Biogenic Gas Potential of Myanmar*

Lynn Myint[1]

Search and Discovery Article #30603 (2019)**
Posted April 22, 2019

*Adapted from oral presentation given at 2018 AAPG Asia Pacific Region, The 4th AAPG/EAGE/MGS Myanmar Oil and Gas Conference, Myanmar: A Global Oil and Gas Hotspot: Unleashing the Petroleum Systems Potential, Yangon, Myanmar, November 13-15, 2018
 DOI:10.1306/30603Myint2019

[1]Retired Chief Geologist (MOGE), Chairman of Myanmar Association of Petroleum Geologists, Yangon, Myanmar (mr.lynnmyint@gmail.com)

Abstract

For the reason of geologically predictable circumstances and accumulation in commercial quantities at shallow depths as free gas or gas hydrates, biogenic gas becomes increasingly important as an exploration target in the global petroleum industry. In Myanmar the biogenic gases are found in Upper Miocene to Pleistocene sediments of two onshore basins (Ayeyarwady Delta Basin and Bago Yoma Basin) and two offshore basins (Moattama and Rakhine). Biogenic gas plays a significant role in Myanmar's offshore natural gas production. A total of 4.735 trillion cu.ft of initial recoverable biogenic gas reserves which is equivalent to 35% of the total proven recoverable natural gas reserves discovered to date in shallow water areas of Rakhine and Moattama offshore basins. Also, very promising indication of commercial biogenic gas accumulations was tested by recent drillings in Rakhine deepwater areas which means the biogenic gas will yield a major portion of the future natural gas reserves of Myanmar. The onshore Ayeyarwady Delta Basin (ADB) and Bago Yoma Basin (BYB) can be considered as the most favorable areas for discovery of commercial biogenic gas, based on the fact that about 32 billion cu.ft of biogenic gas was extracted from Kyagaik gas field and currently producing a considerable amount of gas in the Maubin gas field in ADB and a substantial amount of biogenic gas was produced from Indaing gas field in BYB. This paper analyzed source system and controlling factors for generation and accumulation of biogenic gas, identified favorable locales for accumulation, and delineated potential areas for future exploration. Rapid deposition of thick deepwater sediments from the Bengal, Rakhine and Irrawaddy deltas during the Neogene resulted in conditions prone to the establishment of a prolific biogenic gas petroleum system.

Selected References

Dolivo, E., 2018, The Shwe Yee Htun-2 Gas Test: A Step Forward for A-6 Gas to Our Bulbs: MPRL E&P Newsletter, Insight!, 8th October 2018, p. 1, 10-11.

Hongping, W., L. Fuliang, G. Fan, C. Mao, and M. Hongxia, 2011, Geological Conditions and Accumulation Mechanism of Shallow Biogenic Gas Reservoirs in Andaman Basin: AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011, Search and Discovery Article #10343 (2011). Website accessed April 2019.

BIOGENIC GAS POTENTIAL OF MYANMAR

Lynn Myint

Member of Myanmar Geoscience Society

Email: mr.lynnmyint@gmail.com

FOCUS OF THIS PRESENTATION

- To briefly comment on the potential economic significance of biogenic gas in Myanmar.
- To examine the factors which control the generation, migration and accumulation of commercial quantities of biogenic gas.
- To review the characteristics of major biogenic gas accumulations.
- To identify promising locations for commercial biogenic gas accumulation.

OUTLINE

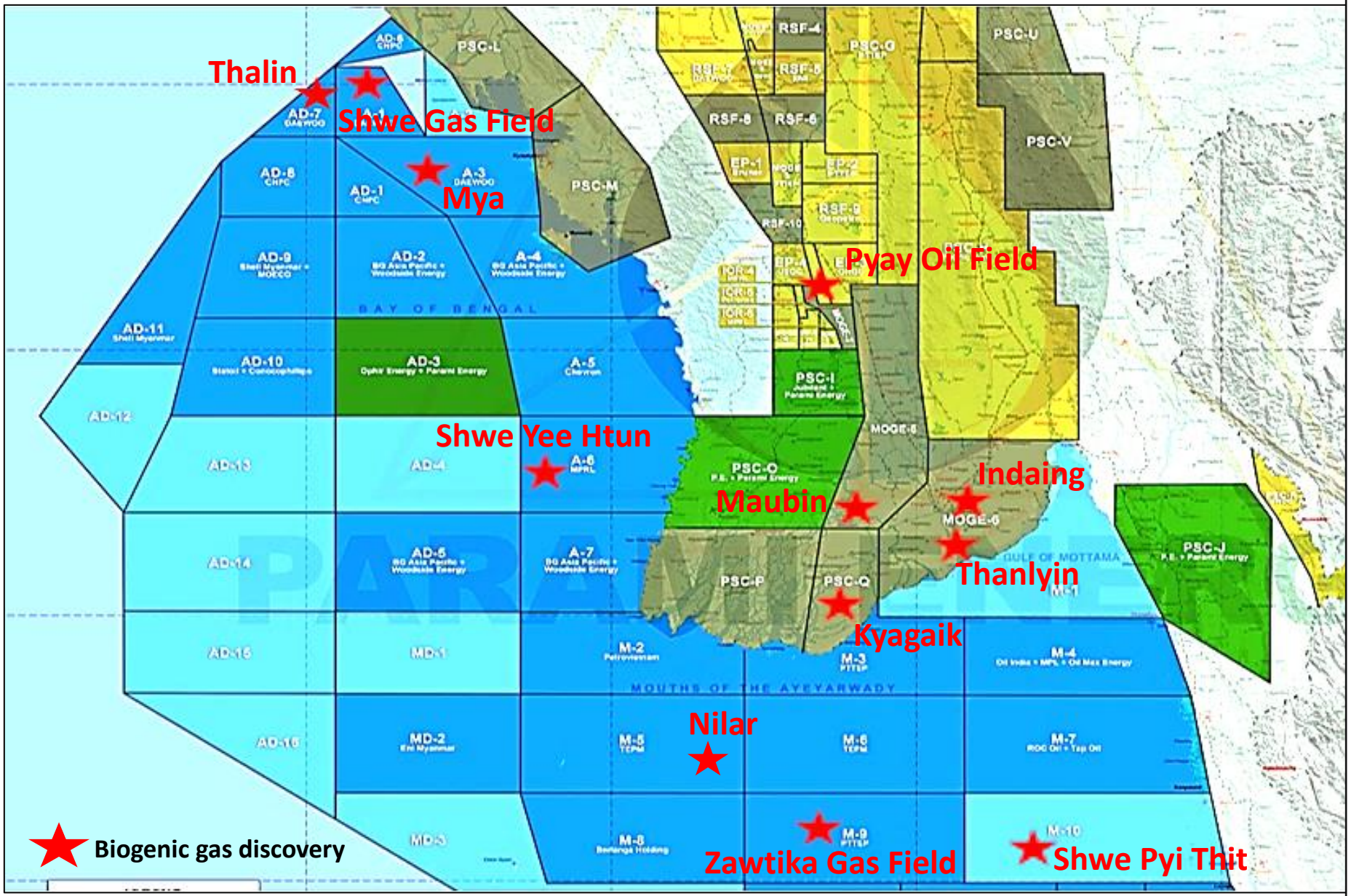
- Economic significance of Biogenic Gas in Myanmar
- Biochemical Processes for Generation of Biogenic Gas
- Key Components playing a role in Biogenic Gas Generation and Trapping
- Biogenic Gas Generation - Migration-Accumulation Model in Rakhine Offshore Basin
- Biogenic Gas Generation - Migration-Accumulation Model in Moattama Offshore Basin
- Onshore Biogenic Gas Occurrences
- Identification of promising biogenic gas exploration target areas
- Conclusion

Economic significance of Biogenic Gas in Myanmar

- Hold 35.4% of total recoverable proved natural gas (Bio+Thermo) reserves of Myanmar offshore to date.
- Low drilling cost
  - Accumulation in commercial quantities at shallow depths.
  - Very low risk for high pressure/ temperature drilling hazard.
- Low risk exploration (geologically predictable circumstances).
- Biogenic reservoirs are compensated by the biogas generated uninterruptedly.

Therefore Biogenic gas becomes increasingly important as an exploration target in Myanmar Petroleum Industry.

LOCATION OF BIOGENIC GAS DISCOVERIES



Onshore

Pyay Embayment Basin

Pyay Oil Field (IOR-4)

Ayeyarwaddy Delta Basin

Maubin Gas Field (MOGE-5)

Kyagaik area (PSC-Q)

Bago Yoma Basin

Indaing, Thanlyin (MOGE-6)

Shallow water

Rakhine offshore Basin

Shwe (A-1)

Mya (A-3)

East Moattama Basin

Zawtika (M-9)

Shwepyithit(M-10)

West Moattama Basin

Nilar (M-5)

Badamyar (M-5)

Deepwater

Shwe Yee Htun Prospect (A-6)

Thalin (AD-7)

RECOVERABLE RESERVES OF OFFSHORE BIOGENIC GAS FIELDS
(As of 1-4-2017)

Basin	Biogenic Gas Field	Initial Recoverable Reserves (TCF)
Rakhine	Shwe + Shwe Phyu + Mya	3.045
East Moattama	Zawtika	1.690
Total Biogenic		4.735
Total Biogenic + Thermogenic		13.365
Total Biogenic Gas %		35.4%

Generation of Biogenic Gas – Biochemical Processes

Step -1. Processing of organic matter by Sulphate Reducing Bacteria (SRB) to provide chemical feedstock for methane production.
Step-2 . Conversion of chemical feedstock to methane by bio-methanogens

Humic Higher Plant Derived Organic Matter

↓

Sulphate Reducing Bacteria In Anaerobic Environment

↓

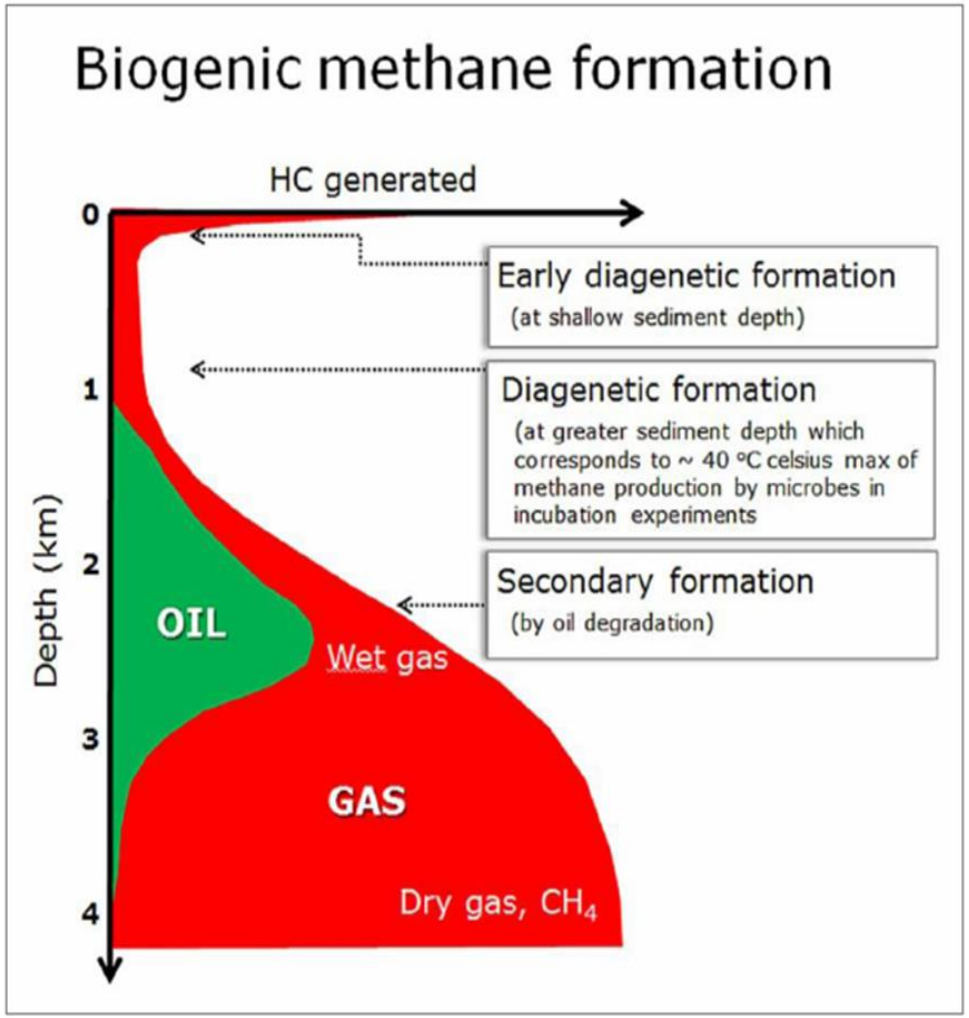
Chemical Feedstock CO_2 and CH_3 COOH

↓

Methanogens in Sulphate Free Anaerobic Environment

↓

CH_4 +H_2O+ CO_2
Biogenic Methane



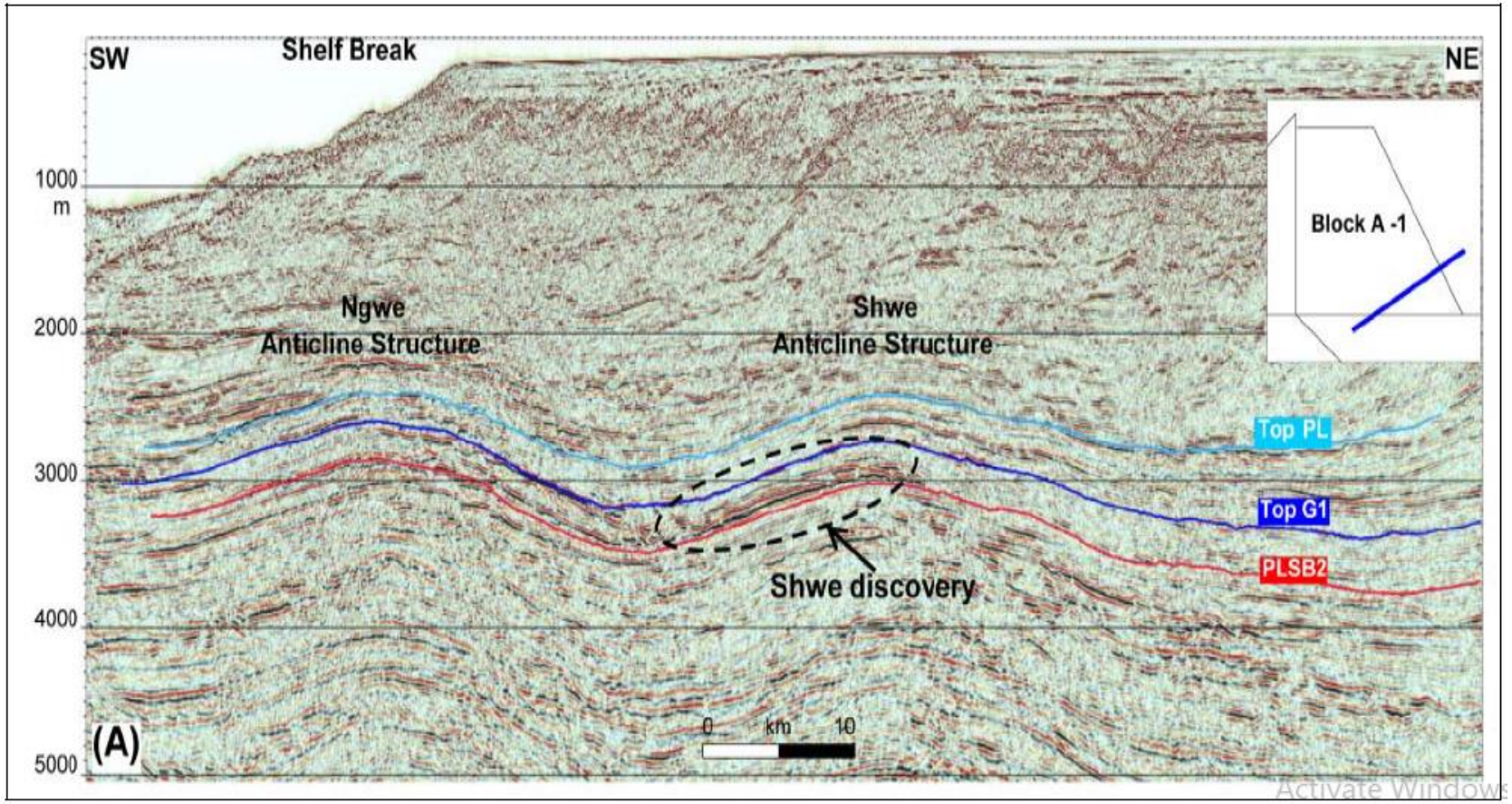
Key Components playing a role in Biogenic Gas Generation and Trapping

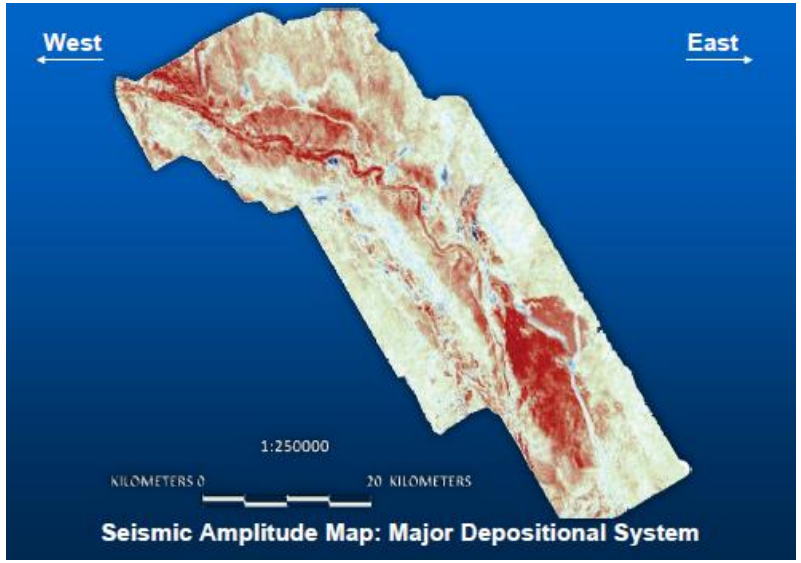
- **Depositional Environment** – Fluctuating depositional setting providing for change in sedimentation grain size resulting in fine (source) and coarse (reservoir) clastic sequences. Probably critically important factor.
- **Sediment Deposition Rate** - As high as possible in order to allow rapid burial and preservation of organic matter (from burrowing organisms). And to provide sufficient overburden that will result in placement of effective seals as quickly as possible. Probably critically important factor.
- **Organic Matter Supply** – As high as possible to provide matter for SRB processing into methanogen feedstock. However, concentration does not appear critical to process as biogenic source rocks appear effective at lower organic matter richness than that required for effective thermogenic source rocks. What does appear important is the nature of the organic matter. Must be higher plant derived, humic, terrestrial material. Overall, OM concentration probably not a critical factor.
- **Depo-Environment Chemistry** – Neutral, gradual change from oxidising to reducing, anaerobic environment with conversion of sulphate to sulphide dominant substrate. Gradual change in such conditions is optimal such that onset of biogenic methane generation takes place at as greater depth as possible. Critically important factor.
- **SWIT & Temperature Gradient** – As low SWIT and geothermal gradient/heat flow as possible. Lower gradient and heat flow will allow biogenic source rocks a longer period of residence in the biogenic gas generation window (and therefore maximum opportunity for complete transformation of feedstock to bio-methane). Probably critically important factor.
- **Pressure** – In certain deep water depositional settings, may play a role (together with SWIT) in formation and stabilisation of methane hydrate that may act as an intermediate trapping mechanism. Probably not critical.
- **Timing of Reservoir Deposition, Trap Formation & Sealing** – Trap formation (and presence of effective seal) as early as possible in the depositional process such that vertical biogenic gas diffusion can be captured as it occurs. Critically important factor.

BIOGENIC GAS GENERATION – MIGRATION-ACCUMULATION MODEL
SHWE GAS FIELD, RAKHINE OFFSHORE BASIN

- The Shwe biogenic gas is stratigraphically trapped in deepwater turbidite sandstones, and occurs between 2,900 and 3,300 meters sub-sea. Biogenic origin was proven by its dryness (>99% methane) and enriched light isotope character ($\delta^{13}C$ ranging from 60 to 70 ‰).
- Simulation results (Yang et al., 2013) indicate that; (1) there were three biogenic gas generation peaks during the Late Miocene, Early Pliocene, and Late Pliocene. Most of biogenic gas was generated from Middle Miocene and Early Pliocene shale, (2) the existence of paleo-hydrates during Miocene to Pliocene period played an important role in initial stage gas accumulation and trapping system, with the hydrates acting as seals.
- The paleo-hydrate was later released by changes in P-T condition due to sediment burial.
- The later stage of sealing is thought to be provided by thick shale overburden as well as homogeneous thin-bedded turbidite shale, and authigenic carbonate cement beds within reservoir sandstones.
- Main reservoirs are developed perpendicular to the uplifted zone in the area.

TRAPPING GEOMETRY AND RESERVOIR OF SHWE GAS FIELD

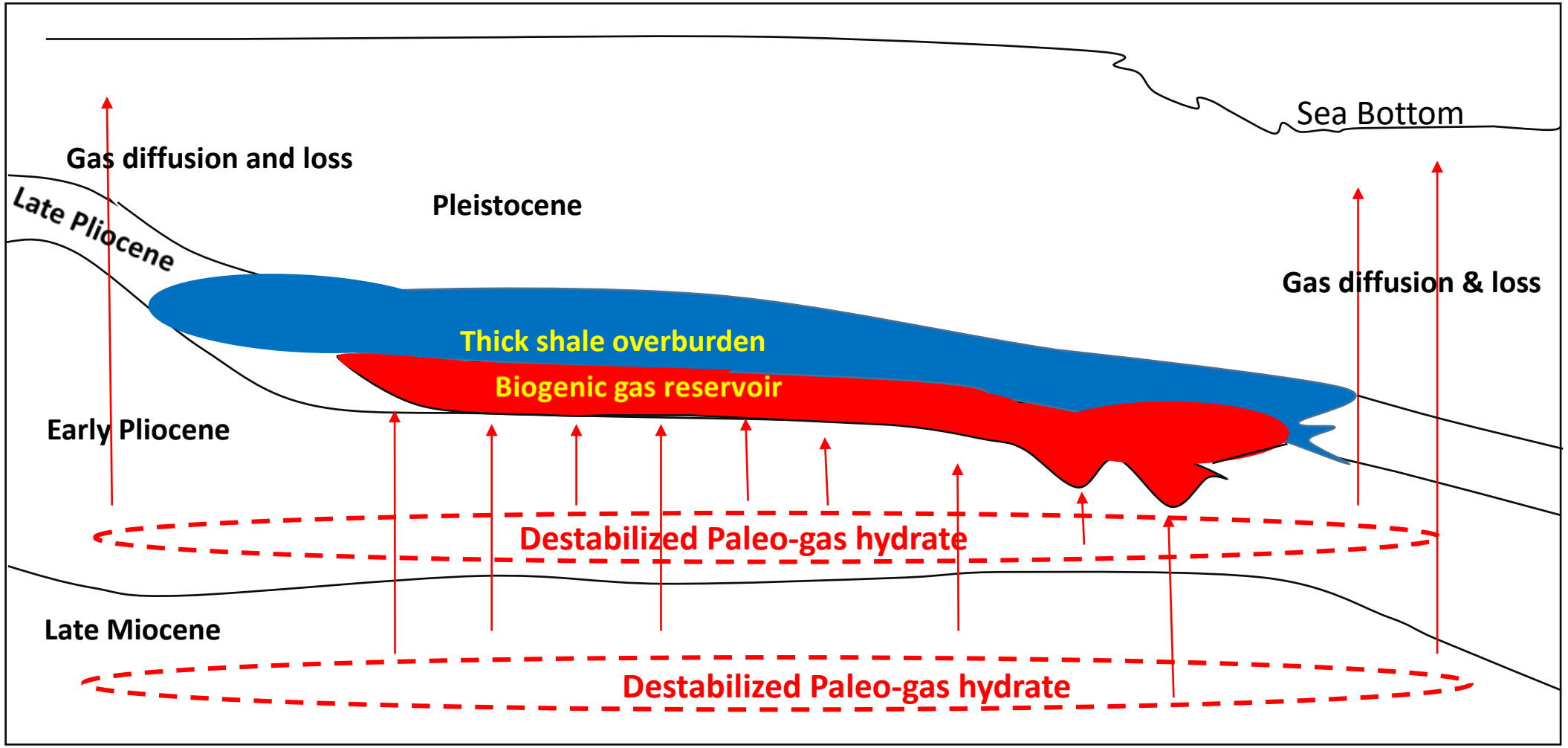




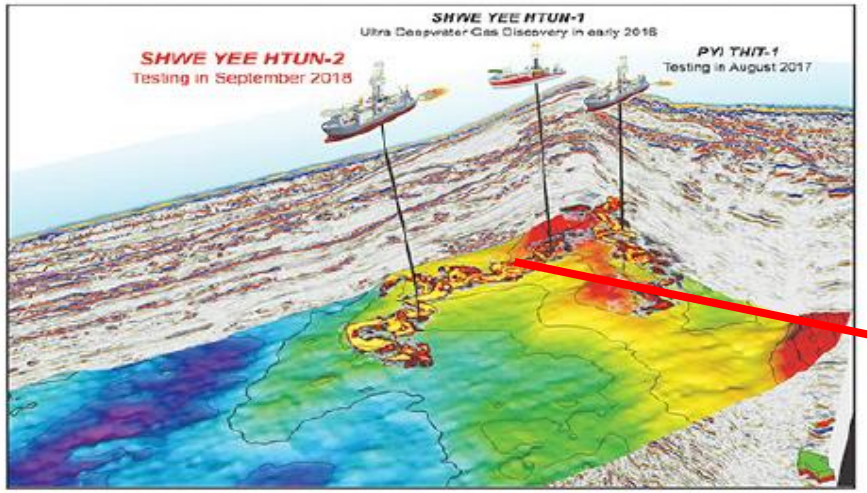
Source – Yang et al., 2013

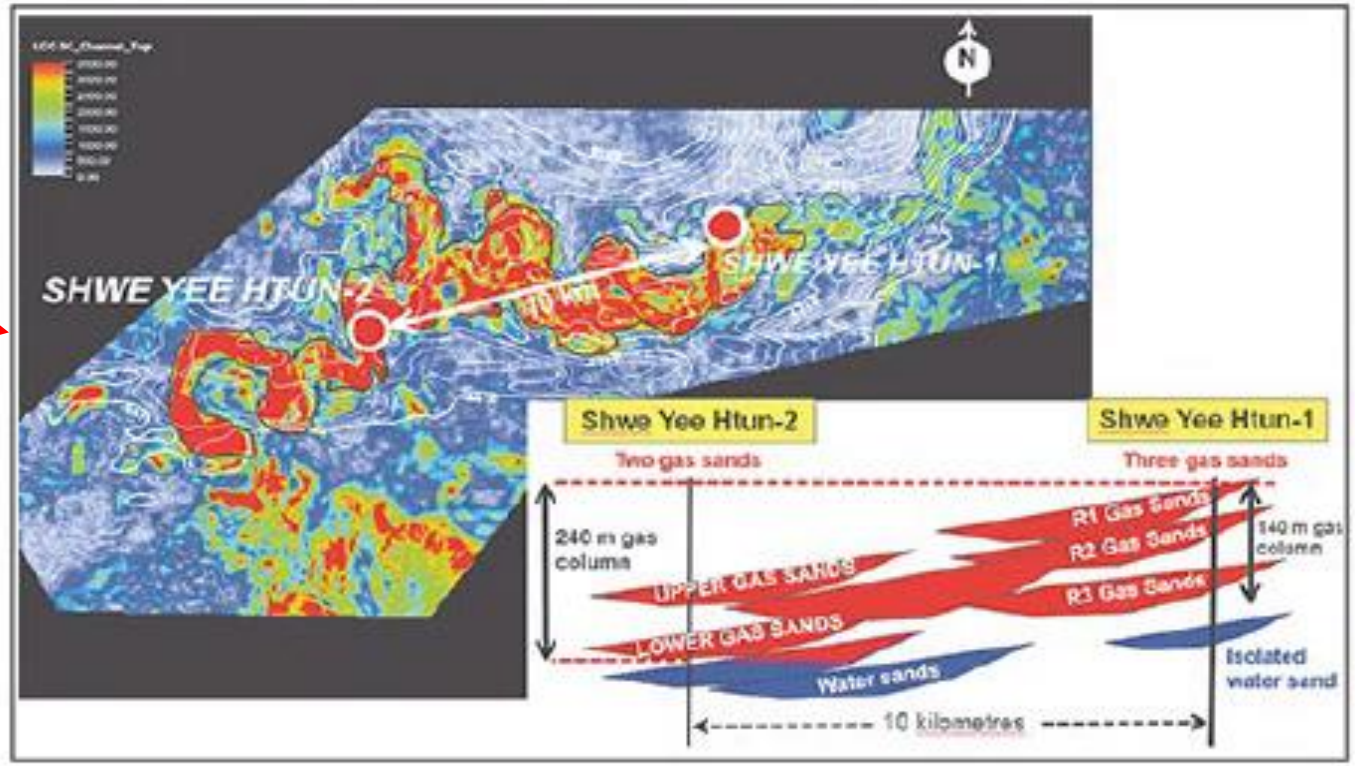
Shwe biogenic gas field trap appears to have both a structural and stratigraphic trapping component. Productive reservoirs are mainly Pliocene age basin floor turbiditic fans.

Conceptual Biogenic Gas Migration Model
Shwe Biogenic Gas Field, Rakhine Shallow Water Block (A-1)



Biogenic Gas Bearing Confined Sandy Channel *Levee* Complex
Block A-6, Rakhine Deepwater Basin



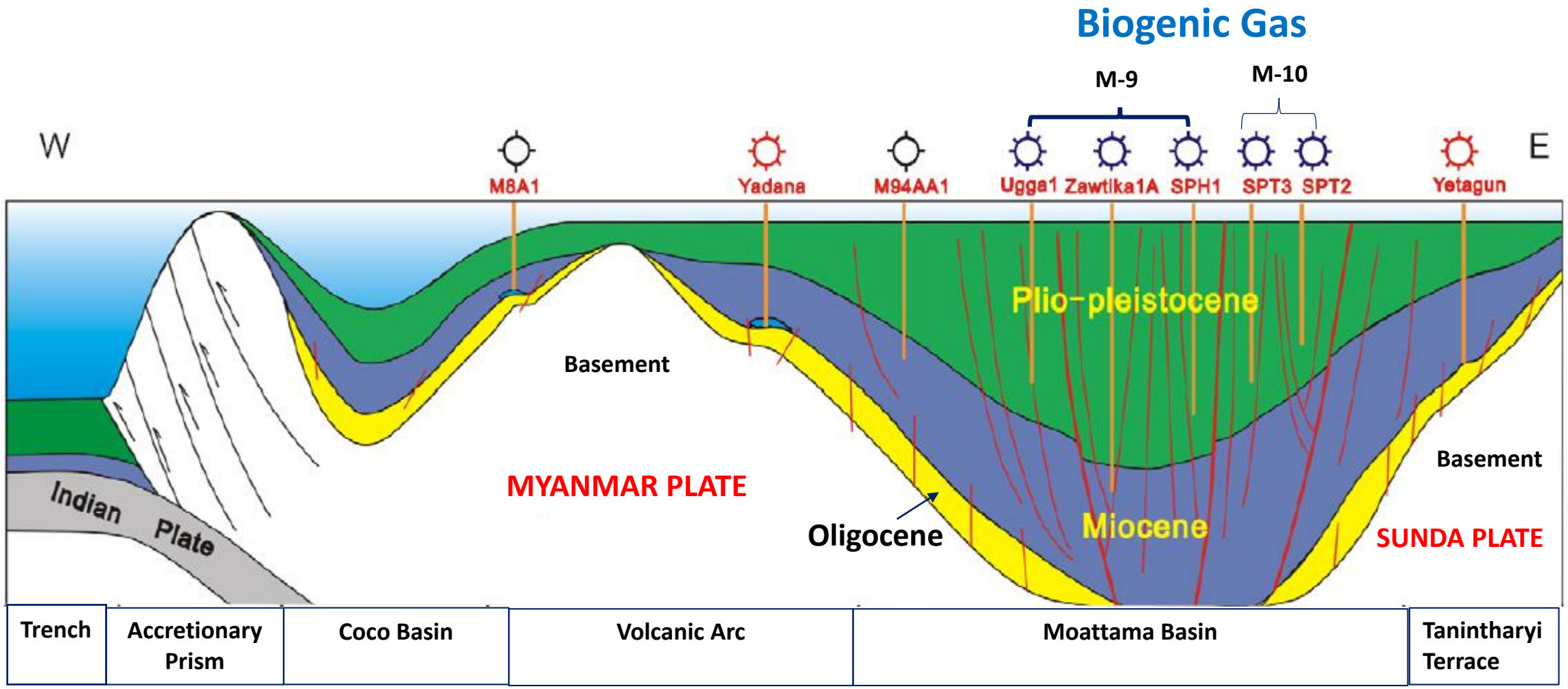


Source: MPRL E&P Newsletter 8th October 2018

BIOGENIC GAS GENERATION - MIGRATION - ACCUMULATION MODEL MOATTAMA BASIN

- **The conditions that favours for accumulation of biogenic gas in the Moattama Basins are :**
  - **Rapid deposition (sedimentation rates more than 750mm/ky).**
  - **Pliocene source rocks which were deposited in typical fluvio-deltaic environments. Depositional environments that have been subjected to frequent marine transgression and regression are well suited to the deposition and preservation of biogenic methane systems. Such depositional cycles are interpreted to be typical through Plio-Pleistocene times in the Zawtika biogenic gas discovery area.**
  - **Presence of humic material which is the best organic material for biogas generation.**
  - **TOC ranges from 0.5 to 1 , HI ranges from 100 to ~300.**
  - **Organic material type is Ⅱ/Ⅲ.**
  - **Shallow bury (less than 2000m), immature.**
- **Biogenic gas reservoirs occurred in Pliocene-Pleistocene strata associated with massive extensional strike-slip faults in depocenter, and the water depth is less than 200m.**
- **Possible accumulation model of biogenic gas reservoirs is that destabilization of the paleo-hydrate and secondary migration along faults.**

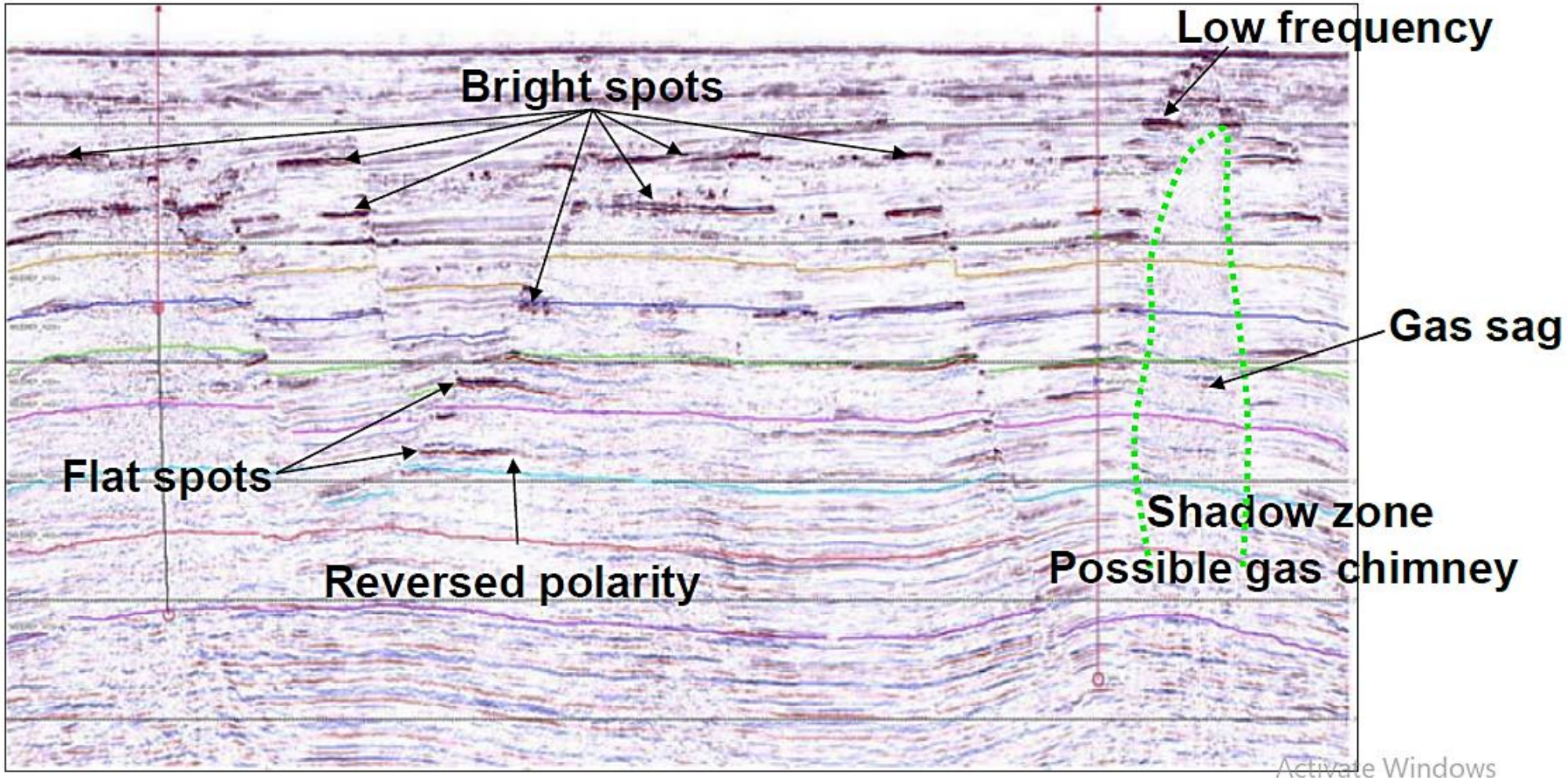
Biogenic gas reservoir distribution in Moattama Basin



$\delta^{13} C_{CH4}$ and $\delta^{13} C_{CO2}$ value of Biogenic and Mixed Gas Produced in Mottama Basin

Well	Block	Depth mTVD	Formation Temp °C	$\delta^{13} C_{CO2}$	$\delta^{13} C_{CH4}$	CH_4 origin
Shwe Pyi Htay	M-9	1477.0	67		-65.8	Biogenic
Nilar	M-6	1340.0	60		-62.1	Biogenic
Badamyar	M-5	950.0	46		-54.1	Mixed
Aung Lar Ba-1	M-12	2537.0	106	-17.59	-55.95	Mixed

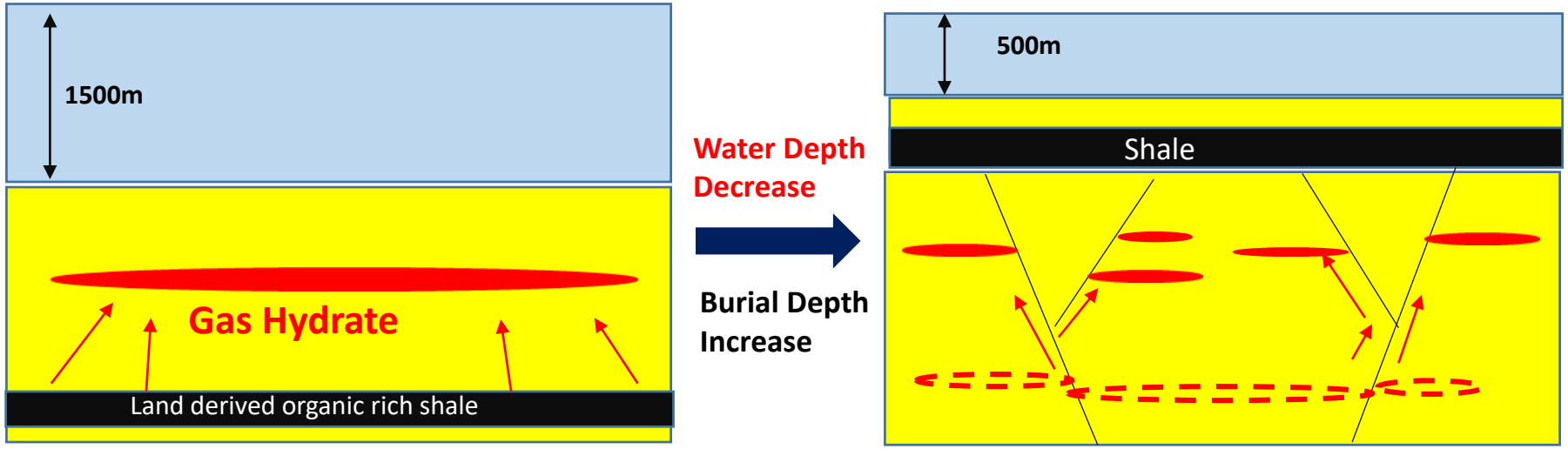
Note: Mixed may result from degradation of biogenic gas or oil.
Values for onshore and Rakhine deepwater biogenic gas are not available.



Wang Hongping et al. 2011

A 2D seismic section in East Moattama Basin showing obvious seismic anomalies and biogas discoveries in shallow parts. Anomalies near faults.

BIOGENIC GAS GENERATION AND MIGRATION MODEL IN MOATTAMA BASINS



Generation

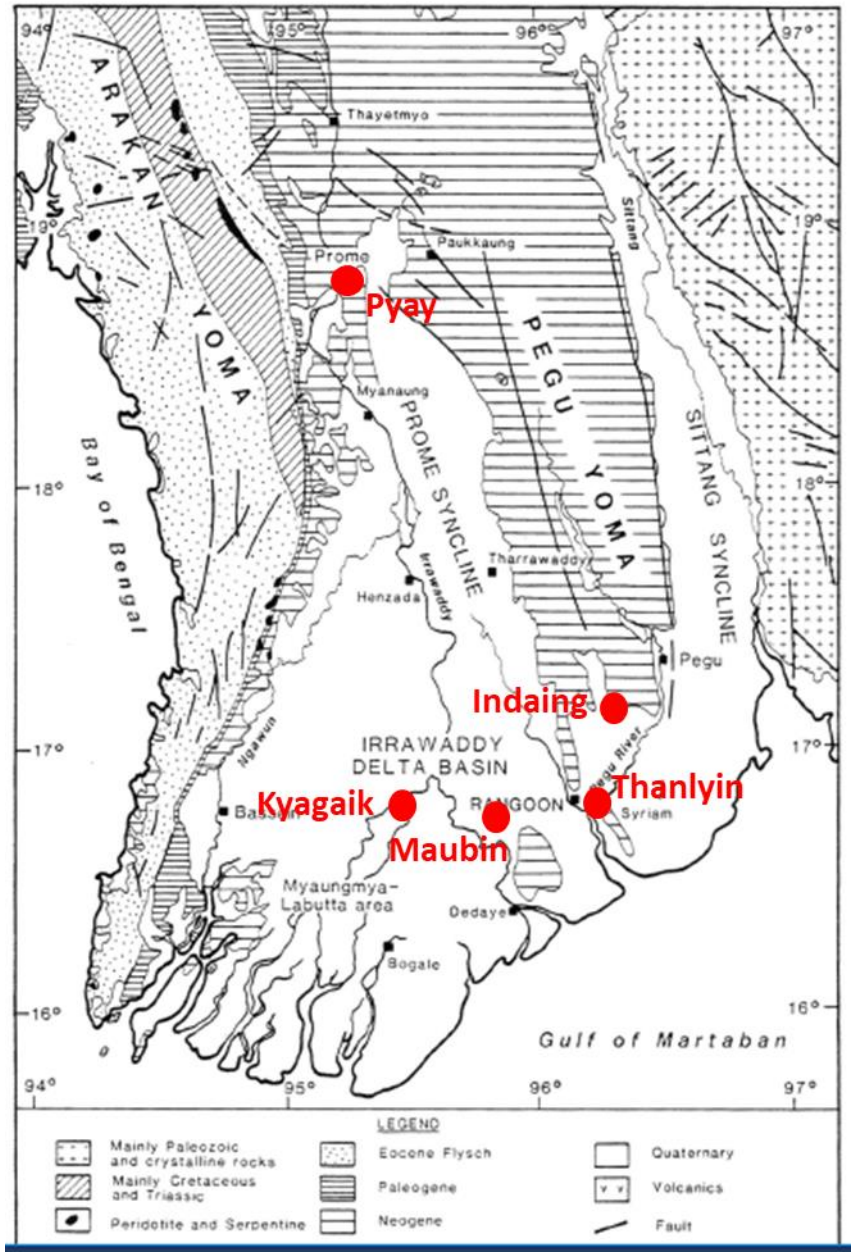
Organic sediment → (Rapid deposition / Methanogenesis) → Biogas → Hydrate

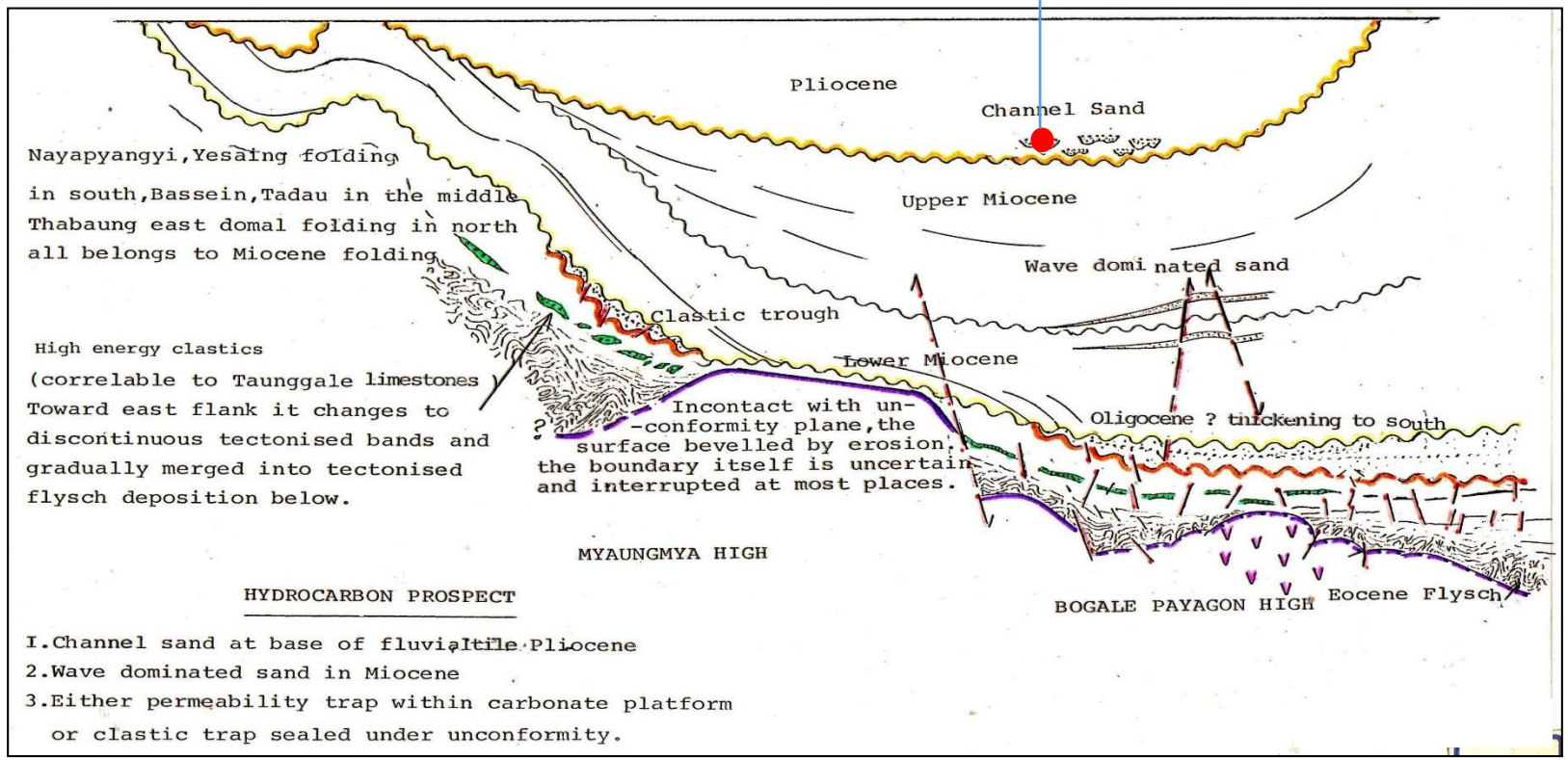
Paleo-Hydrate → (Water Depth decrease / Burial Depth increase) → Free Gas

Migration

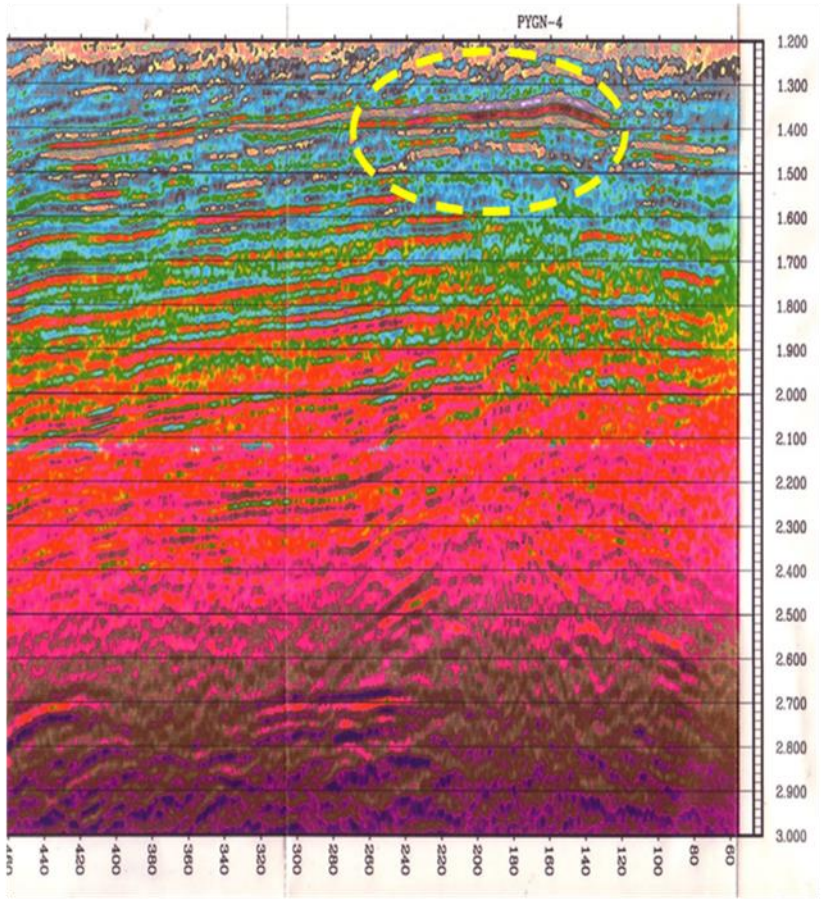
Deep → (Secondary Migration by Fault) → Shallow

Stratigraphic level of biogenic gas bearing sandstones Kyagaik and Maubin gas fields



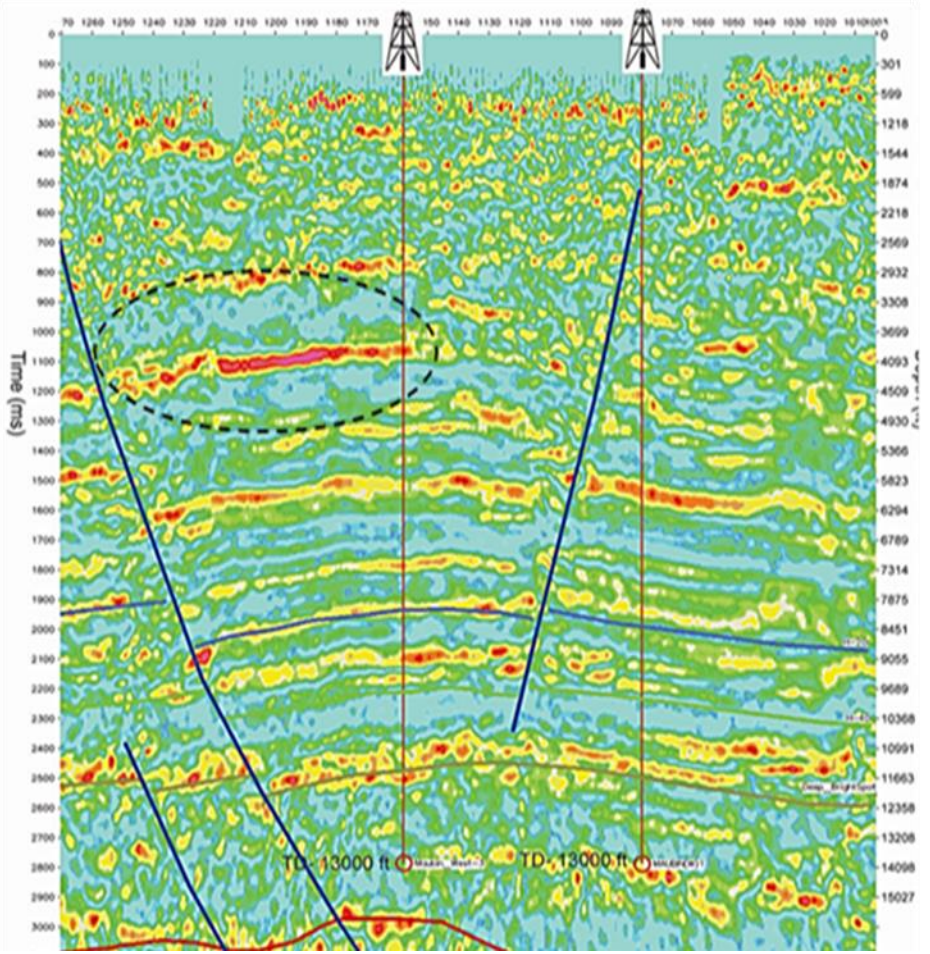


COMPOSITION ANALYSIS OF KYAGAIK BIOGENIC GAS AYEYARWADDY DELTA ONSHORE MYANMAR



Analysis Result of Biogenic Gas Kyagaik Gas Field	
Well No	1
Date	05-04-1983
Perforation Depth	4665-4675
Methane	99.76
Ethane	0.22
Propane	0.01
i-Butane	0.01
SG (computation)	0.5552
$T_{critical}$	343.547
$P_{critical}$	667.876

Maubin Gas Field, Ayeyarwaddy Delta Basin
Shallow Biogenic Gas bearing Pliocene sandstone layer

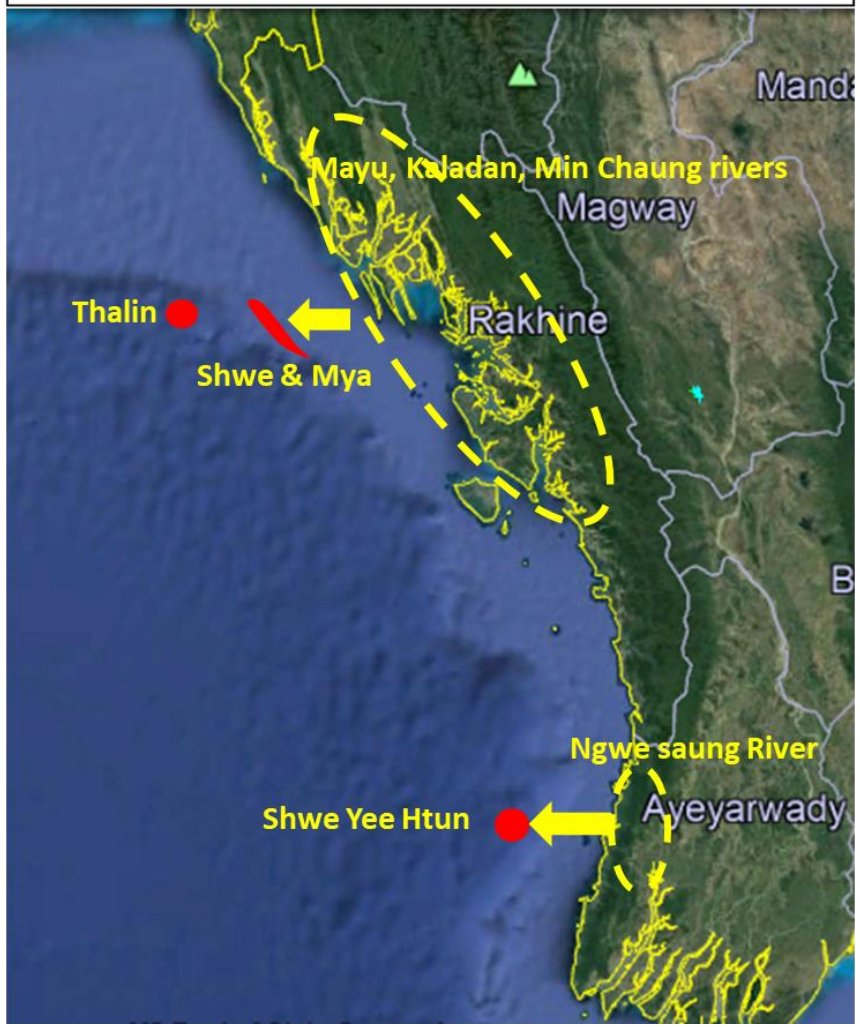


❖ **Note bright spot anomaly within the yellow and black circle which indicates biogenic gas bearing layer.**

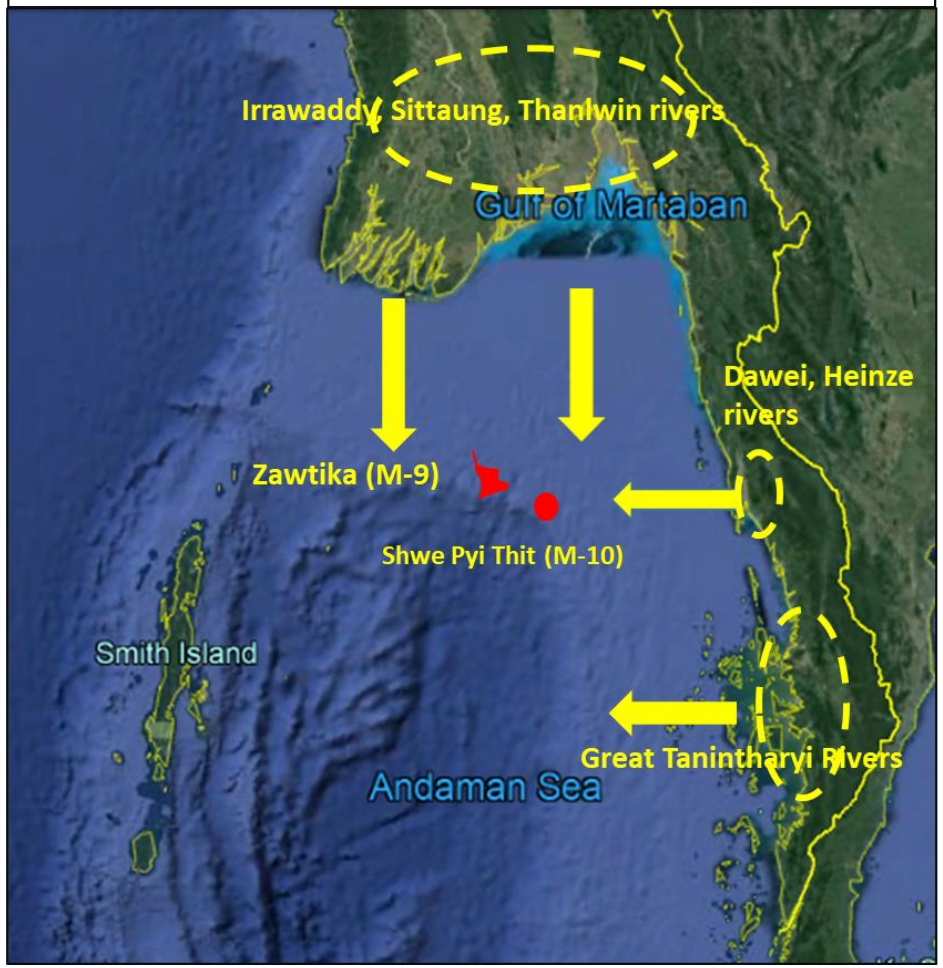
Source: MOGE

These figures display locations of offshore Myanmar biogenic gas discoveries in relation to sources of organic matters. Although these are present day sea level settings, the biogenic gas prone areas are proximate to large rivers that have been able to provide high volume of right type of organic matter through Middle Miocene to recent times. Such will be important when considering the likelihood of biogenic gas discovery in unexplored parts of the basins.

Large rivers transported land derived organic rich sediments into Rakhine Offshore Basins are Mayu, Kaladan, Min chaung and Ngwe Saung rivers.



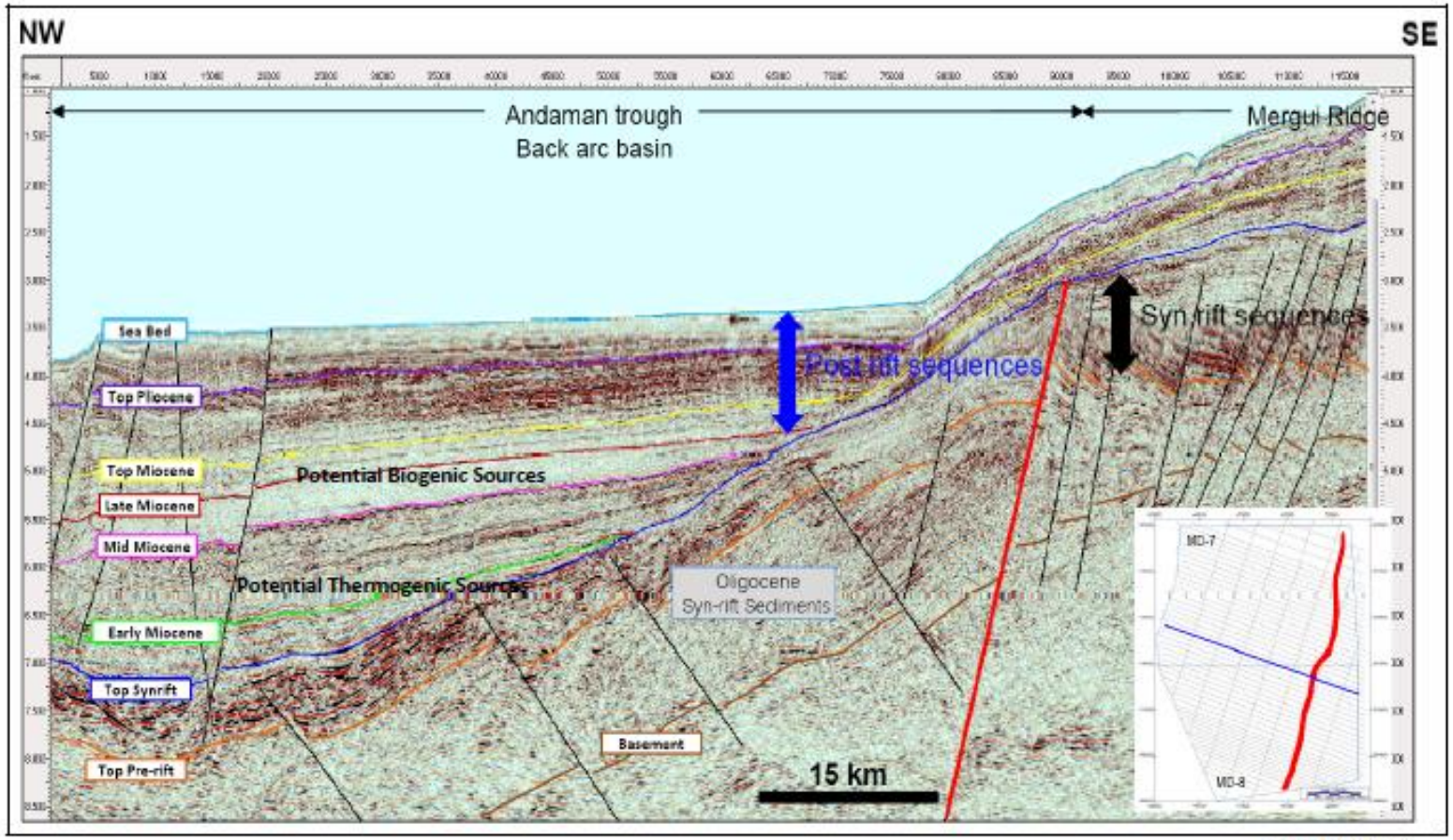
Large rivers transported land derived organic matter rich sediments into Moattama Offshore Basin during post-rift phase are Irrawaddy, Sittaung, Thanlwin , Dawei, Heinze and Great Tanintharyi rivers



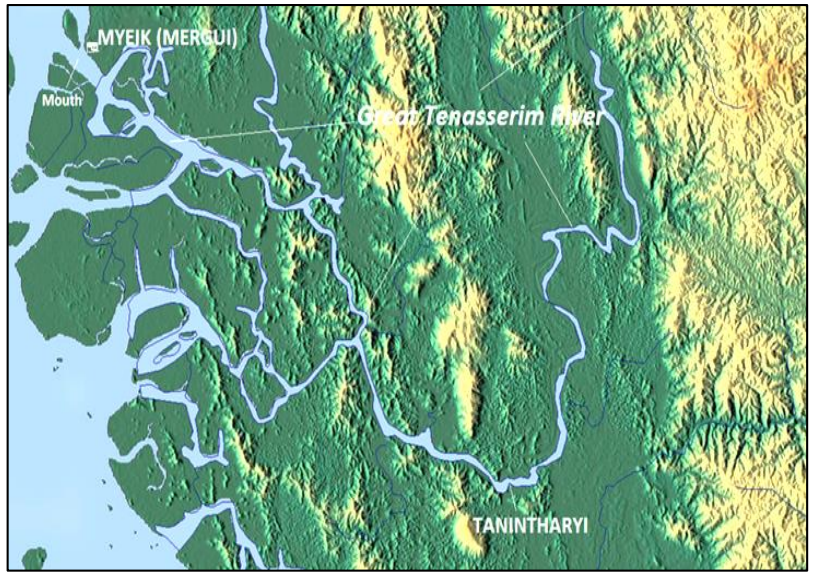
Sediment transport direction

Biogenic Gas Discovery

Biogenic Gas Potential of East Andaman Basin



PTTEP, 2015



Great Tanintharyi River

Pull apart setting created by trans-tensional right lateral movement in late post-rift subsidence Phase (Late Miocene-Holocene) caused huge subsidence with water depth rising as high as 3000 m. Sediments were initially deposited in shallow marine and gradually passing into the deepwater to ultra-deepwater setting at present time. Analysis of the seismic data reveals typical shallow marine and deep water deposition elements (e.g. channel-levee complexes, incised valleys, canyon cuts, gullies, sheet sands, slumps, fan/ lobes, gravity flows/ mass transport complexes etc.). Thickness of the late post-rift sediments reached to 2500 m at places. It can be envisaged that Great Tanintharyi River may provide higher plant derived, humic, terrestrial organic matters into EAB during the Pliocene to Recent. The restricted marine environment and rapid deposition of the deepwater sediments in late post-rift phase could lead to a biogenic gas system.

CONCLUSION

- **Biogenic gas traps in Rakhine Offshore Basin have both a structural and stratigraphic components. Productive reservoirs are Pliocene age basin floor turbiditic fans and confined channel–levee complexes associated with anticlines.**
- **Biogenic gas traps in Mottama Offshore Basin have only structural component. Biogenic gas reservoirs occurred in Pliocene-Pleistocene strata associated with massive extensional strike-slip faults in depocenter.**
- **Biogenic gas prone areas in offshore are proximate to large rivers that have been able to provide high volumes of the right type of organic matters. Such will be important when considering the likelihood of biogenic gas discovery in unexplored parts of the respective basin.**
- **The occurrences of biogenic gas in Pyay Embayment, Bago Yoma and Ayeyarwaddy Delta highlighted that their biogenic gas potential is significantly high. Productive reservoirs are estuarine channels associated with normal fault related two-way closures. Bright Spot anomaly in seismic sections of these areas may be used as direct biogenic gas indicator.**
- **Ayeyarwaddy Delta Basin is the most promising onshore target area for exploration of biogenic gas and should be prioritized especially in the depocenter area.**
- **Advanced transitional zone seismic survey is needed to identify commercial natural gas plays both biogenic and thermogenic in the onshore block PSC-O, PSC-P, PSC Q and southern parts of MOGE-5 and MOGE-6.**

THANK FOR YOUR ATTENTION