Geological Conditions and Accumulation Mechanism of Shallow Biogenic Gas Reservoirs in Andaman Basin*

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Search and Discovery Article #10343 (2011)
Posted August 8, 2011

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011

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Abstract

Many shallow biogenic gas reservoirs have recently been discovered in Miocene-Pleistocene strata in the Andaman offshore area, and most of them occurred within or adjacent to the depocenter filled with approximately 5000 m thickness of Neocene sediments. The large biogenic gas field Zawtika 1A in Block M09 was discovered in 2007, with proven gas reserves greater than 2 TCF. And its reservoirs are the Miocene-Pliocene Delta Front Sandstones, which were buried generally 750-1580 m in depth, and the shallower biogenic gas reservoirs in Pleistocene strata with burial depths of less than 500 m.

The seismic data of biogenic gas sections in Andaman Basin displays reflection characteristics such as blanking, enhanced reflection patterns, bright spots, flat spots, reverse polarity, shadows in instantaneous frequency, and increase in amplitude with the offset, which are easy to identified.

There are eight beneficial geological factors of Andaman Basin for controlling biogas generation and accumulation: 1) Favorable biogenetic gas generation conditions including rapid deposition, abundant immature organic matter, reducing environment, low geothermal gradient, etc.; 2) Massive unconsolidated clastic reservoirs which were characterized by wide distribution, shallow burry, vertical superimposition, approximately 24-40% porosity and 500-3000 md permeability; 3) Effective seal and preservation conditions; 4) Increase of temperature and decrease of pressure caused by faults, which are favorable for melting of hydrate and releasing of gas; 5) Effective secondary migration pathways, including faults and permeable sandstones; 6) Synsedimentary traps, which are favorable for accumulating biogas; 7) The biogas reservoirs were compensated by the biogas generated uninterruptedly; 8) Additional thermogenic gas supplement from deep mature source rocks.

We establish a possible accumulation model of these large biogenetic gas reservoirs based on destabilization of the paleo-hydrate and secondary migration. There are six stages of geological processes working together in the following sequential order: deposition of organic-rich sediments → rapid deposition and methanogenesis in reducing environment → formation of gas hydrate → increase of temperature and decrease of pressure (fault activity) leading to melting of hydrate and releasing of gas → secondary migration and subsequent entrapment in porous and permeable clastic reservoirs → dynamic balance between continuing escape and supplement.

References

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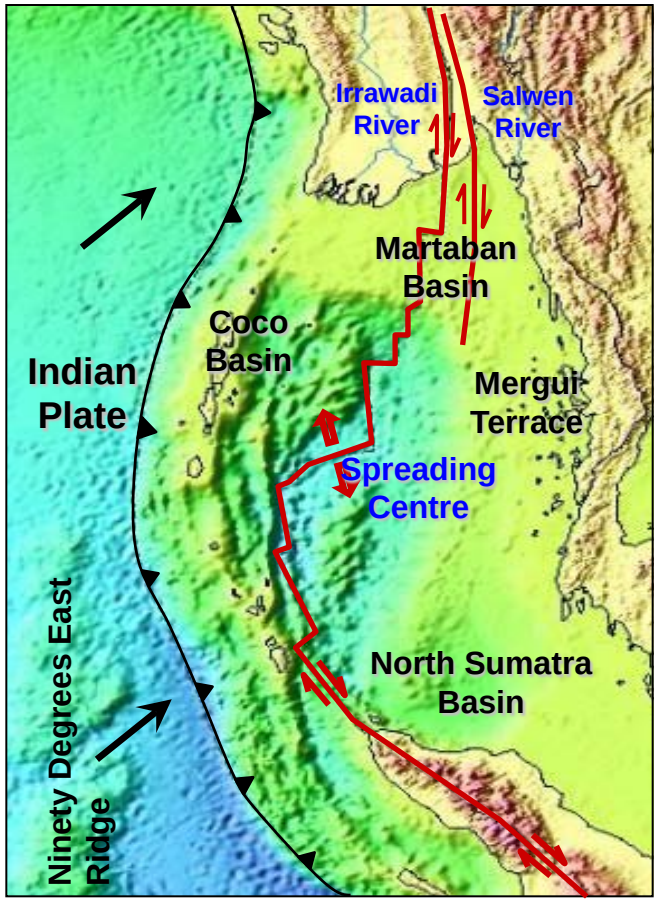
Outline

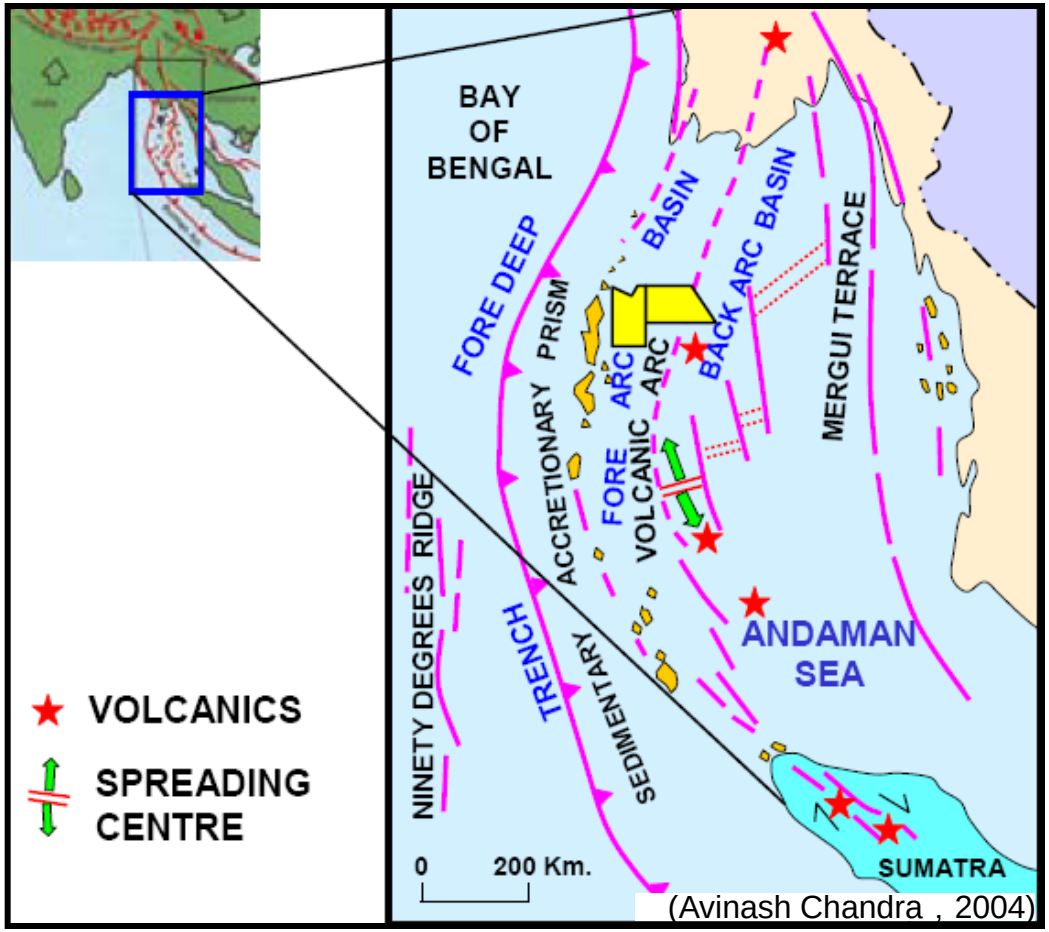
- Regional tectonic
- Biogas reservoir distribution
- Biogas reservoir seismic reflection
- Biogas reservoir formation conditions
- Biogas reservoir accumulation model
- Conclusions

ANDAMAN BASIN

Regional tectonic

- Island arc trench system with extensional strike-slip setting
- Irrawaddy River and Salween River offering the source of sediments





(Avinash Chandra , 2004)

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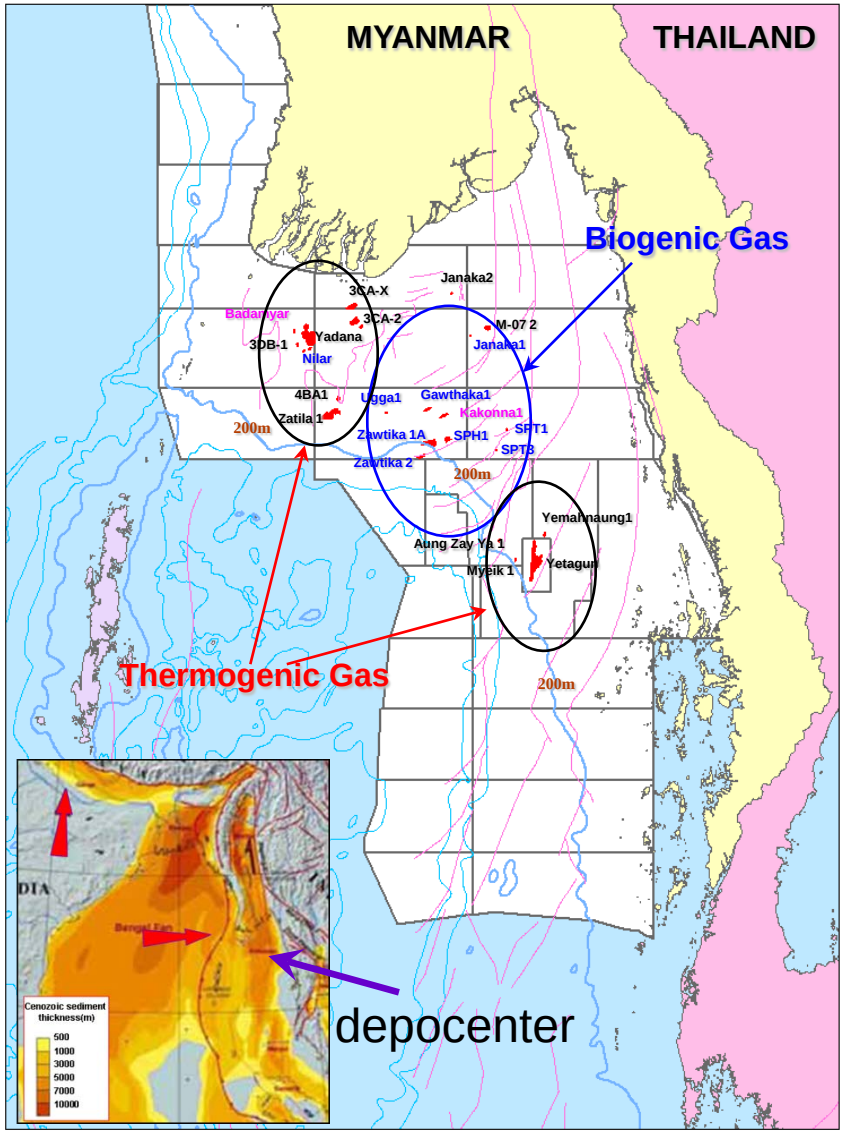
Biogas reservoir distribution



- Most of biogas reservoirs occurred in or adjacent to the depocenter
- Water depth less than 200m
- Shallow burial depth less than 2000m

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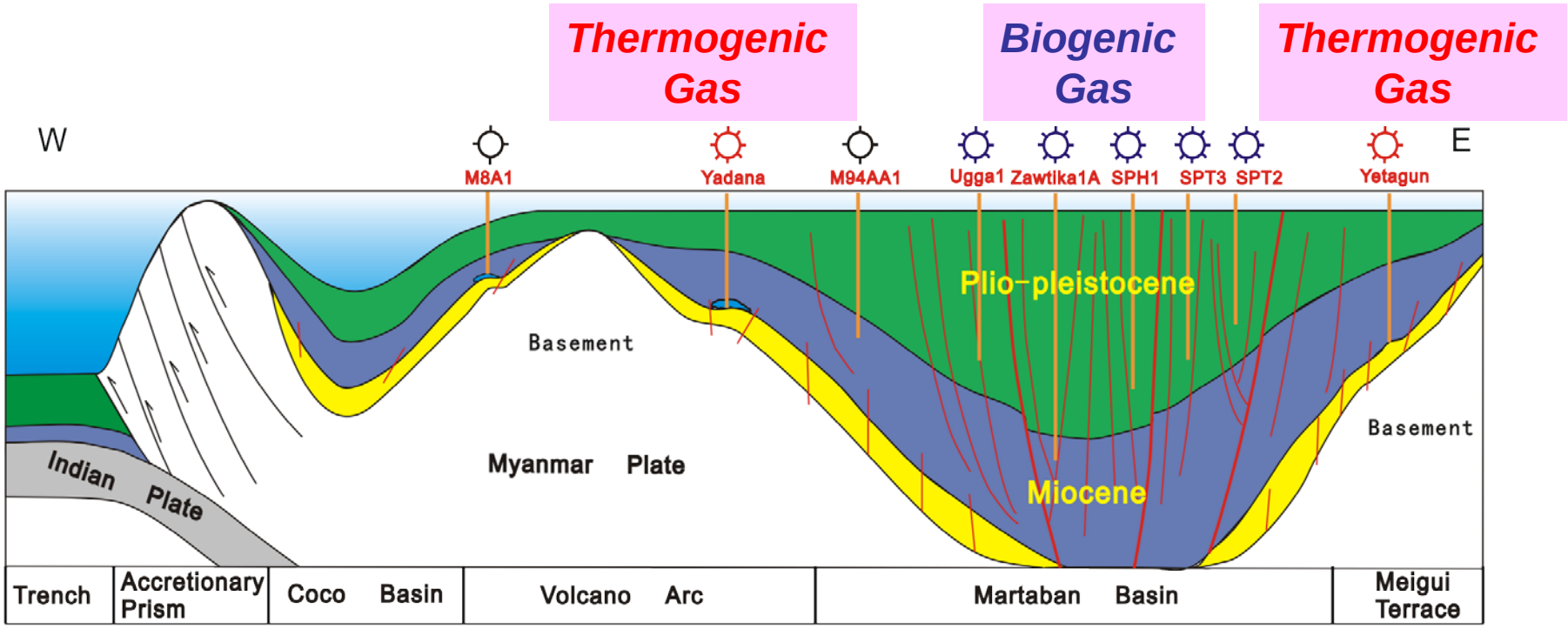
Biogas reservoir distribution

- Most of thermogenic gas reservoirs discoveried in Miocene strata
- Biogenic gas reservoirs occurred in Piocene- Pleistocene strata
- Massive extensional strike-slip faults in depocenter



Regional west-east geologic section in Andaman basin

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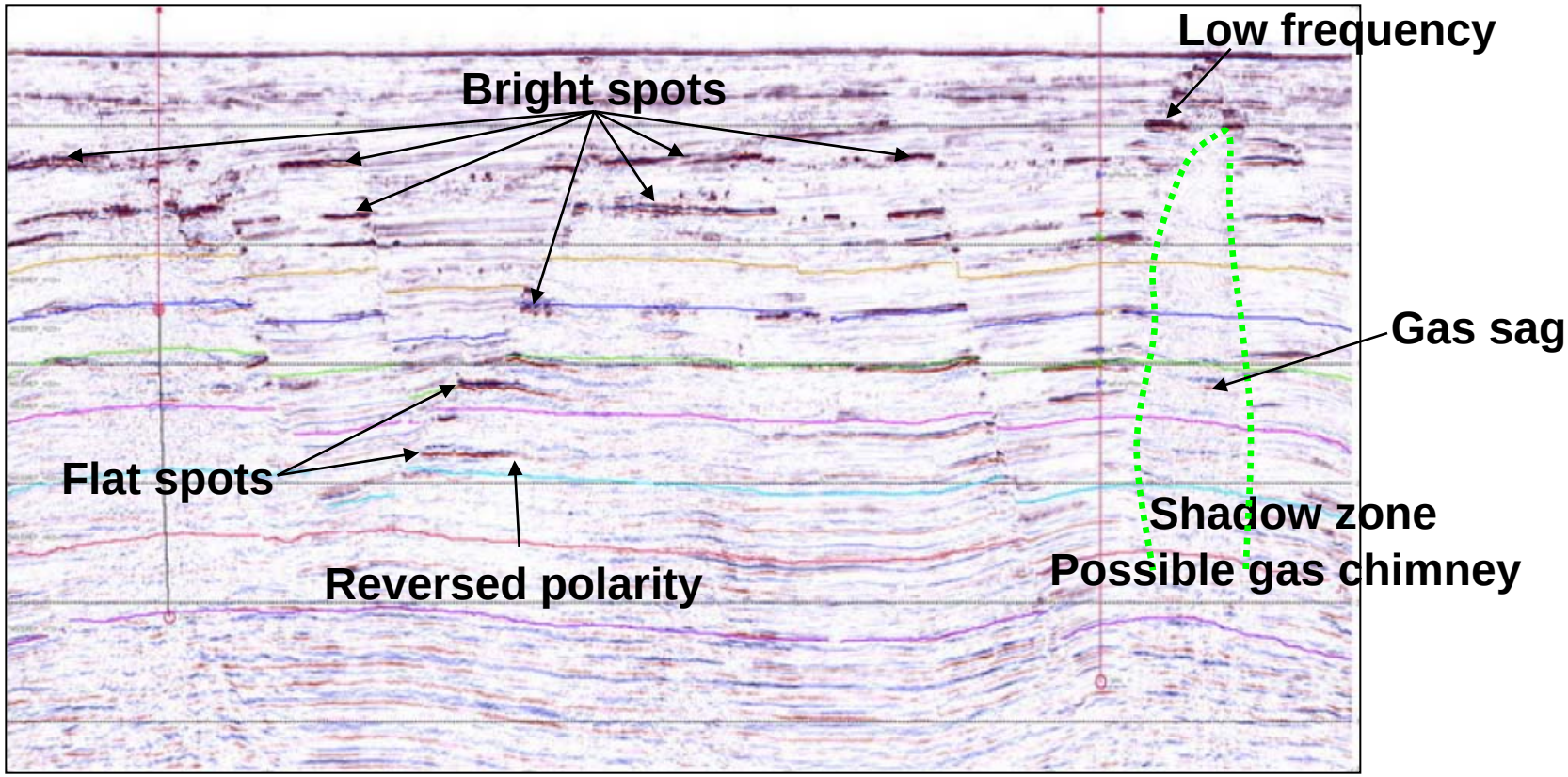
Biogas reservoir seismic reflection

- Obvious seismic anomalies and biogas discoveries in shallow parts
- Anomalies near faults
- No anomaly and no discovery In deep parts



xxx seismic section in Andaman basin

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Biogas reservoir formation conditions

Favorable biogas generation conditions

- Rapid deposition (sedimentation rates more than 750mm/ky)
- Pliocene source rock：Typical of fluvio-deltaic environments
- Humic material is the best organic material for biogas generation
- TOC：0.5~1 , HI：100~300
- Organic material type:Ⅱ/Ⅲ
- Shallow bury (less than 2000m), immature

Massive clastic reservoirs

Syn-sedimentary traps

Massive Faults

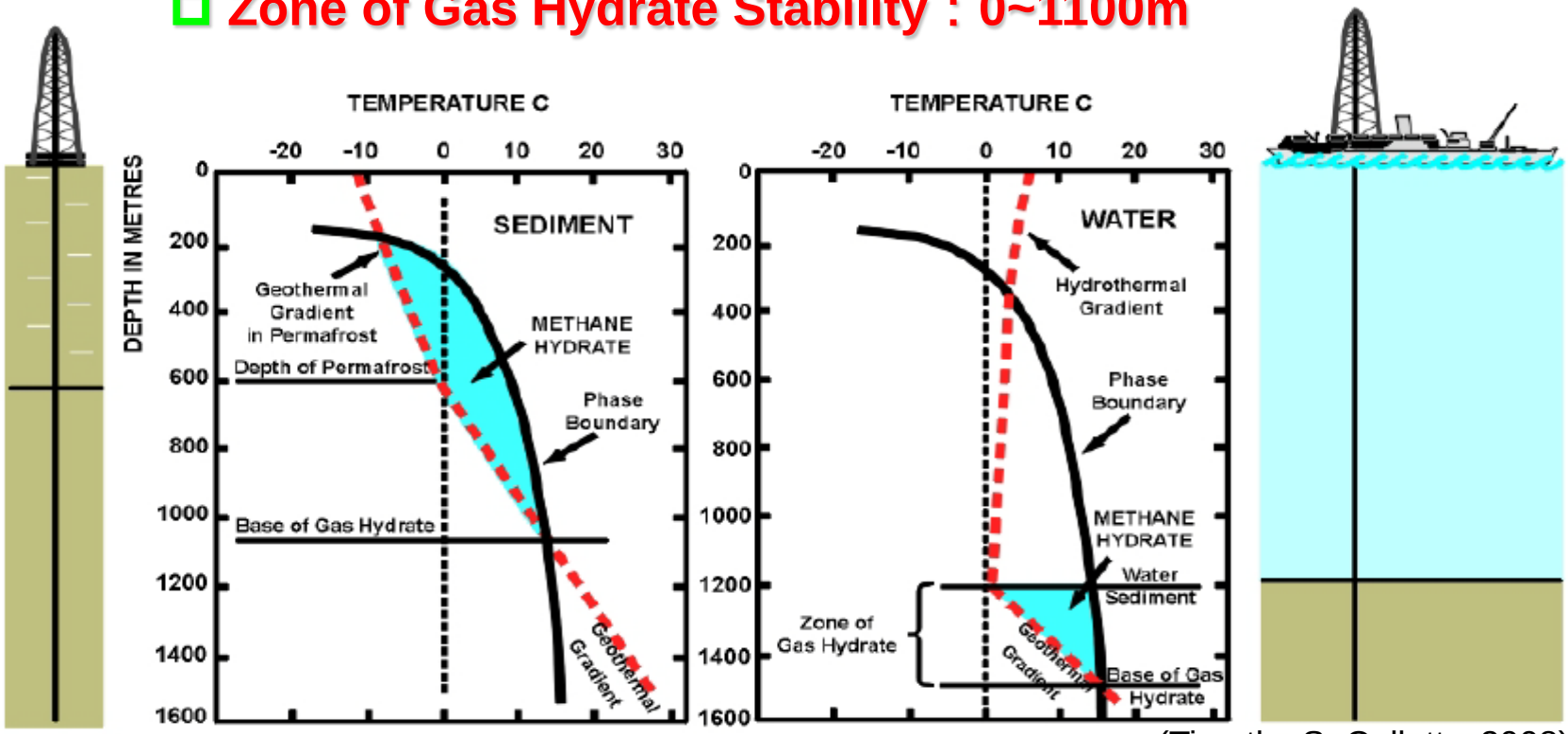
Effective seal and preservation

Uninterruptedly generating biogas

Additional mixed thermogenic gas

Biogas reservoir accumulation model

- Gas Hydrate Stability：Temperature and Pressure
  - Arctic regions with permafrost
  - Marine sediments (water depth>500m)
- Zone of Gas Hydrate Stability：0~1100m



(Timothy S. Collett，2008)

Permafrost　　Marine

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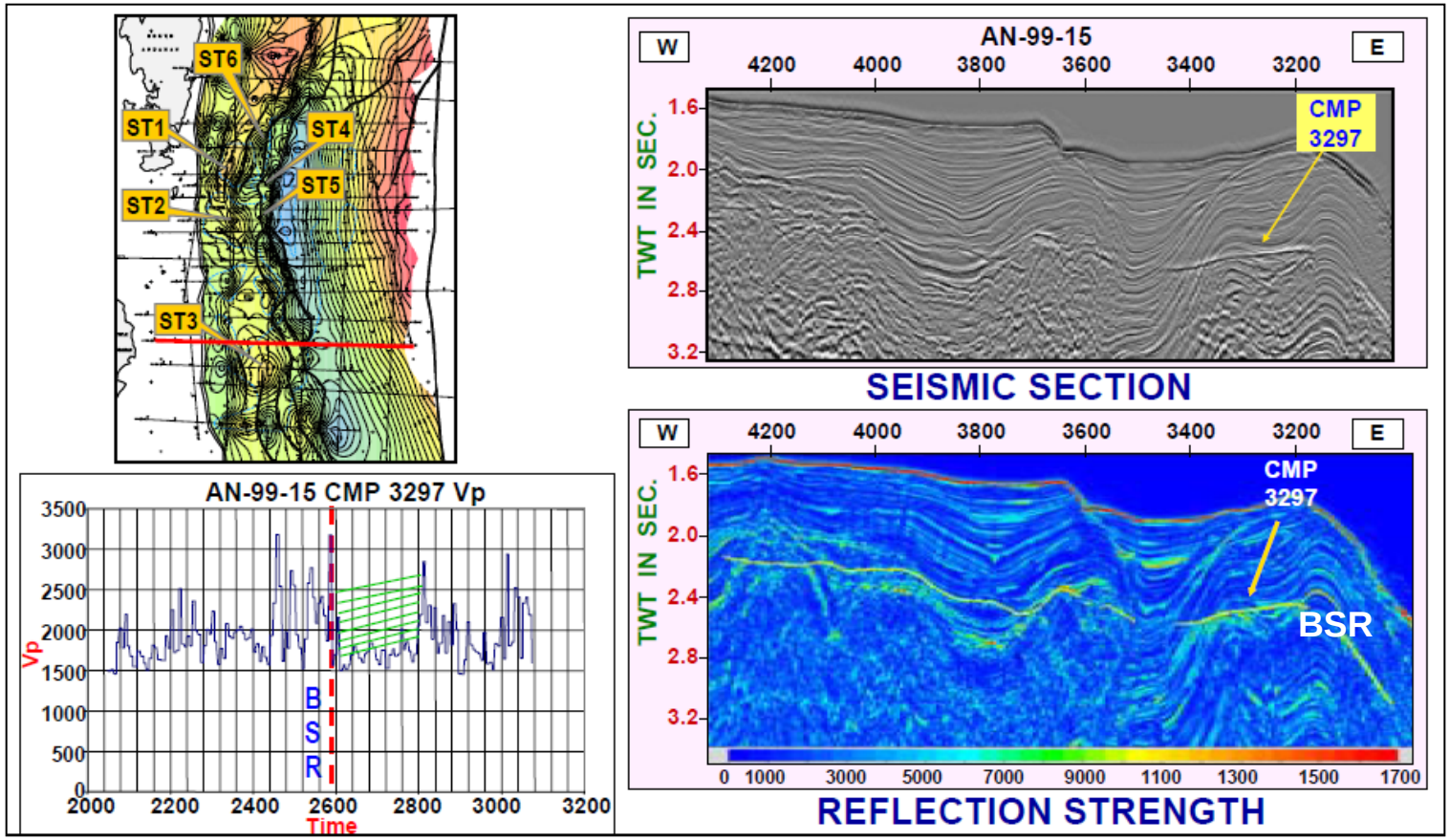
Biogas reservoir accumulation model

- Water depth:1200~1400m
- Zone of Gas Hydrate Stability:800m



(Avinash Chandra，2004)

xxx seismic section in western Andaman basin

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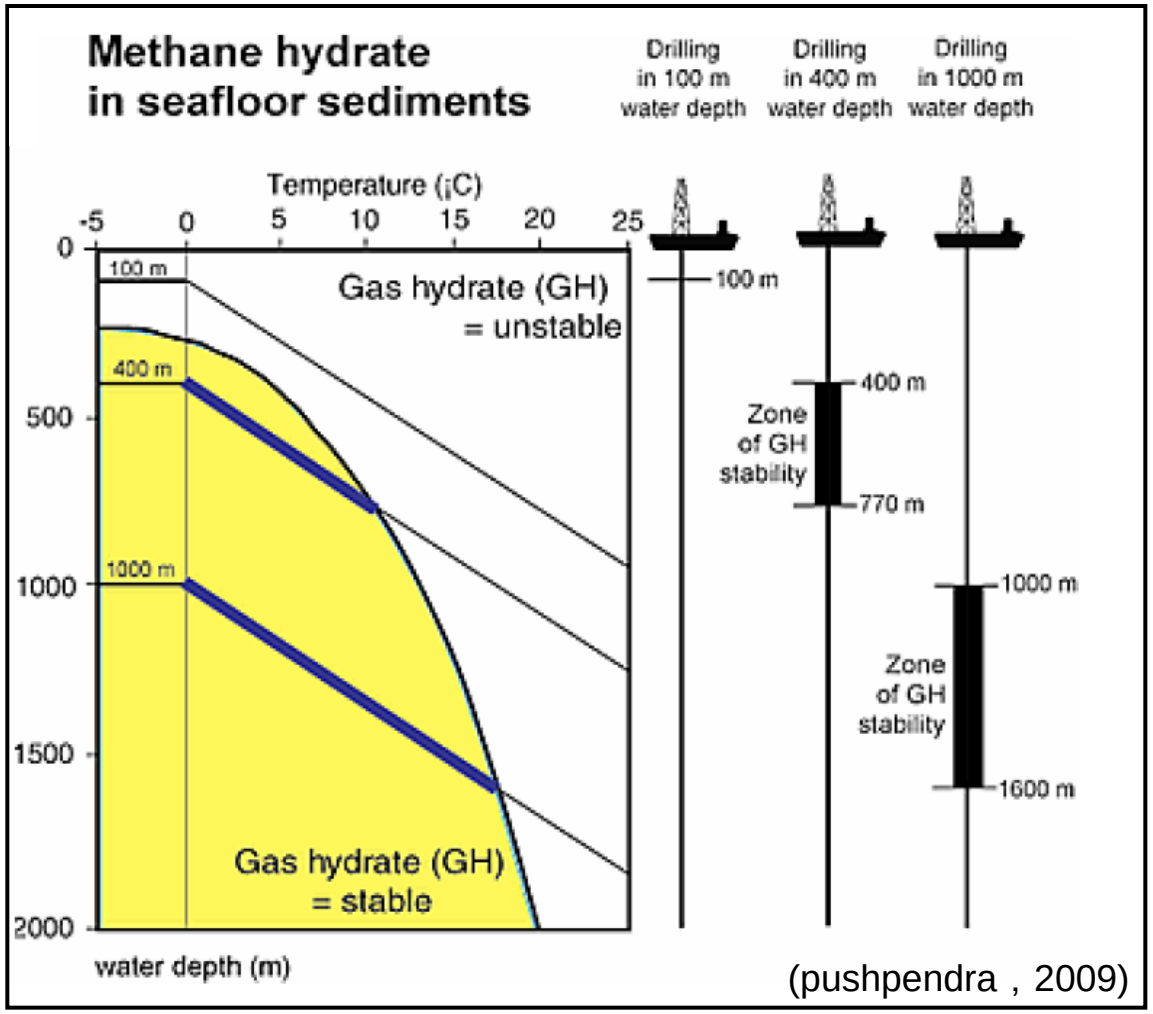
Biogas reservoir accumulation model

Geologic Controls for Hydrate Stability

- Pressure
- Temperature

- Water Depth
- Burial Depth

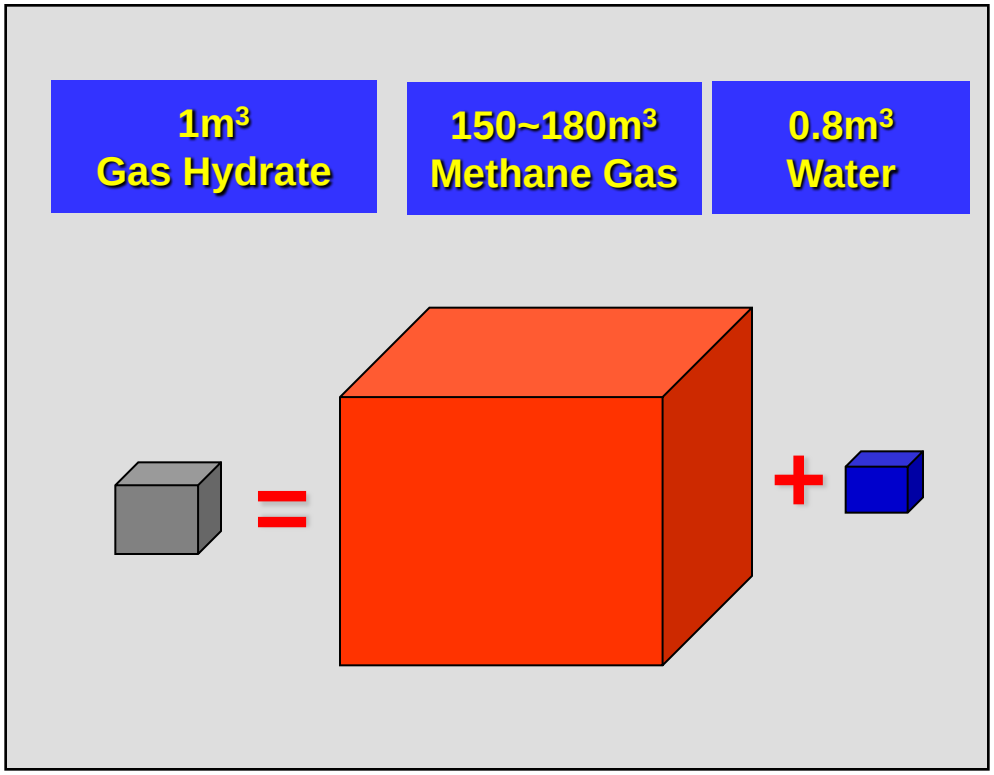


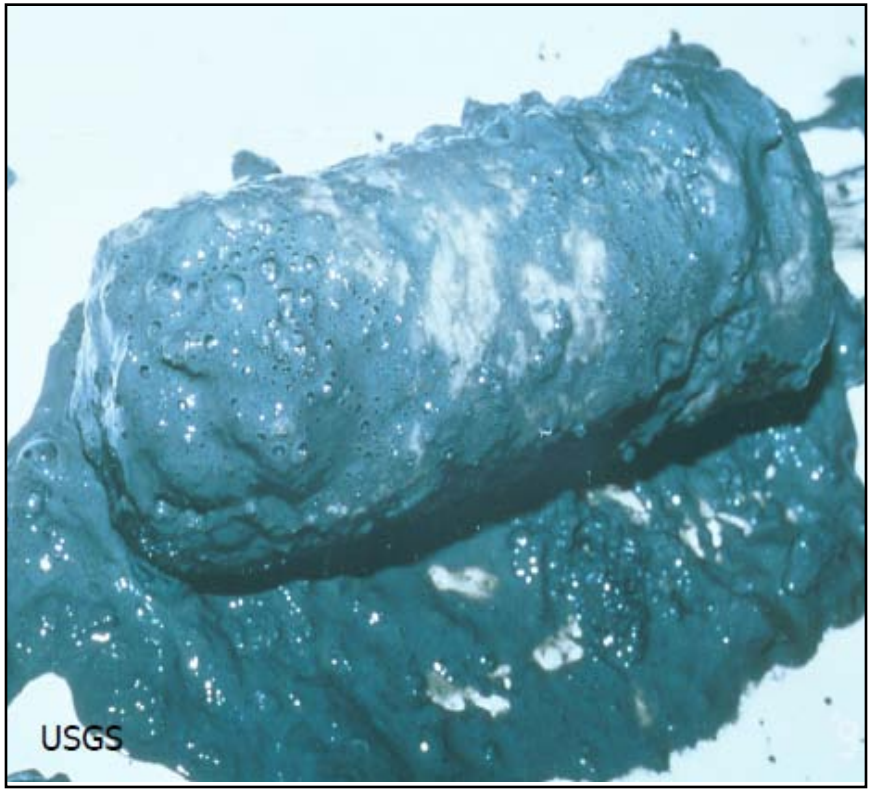
(pushpendra , 2009)

Biogas reservoir accumulation model

High Gas Liberation

- The gas hydrate is a kind of crystalline solid
- It can release large volumes gas, when the gas hydrate is melt
- One volume hydrate is equivalent to 150~180 volumes methane gas





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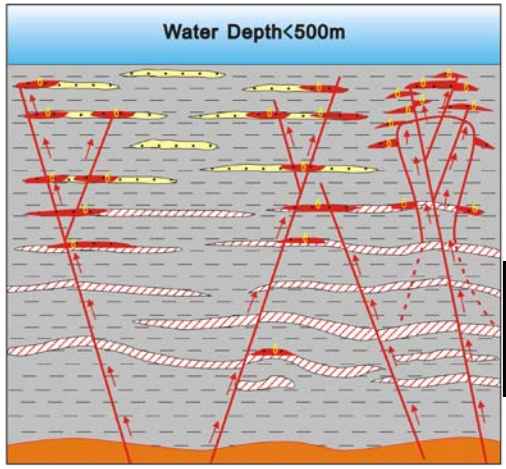
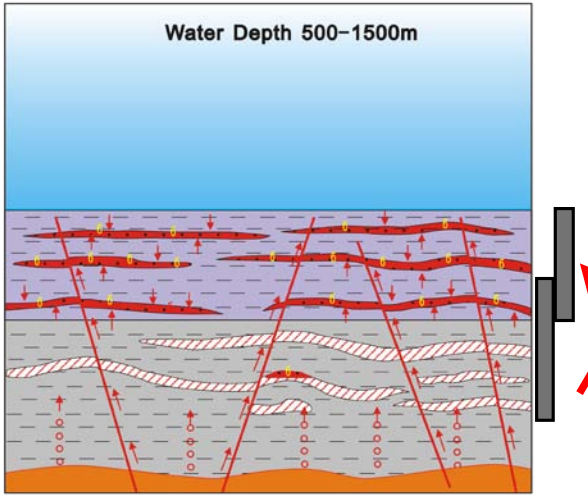
Biogas reservoir accumulation model

Accumulation model

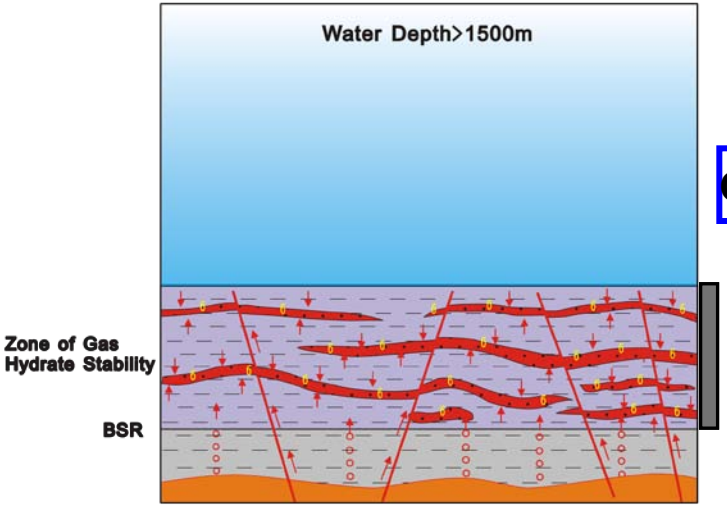
No gas hydrate



Transferring gas hydrate stability Zone



Many biogas reservoirs accumulated near faults in shallow parts



Water depth >500m

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

Water Depth release

Paleo-Hydrate → Free Gas

Burial Depth

Deep → (by fault, secondary migration) → Shallow

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Conclusions

- Many shallow biogenic gas reservoirs occurred in or adjacent to the depocenter. They are near faults and the water depth is less than 200m.
- The seismic data of biogenic gas sections in Andaman basin displays obvious seismic reflection anomalies. It's easy to be identified.
- There are seven beneficial geologic factors of Andaman basin for controlling biogas generation and accumulation
- We establish a possible accumulation model of biogenic gas reservoirs based on destabilization of the paleo-hydrate and secondary migration.
- If the water depth is less than 500m in initial deposition, there will be no gas hydrate. The biogas would be easy to be escaped. So, it's hard to accumulate gas reservoirs.
- If the water depth becomes less than 500 meters , all of the gas hydrates will be melt and release large volumes free gas .Then there will be many gas reservoirs accumulated near faults in shallow parts.


Thank You !
Cease to struggle and you cease to live. -- Thomas Carlyle
AUSTRALIA
OCEANIA
NEW ZEALAND
VANUATU
TONGA