to 1 week , resulting in significant cost saving.
- The use of good seismic quality 3D seismic data and advanced geophysical applications on amplitude extraction proved to be viable in predicting good sand body fill with hydrocarbon.
- A significant hydrocarbon volume which free of inert gas is proven and tested in this new play at DS-1.
- This success provided new opportunity for exploration entity to move forward and discover more gas resources.

## Acknowledgement

We would like to extend our appreciation and gratitude to PETRONAS for the approval on presenting this paper.