



## ORAL PRESENTATION

---

**Day 2: 8<sup>th</sup> March 2023**

### **Session 7: SARAWAK**

**Co-Chair: Peter Grant, DeepC Store**

**Co-Chair: Damion Rudd, Harbour Energy**

---

13:40	Exploration History of the Miocene Carbonate Play in Central Luconia, Offshore Sarawak – a World-Class Gas Province	Sofiyah Mokhtar	Shell
14:05	New Exploration Insights from the Latest MultiClient 3D in Offshore Sarawak, Malaysia	Tad Choi	PGS-TGS-Schlumberger
14:30	Natural Experiments in Long Term CO <sub>2</sub> Storage: Observations from Sarawak	Mark Sams	Ikon Science
14:55	Application of Real Time Isotope Logging for Reservoir Evaluation in Central Luconia Province	Ahmad Shoeibi	Geolog



## ORAL PRESENTATION

---

# Exploration History of the Miocene Carbonate Play in Central Luconia, Offshore Sarawak – a World-Class Gas Province

Sofiyah Mokhtar<sup>1</sup> and Peter Winefield<sup>1</sup>

<sup>1</sup> Shell

[Sofiyah.Mokhtar@shell.com](mailto:Sofiyah.Mokhtar@shell.com)

---

The Central Luconia geological province located in shallow waters approx. 100 miles offshore Sarawak is one of Malaysia's most prolific gas provinces with ongoing exploration, development, and production since the late 1960s. It spans an area of some 45,000 km<sup>2</sup> with current & produced volumes exceeding 65 TCF (~12 BBOE) in isolated carbonate platforms of Middle to Upper Miocene in age with approx. 200 individual platforms currently mapped. The shape, geometry and orientation of each platform vary from pinnacle-shaped km's scale features (e.g., B-11, Cili Padi-1, Timi-1 etc) to 10's km-scale mega platforms (e.g. Jintan, F-6, E-11) and appear linked to distinct structural domains.

Exploration activities began in 1968 by Shell with the first seven wells being unsuccessful before the discovery of the significant F6 gas accumulation in 1969 leading to a number of following discoveries and the subsequent development of the Malaysian LNG Sendirian Berhad (MLNG), Malaysia's first LNG plant in 1978. Several phases of exploration have continued with the most recent delivering a significant increase in the creaming curve for the play. Carbonate reservoir heterogeneities and gas contamination are key in production performance and commercial value respectively whilst critical exploration success factors remain charge focus and the hydrocarbon column length particularly in relatively narrow pinnacle-shaped features. In the last few years, new 3D broadband seismic data with improved regional coverage has largely confirmed the extent of many previously mapped platforms with the addition of some new features on the margins of the province and numerous smaller platforms. As a result, several key operators have launched well campaigns with recent outcomes continuing to challenge long-held paradigms on the carbonate play in Central Luconia. This includes the improvement of fast-track development for some discoveries and encouraging further exploration activity towards the perceived margins of the play.

## SPEAKER BIOGRAPHY

Sofiyah is an Exploration Geoscientist in Shell Malaysia. She started in 2018, in the Asia Regional Ventures team after her postgraduate studies on carbonate sedimentology & stratigraphy, and since 2021 has been on the hydrocarbon maturation team for Sarawak. She is also currently pursuing a part time masters in renewable energy engineering at Heriot Watt University.

## ORAL PRESENTATION

# New Exploration Insights from the Latest MultiClient 3D in Offshore Sarawak, Malaysia

Dr Tad Choi<sup>1</sup>, Nicolas Hand<sup>2</sup> and Ching Tu<sup>3</sup>

<sup>1</sup>PGS, <sup>2</sup>TGS, <sup>3</sup>SLB

[tad.choi@pgs.com](mailto:tad.choi@pgs.com)

The Sarawak MultiClient 3D (MC3D) project commenced in 2020 and the first Phase of the newly acquired Multisensor broadband data currently totals 8,500sqkm (Fig. 1). The PSTM data already shows significant uplift compared to legacy data and new exploration insights will be discussed in this paper. The Sarawak MC3D project follows the success of the Sabah MC3D project that was initiated in 2016 and currently totals 47,000sqkm data coverage over the Sabah Basin (Fig. 1). Petronas' MPM opened additional areas for regional Multiclient 3D and an area of over 100,000sqkm of the Sarawak offshore basin was nominated. The same JV consortium (PGS, TGS and SLB) who conducted the Sabah MC3D was awarded to undertake the Sarawak MC3D project.

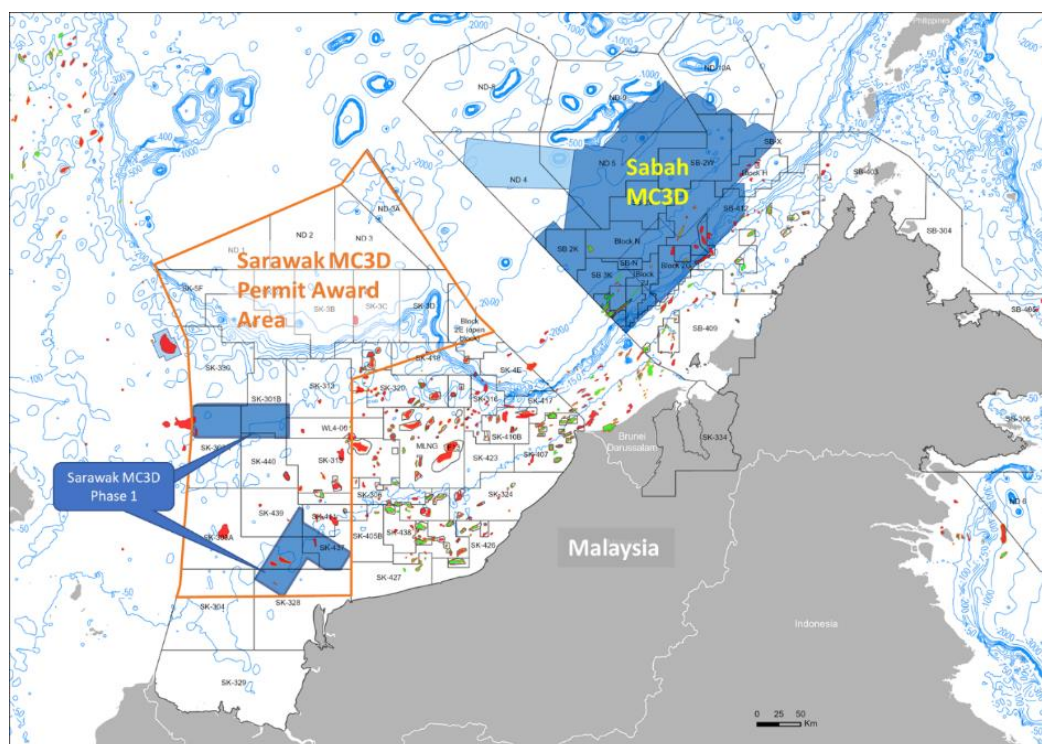


Figure 1. Sarawak MC3D permit award area and data coverage of the newly acquired Sarawak MC3D Phase 1.

The Sarawak Basin consists of Tertiary clastic and carbonate targets comparable to Sabah, being part of the greater NW Borneo Sundaland geological province. The Central Luconia Province has been the major focus of exploration with numerous successful wells targeting post Mid-Miocene Unconformity (MMU) shallow carbonate targets. However, below the MMU the carbonate/siliclastic sedimentary section is not well-imaged on legacy seismic data and an accurate pre-Tertiary basement pick has been challenging. Phase 1 of the Sarawak MC3D covers the West Luconia and SW Luconia/Tatau provinces, respectively (Fig. 2). This newly acquired Multisensor broadband dataset covers a total area of approximately 8,500 sqkm where exploration is targeting pre- and post-MMU clastic and carbonate plays.



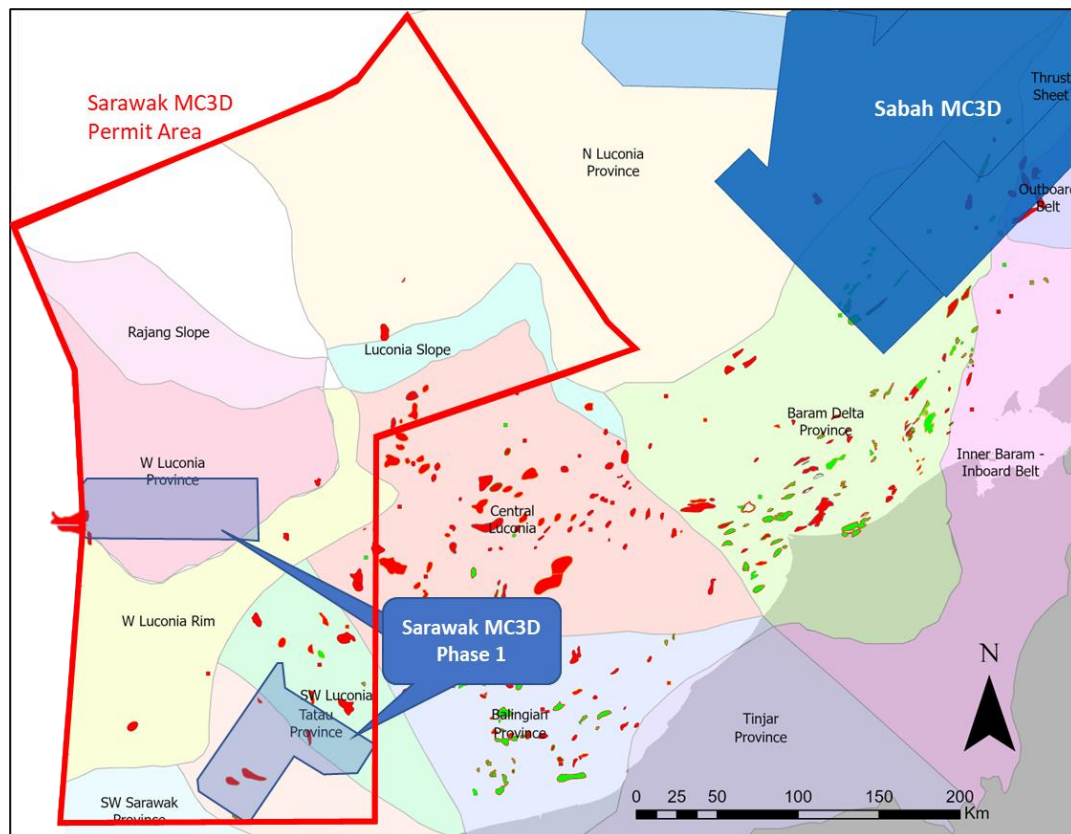


Figure 2. Geological Provinces of the Sarawak Basin.

Phase 1 of the new Sarawak MC3D project will help assess exploration risk and form the basis of renewed play evaluations in the region. The PSTM data, shows detailed channel features (Fig. 3) in the post-MMU section and the pre-MMU section (Cycles I-IV) can be clearly identified and accurately mapped. The pre-MMU syn-rifts formed during the extensional phase of the basin history and the new data helps identify sedimentary packages and de-risk new plays. Furthermore, deeper imaging has allowed the identification of deep-seated faults that will allow for better understanding of basin development history and hydrocarbon migration. Future acquisition phases will result in a larger footprint of broadband seismic data, enabling a better regional scale understanding of the Sarawak Basin, as well as supporting near-field infrastructure led exploration activities.



Figure 3. Fluvial channel systems from the Rajang Delta can be seen near seabed on the Sarawak MC3D PSTM data. Further processing workflows towards the final PSDM dataset is currently ongoing.

## **SPEAKER BIOGRAPHY**

Tad has over 2 decades of experience in the oil and gas industry, primarily in the Asia-Pacific region. He started his career in 2002 at Woodside Energy, where he spent 10 years in Exploration, before joining PGS as a Principal Geoscientist in Singapore in 2012. He then transitioned into Sales & BD, living and working in Singapore and KL for 10 years. He is now back based in PGS' Perth office. He holds a Master's and a PhD degree in geology from Niigata University Japan, where he studied the back-arc basins of Japan. Tad has played a key role in the Sabah MC3D project since its inception in 2015 and is now part of the Sarawak MC3D project team. In his spare time, he plays lead guitar and sings in a Perth 80's rock band called '*ICONIC*'.



## ORAL PRESENTATION

---

# Natural Experiments in Long Term CO<sub>2</sub> Storage: Observations from Sarawak

**Mark Sams<sup>1</sup> and Thivyaadarshini Jayasangar<sup>2</sup>**

<sup>1</sup> *Ikon Science*

<sup>2</sup> *PETRONAS Carigali Sdn Bhd*

[msams@ikonscience.com](mailto:msams@ikonscience.com)

---

Anomalous features observed in seismic data from parts of the Greater Sarawak Basin are believed to be diagenetic fronts associated with the presence of CO<sub>2</sub>. Measurements from well log data show that the elastic properties of shales and silts behind these diagenetic fronts have been altered through a loss of capillary bound micro-porosity. It is hypothesized that this is the result of the action on the clays of carbonic acid, which diffuses along a concentration gradient away from the reservoir rocks, which contain high concentrations of CO<sub>2</sub> that have accumulated in traps along with hydrocarbons. The velocity and density data can be corrected based on an empirical model that matches similar changes caused by normal mechanical compaction, although some chemical alteration must have occurred. We show that the degree and shape of the alteration is sufficient for these effects to be observed on seismic data. The amplitudes and AVO characteristics of the seismic data drastically change due to the alteration thereby making reservoir and fluid prediction significantly more challenging. On the other hand, the presence of alteration might be used as an indirect hydrocarbon indicator as there is a strong correlation within the current data between hydrocarbon presence and shale alteration. The change in elastic properties of the seal rocks through interaction with high concentrations of carbonic acid in the reservoir may have implications for long term CO<sub>2</sub> storage.

## SPEAKER BIOGRAPHY

Mark Sams is Vice President of Services for Ikon Science in Asia Pacific. Mark holds an MSc. and Ph.D. in geophysics from Imperial College, London University. Mark has been based in Kuala Lumpur since 1994 work for PETRONAS, Jason Geoscience, and Ikon Science. His main areas of interest include the practical application of rock physics, deterministic and geostatistical inversion in the Seismic Quantitative Interpretation workflow.



## ORAL PRESENTATION

---

# Application of Real Time Isotope Logging for Reservoir Evaluation in Central Luconia Province

**Ahmad Shoeibi<sup>1</sup>**

<sup>1</sup> Geolog

[a.shoeibi@geolog.com](mailto:a.shoeibi@geolog.com)

---

### Objectives/Scope

Central Luconia is the most important province in the Sarawak Basin for gas production from carbonate successions. During Middle-Late Miocene, pinnacle reefs formed on raised horst blocks that were created by the Late Oligocene-Early Miocene South China Sea rifting.

Porous pinnacle reef carbonates are the main target for gas exploration in this area. Vertically stacked reservoir layers, dominated by mouldic/vuggy porosity in coarse grained skeletal facies, are locally separated by baffle/barrier layers of tight muddier facies. Reef-bounding faults further complicate the overall reservoir distribution and connectivity, locally acting as preferential fluid pathways and possibly breaching the integrity of the overlying seal.

Hydrocarbon column heights in Luconia reefs are controlled by several mechanisms: a) Charge access (migration focus); b) Aquifer overpressure and top seal competency; c) Thief zones interbedded in sealing lithologies.

The present study illustrates the role of advanced mud gas characterization in formation evaluation to address two main questions: is there gas in the reservoir? And, if so, is the seal working?

### Methods/Procedures/Processes

This study used mud gas samples as the source of information on gas across reservoir and seal. Mud gas extraction with controlled temperature, pressure, and mud flow is fundamental for an overall correct and reliable data logging; therefore, two main systems were used to characterize the samples:

- 1) Chemical composition through Gas Chromatography – Flame Ionization Detection (GC-FID) from C1 to C5.
- 2) Carbon isotopes through Gas Chromatography – Cavity Ring-Down Spectroscopy (GC-CRDS) from C1 to C3. When drilling the seal, the shorter analytical cycle of C1-C2 was preferred for higher data resolution, while, when entering the reservoir, the analysis was extended to C3.

### Results/Observation/Conclusions

The proposed methodology was applied in four wells in Central Luconia, which resulted in two gas discoveries and two dry holes.

Gas isotope profiles in seal sediments can be integrated with the basin model to provide insight into plumbing and failure mechanisms during post-well analysis, e.g., understanding the mechanism that controls the pinnacle reef reservoirs or the sealing capacity of the overlying succession, in order to facilitate charge de-risking in undrilled targets.

Using this information, it was possible to carefully decide the final drilling depth of the well and secure the well without further drilling complications. This process allowed the asset team to decide on cancelling open-hole logs for both dry wells, and enabled optimized sampling for further laboratory analyses in the other two wells, which lead to significant cost savings.

### **Applications/Significance/Novelty**

Carbon isotopic ratios help distinguish between biogenic and thermogenic gas, and highlight the degree of mixing, which is key to establishing whether mature gas has diffused through the seal, and, if so, up to which stratigraphic level. Additionally, the carbon isotope log through the seal helps recognize general seal failure due to overpressure from the presence of discrete thief beds, or the absence of thermogenic charge.

In this study, we propose a quasi-real-time approach at wellsite as an alternative to standard Isotubes collection and laboratory analysis, with an overall gain in terms of response timings and data density.

### **SPEAKER BIOGRAPHY**



Ahmad Shoeibi obtained a BSc Degree in Reservoir Engineering from Azad university of Iran. Ahmad has worked in a variety of roles for Geolog International B.V in countries in the Middle East and Central Europe. He has performed detailed integrated formation evaluation analysis, specializing in Fracture Detection, Geo-Steering and Reservoir Evaluation using surface logging techniques. Ahmad is currently employed as a Regional Formation Evaluation Manager for Middle East and Far East. Ahmad has co-authored a number of papers in the AAPG, EAGE, IPTC, SPE and SPWLA.