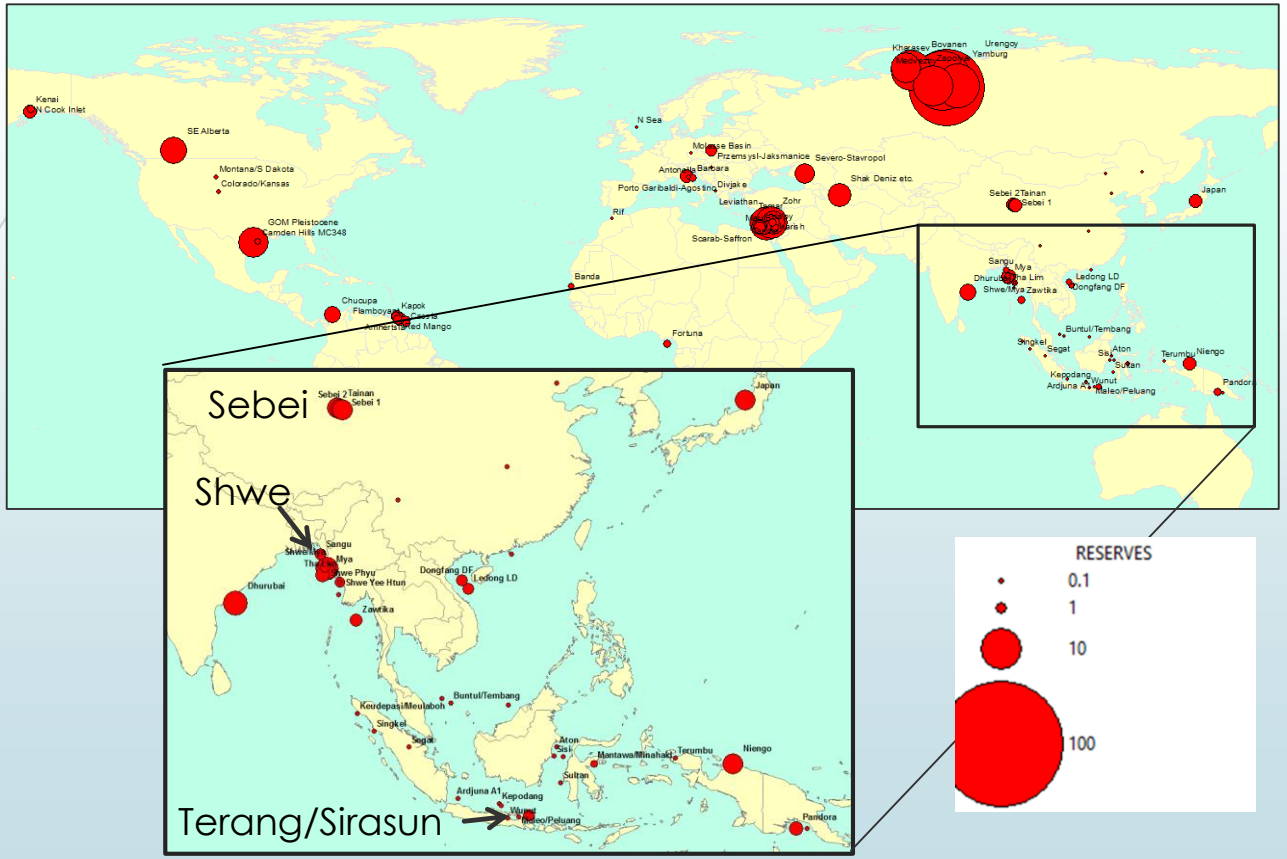
Physics and Biology of Biogenic Gas Plays: Implications for South-East Asia

Duncan Macgregor

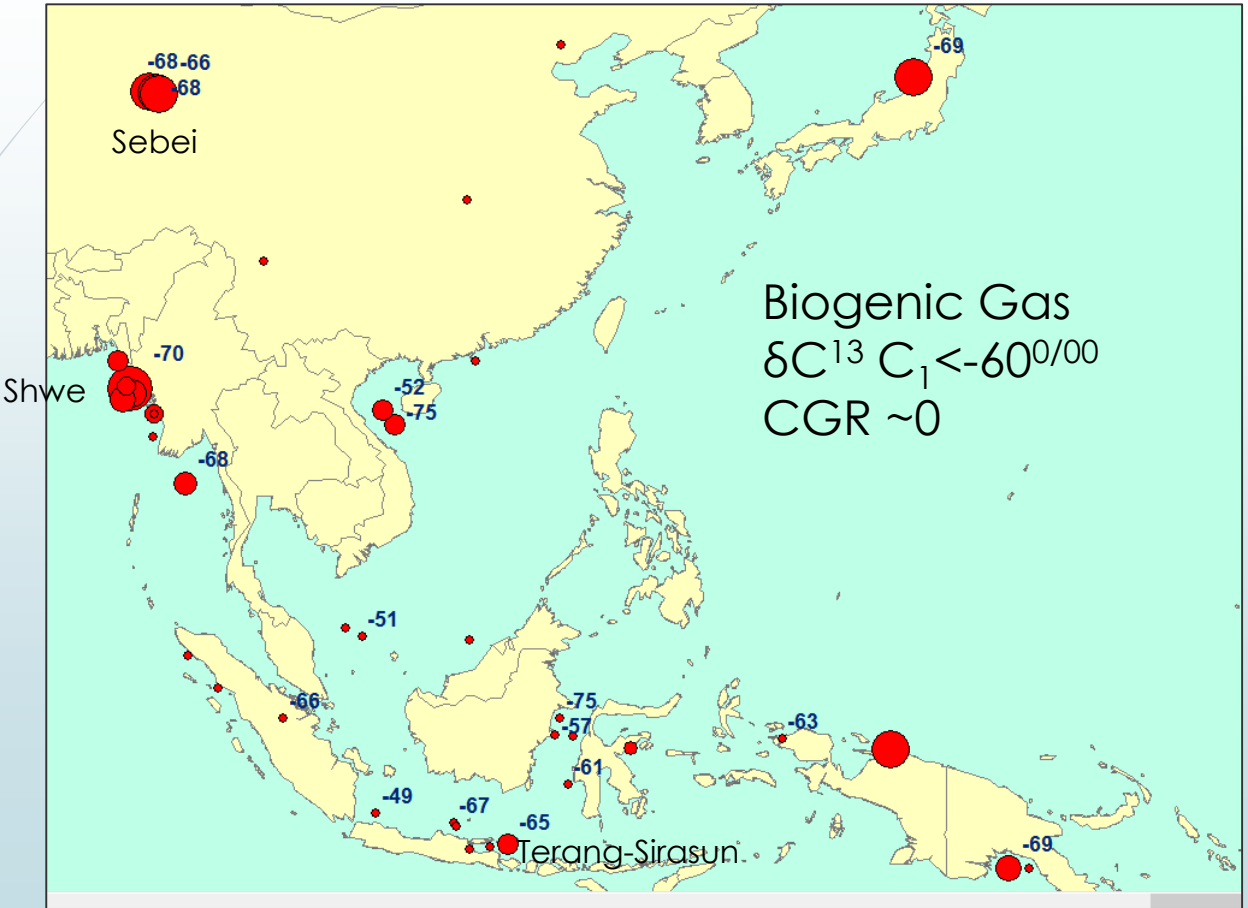
Order of Presentation

- Biogenic Gas Distribution and Models
- SE Asia PVT Studies
- Screening Criteria
- Conclusions

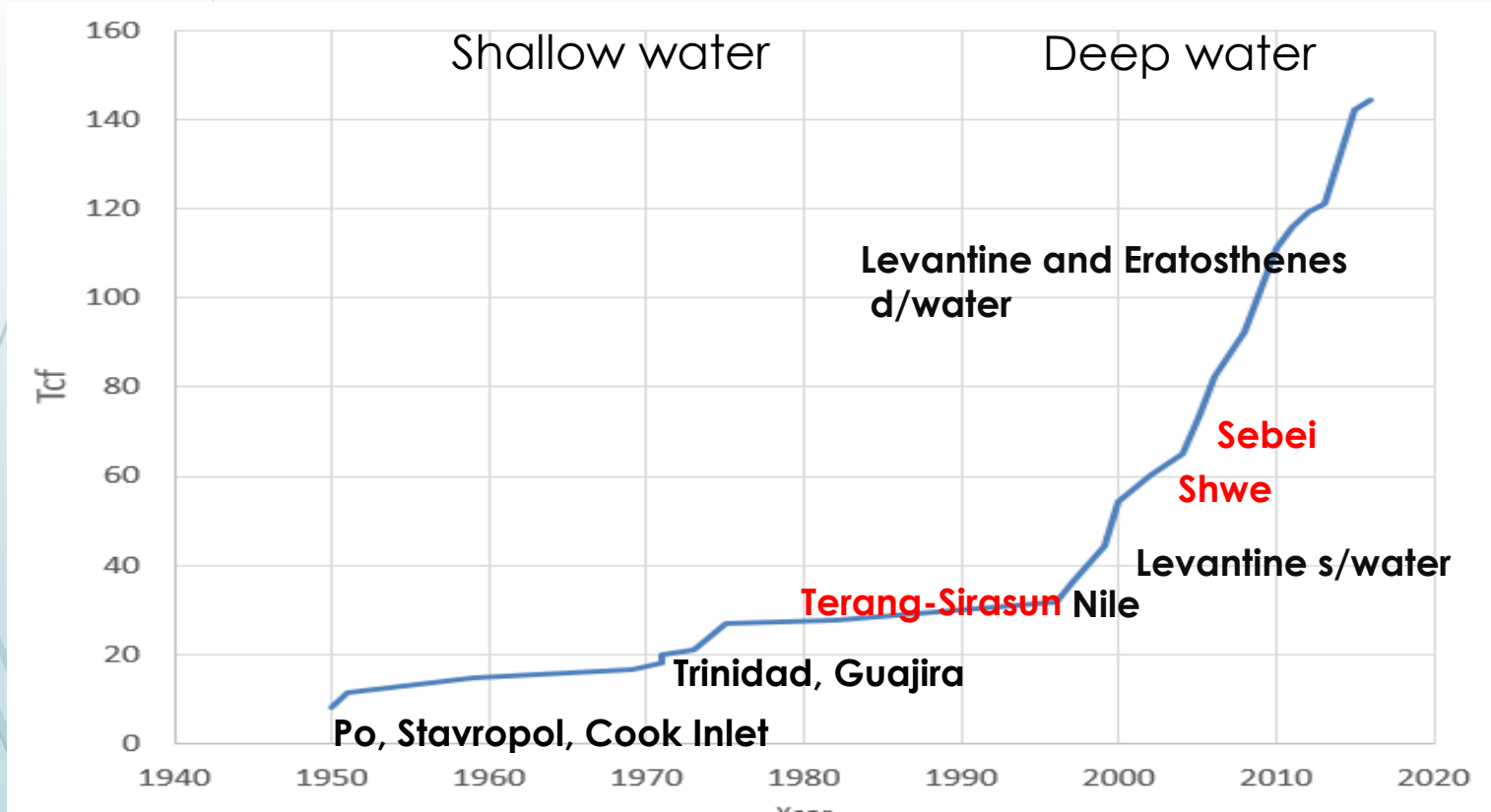
Global and SEA Biogenic Gas Reserves



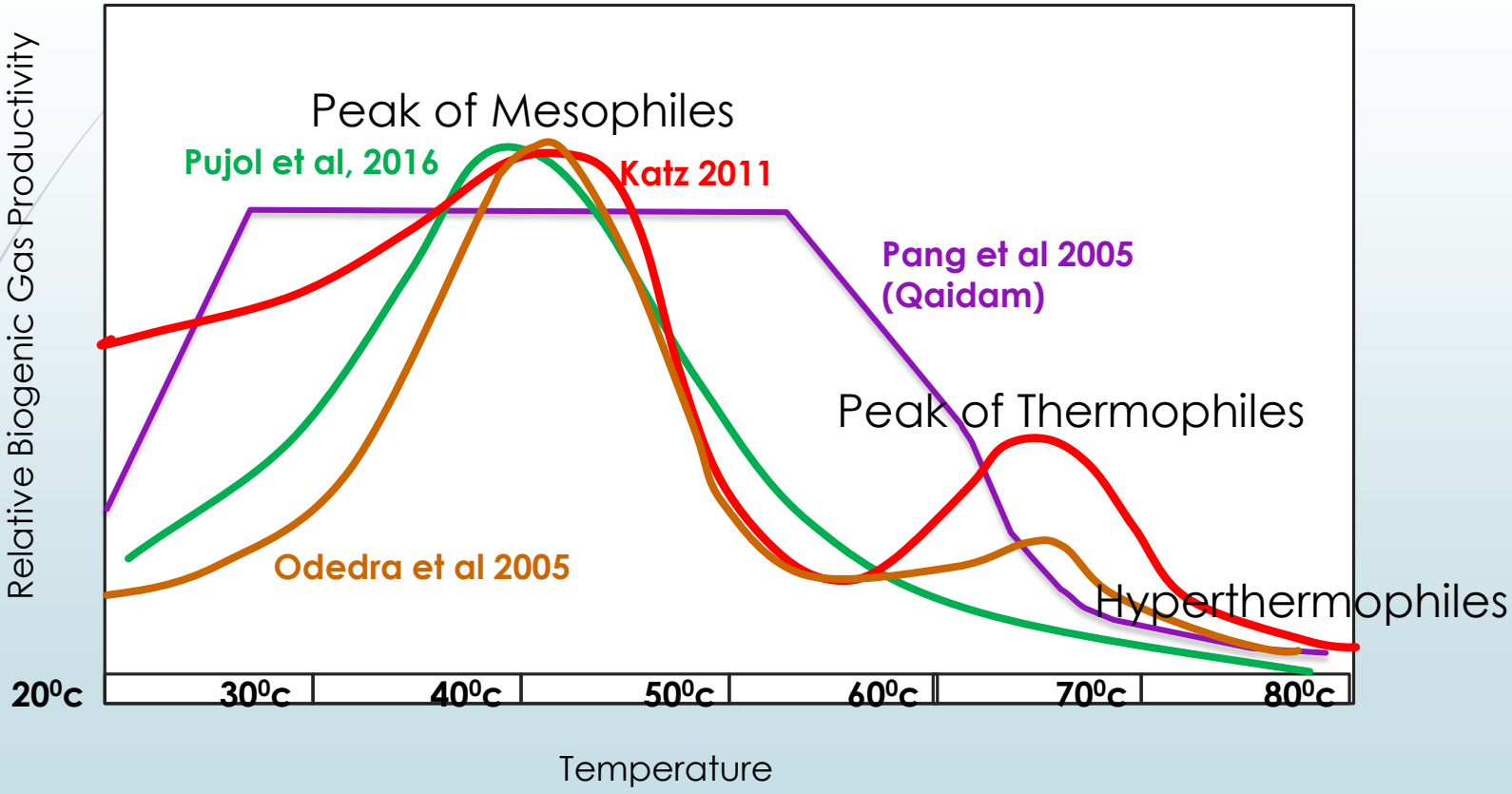
Isotopic Composition



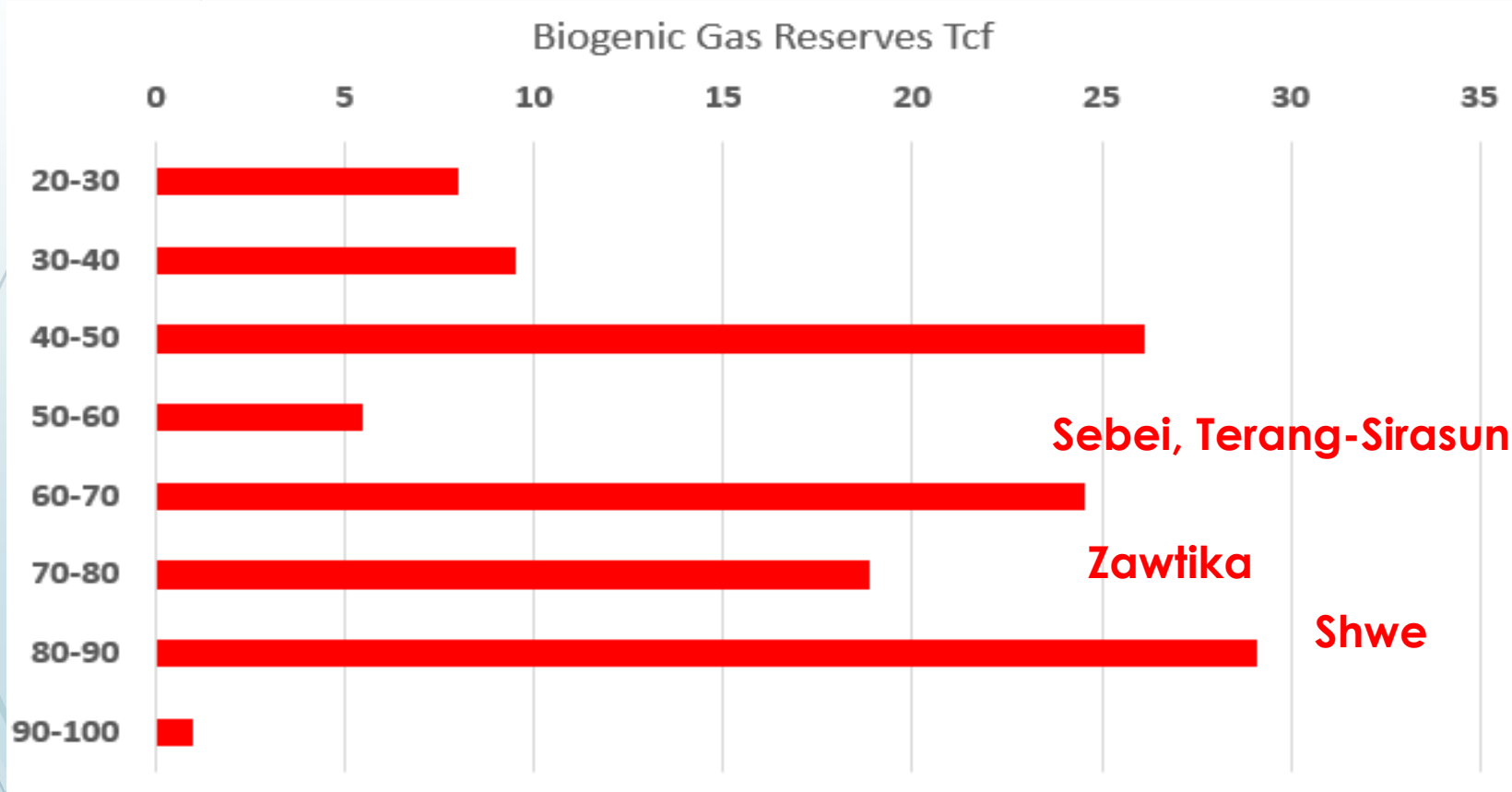
Cumulative Discovery Curve : Global Biogenic Gas Reserves (excluding West Siberia)



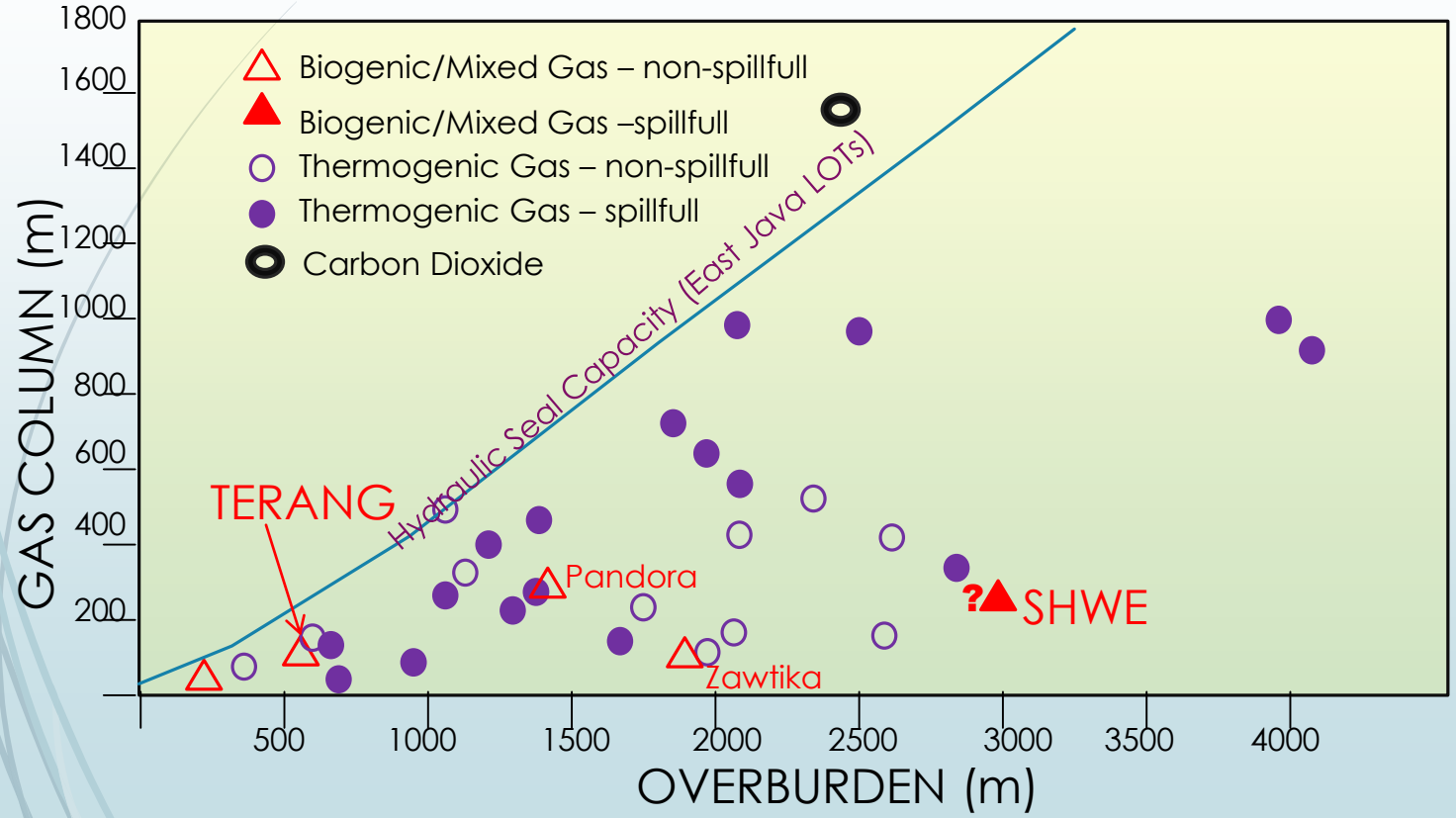
Summary of Methanogen Activity Models



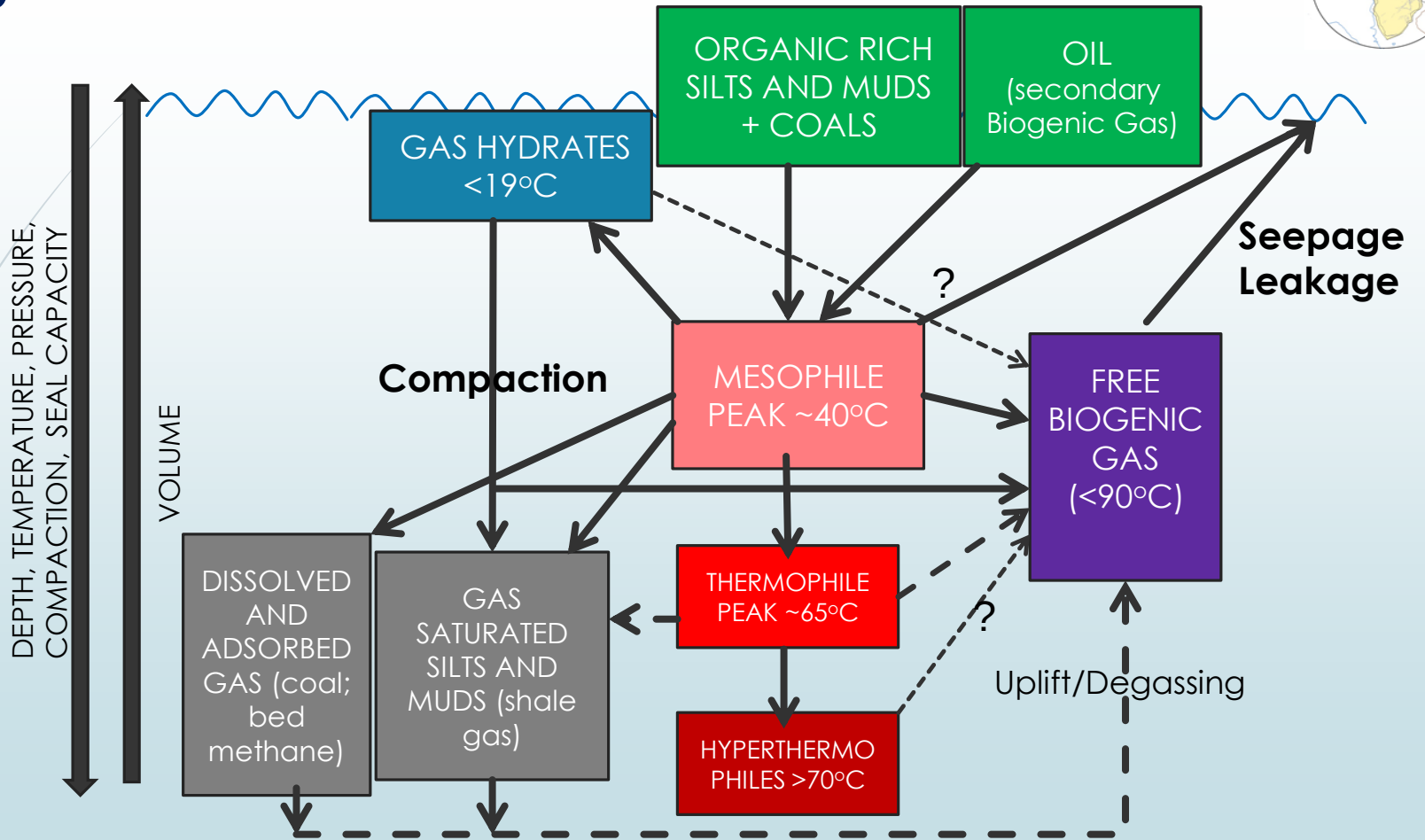
Reservoir Temperature of Biogenic Gas Reservoirs



SE Asia Gas Columns



Biogenic Gas Habitats



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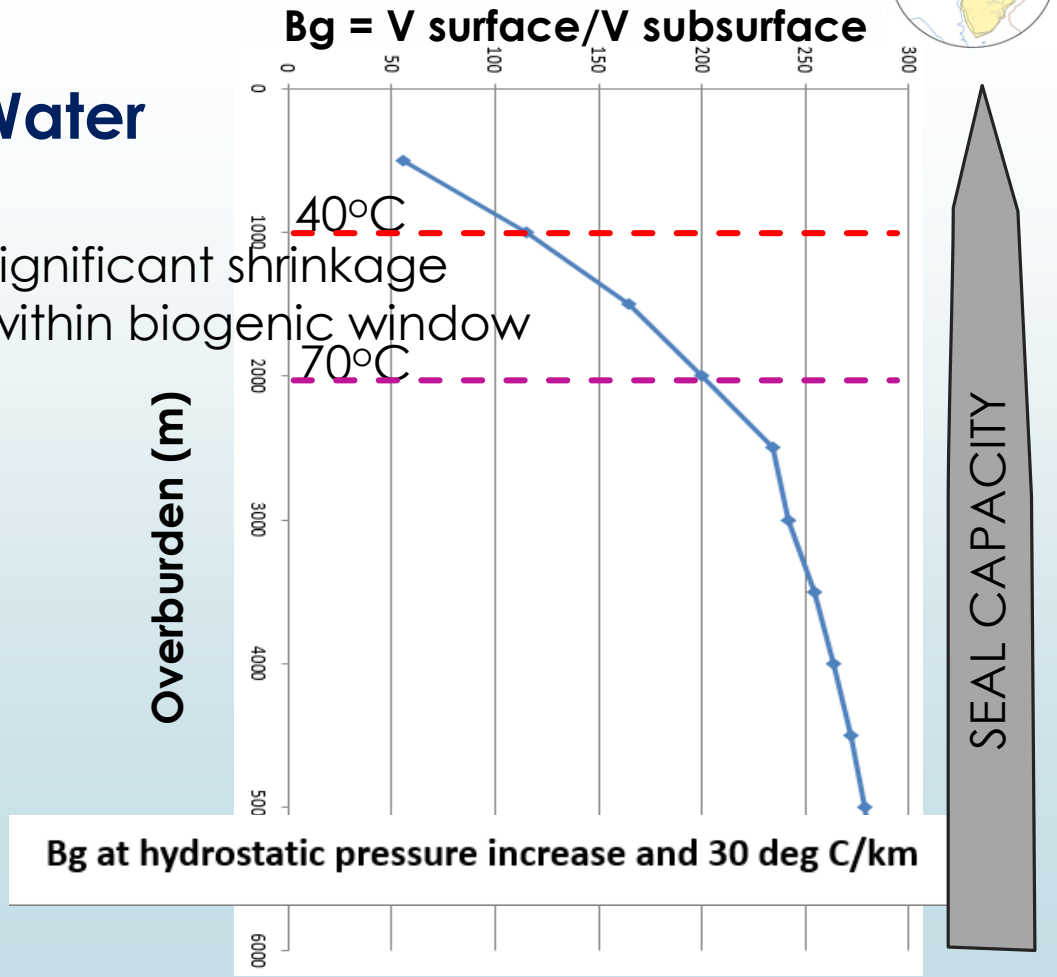
Temperature-Overburden-Gas Expansion Factor Relationships : Shallow Water Setting

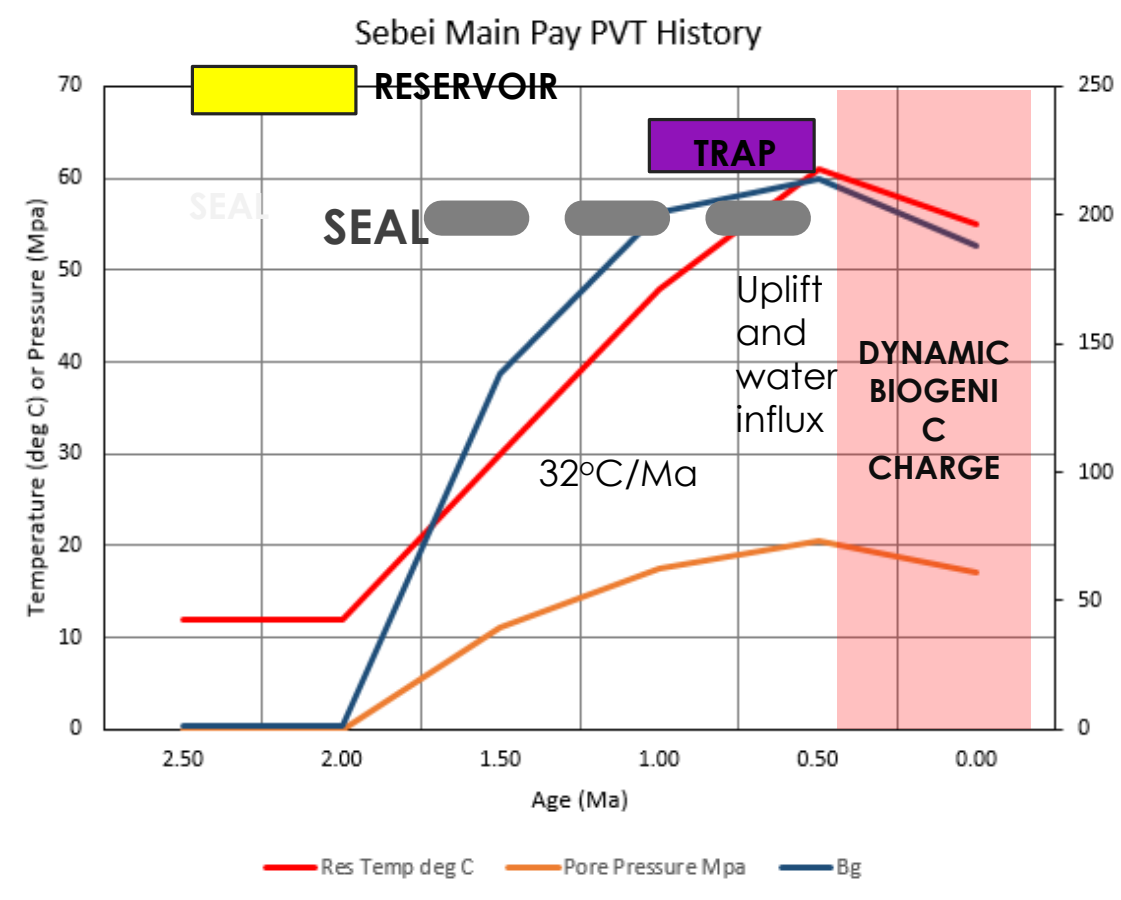
Boyles Law (ideal gas)

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

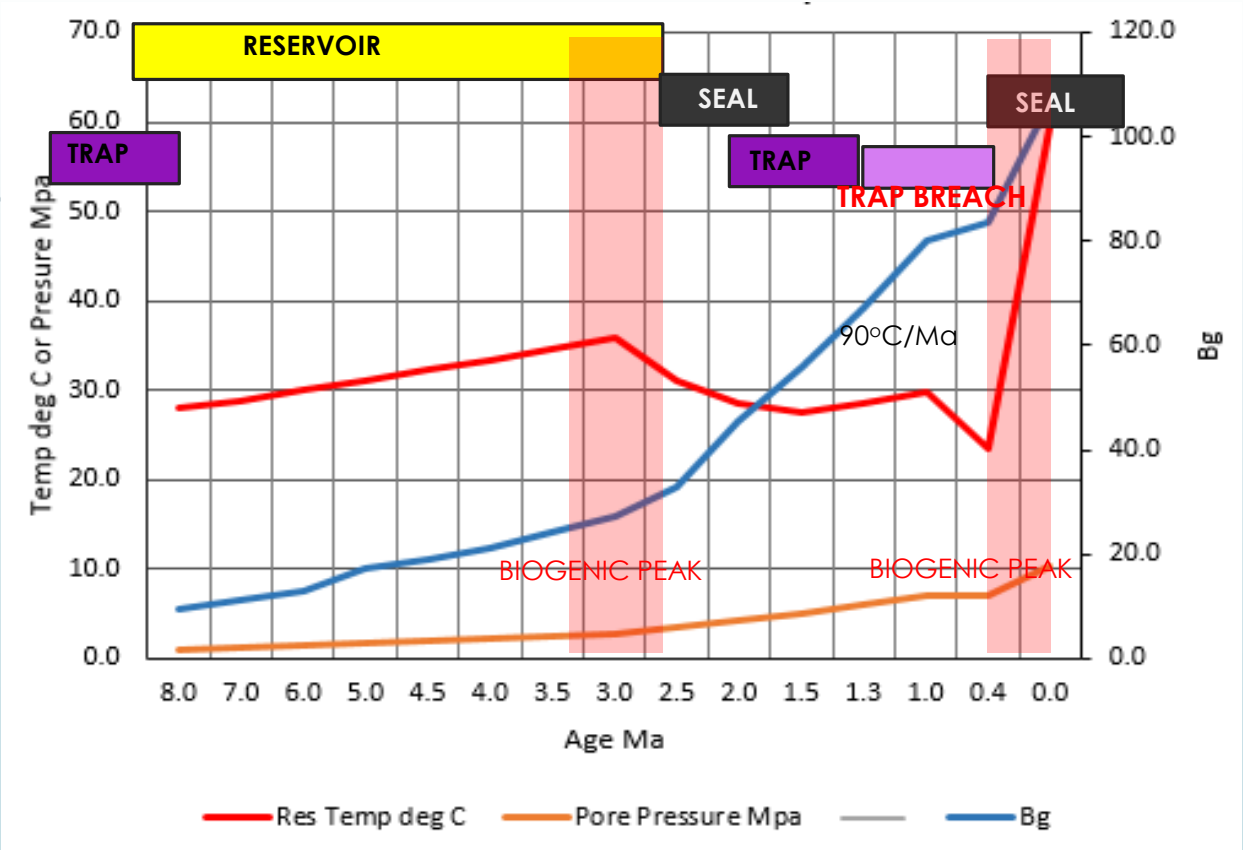
Amended for non-ideal gas (methane) by compressibility factor z



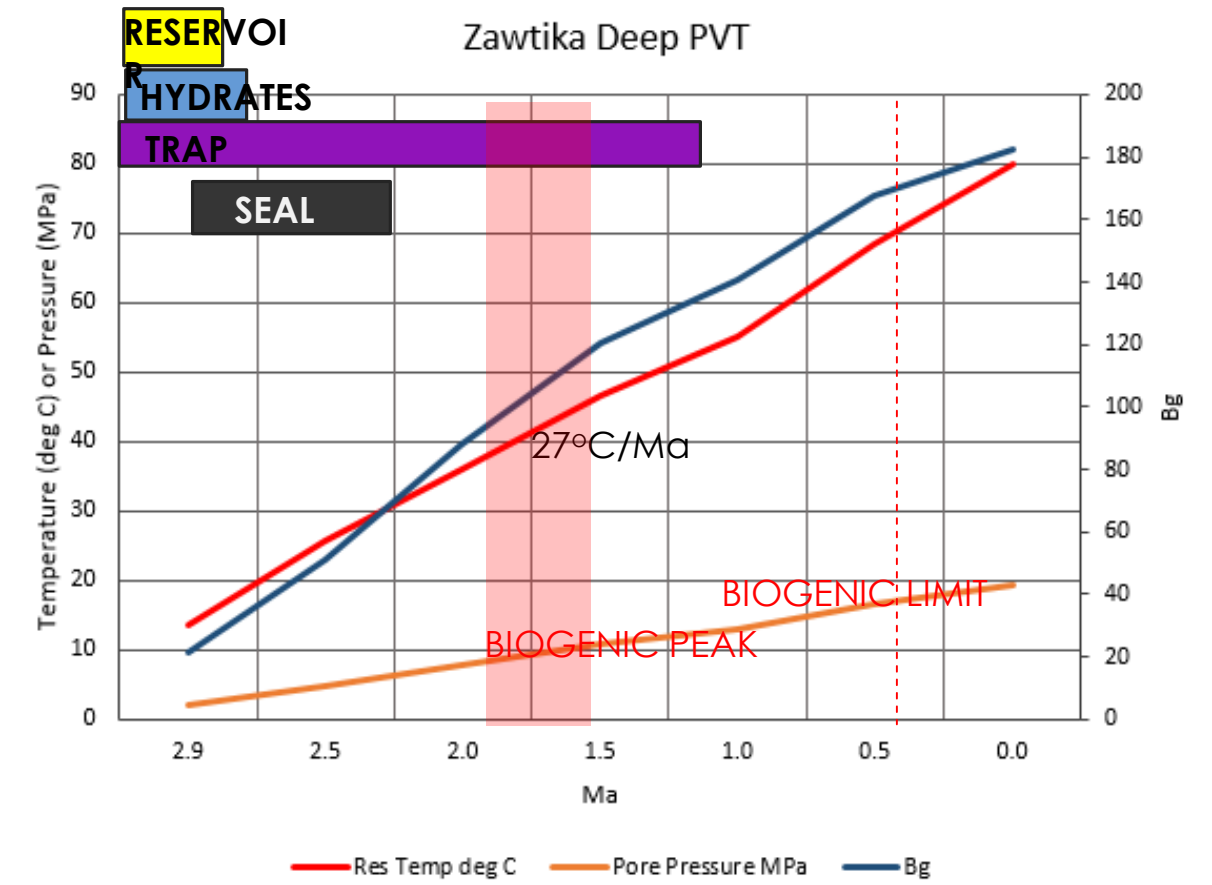
Sebei PVT History



Terang-Sirasun PVT History



Zawtika PVT History



Temperature-Overburden-Gas Expansion Factor Relationships : Deep Water Setting

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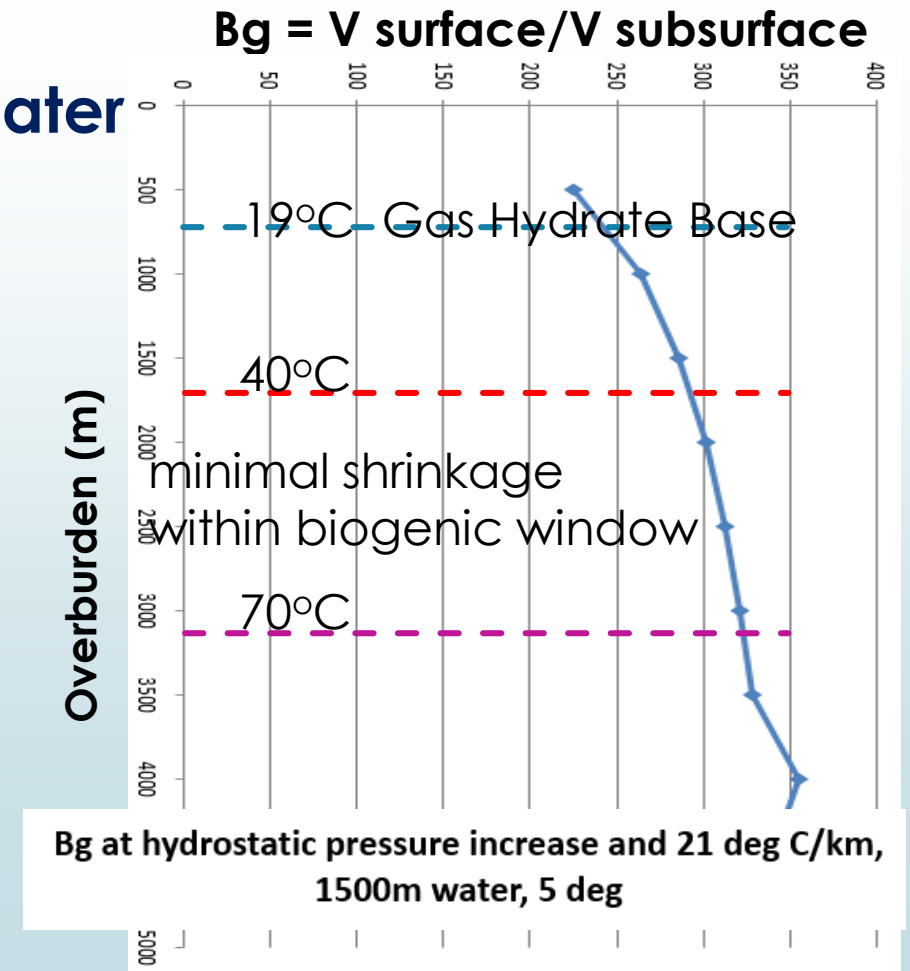
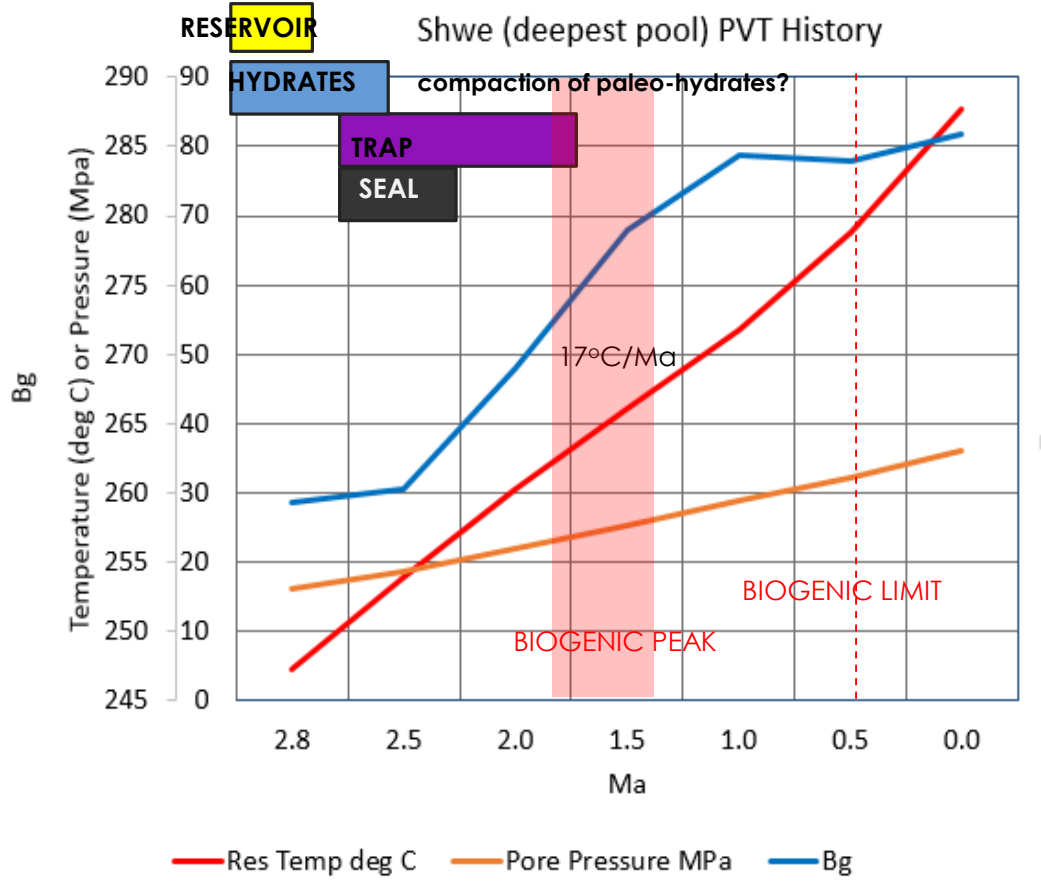


Shwe PVT History



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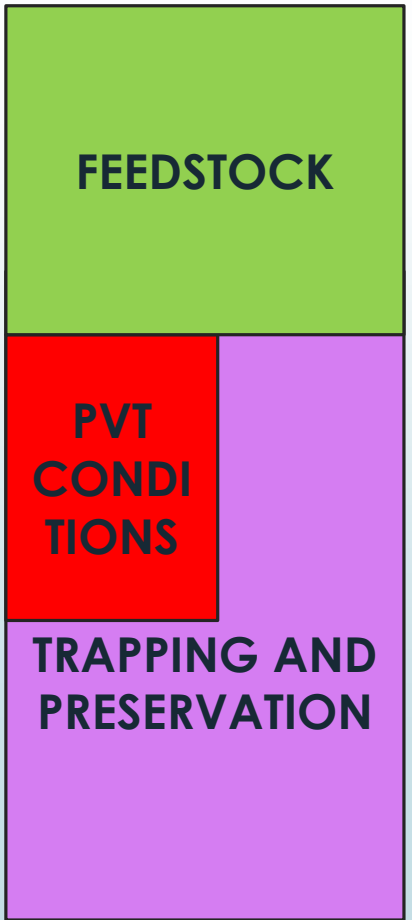
Key Factors for Biogenic Gas

- Type iii kerogen supply, often a delta/prodelta
  - TOC >0.3% but hundreds/kilometres thick
- Anoxia and/or Rapid Deposition
  - Burial rates between 200-1000m/Ma (5-25 deg C/km)
- Undercompacted Sediments – 2µm pore spaces NOT SHALES
- Low Temperatures / Geothermal Gradient
  - Ideally low surface temperature (deep water)
  - Typically below 25 degC/km
- Highly pressured deep marine setting during deposition
  - Reduces potential for shrinkage on leaving biogenic window
- Early Trap and Seal Formation
  - Trap in place and seal compacted while in main stages of biogenic window
  - Syn-sedimentary structural traps
  - Carbonate Buildups

Rice, 1989

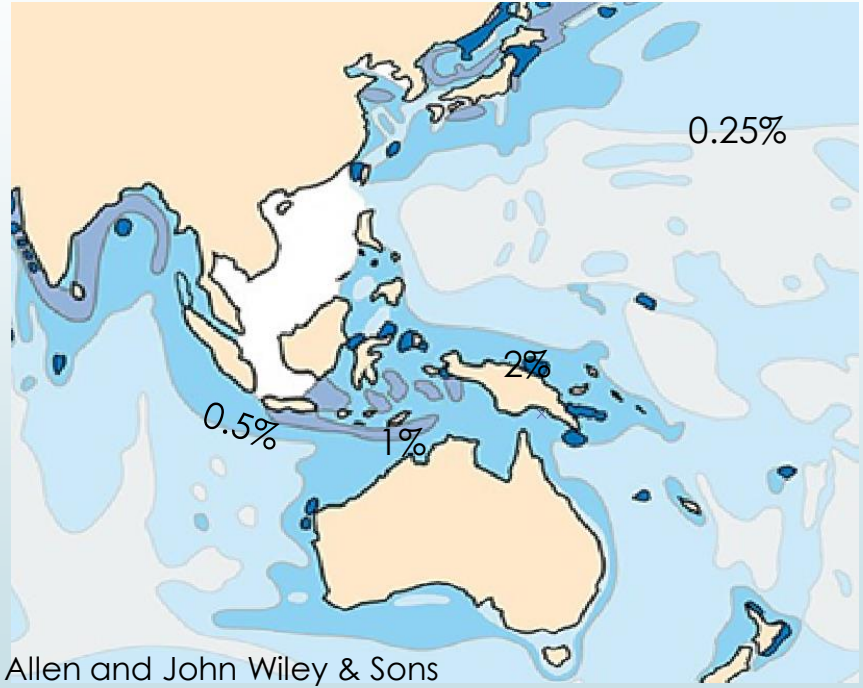


Biogenic Gas Basin Screening Matrix

BIOGENIC GAS SUCCESS FACTORS

	Absent	Possible	Probable	Known
	1	2	3	4
FEEDSTOCK				
Thick (hundreds of m) series of type iii kerogen bearing sediments (e.g. prodelta)				
Anoxia and/or depositional/heating rates of 3-25degC/Ma				
Undercompacted Sediments with >2µm pore spaces				
Extensive migration carrier bed				
Evidence for gas hydrates if/when in deep marine setting				
PVT CONDITIONS				
Low surface temperature and/or geothermal gradient (<25 deg C/km)				
Highly pressured deep marine setting during deposition				
TRAP FORMATION				
Very early trap formation (ideally in place by 40 deg C)				
Reasonably compacted mud seal (circa 500-600m burial) or evaporite				
EFFECTIVE RESERVOIR				

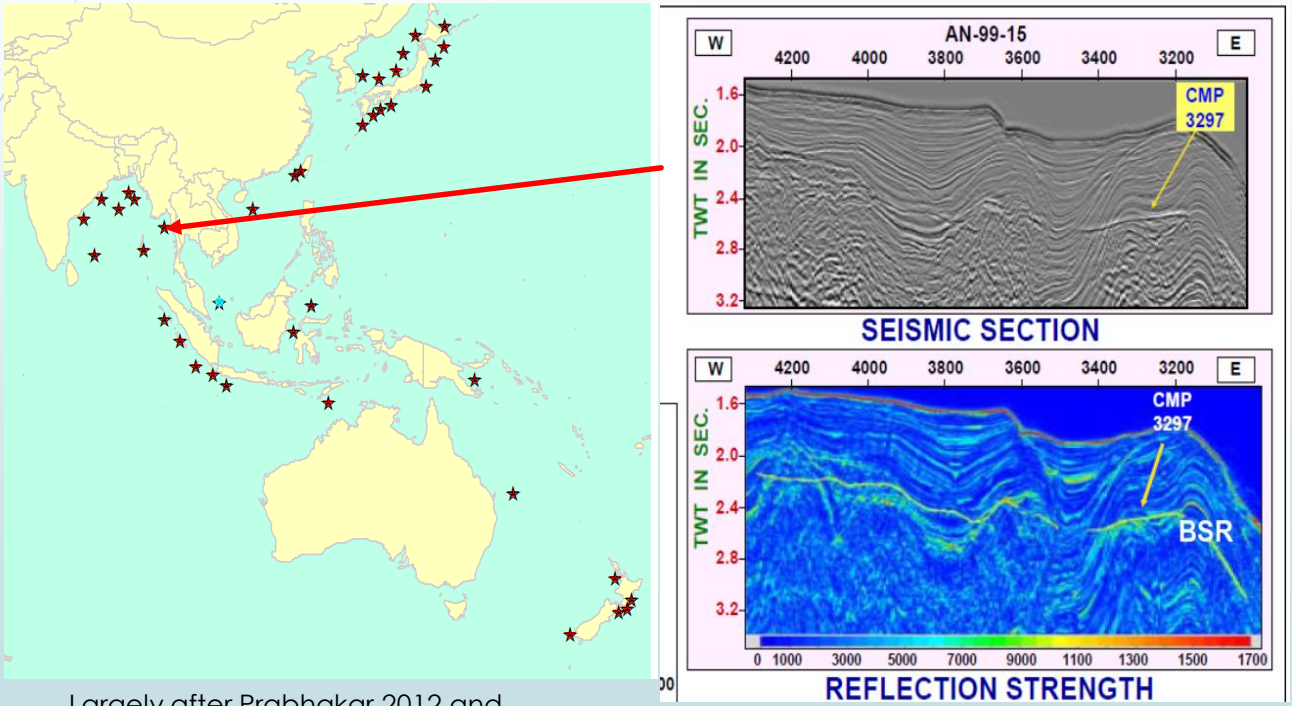
Biogenic Screening : Organic Feedstock- Present Day TOC



Acknowledgement : P and J. Allen and John Wiley & Sons for making this figure from their book 'Basin Analysis : Principles and Application to Petroleum Play Assessment' available for educational purposes on the internet

Biogenic Screening : Gas Hydrates/Bottom Simulating Reflectors

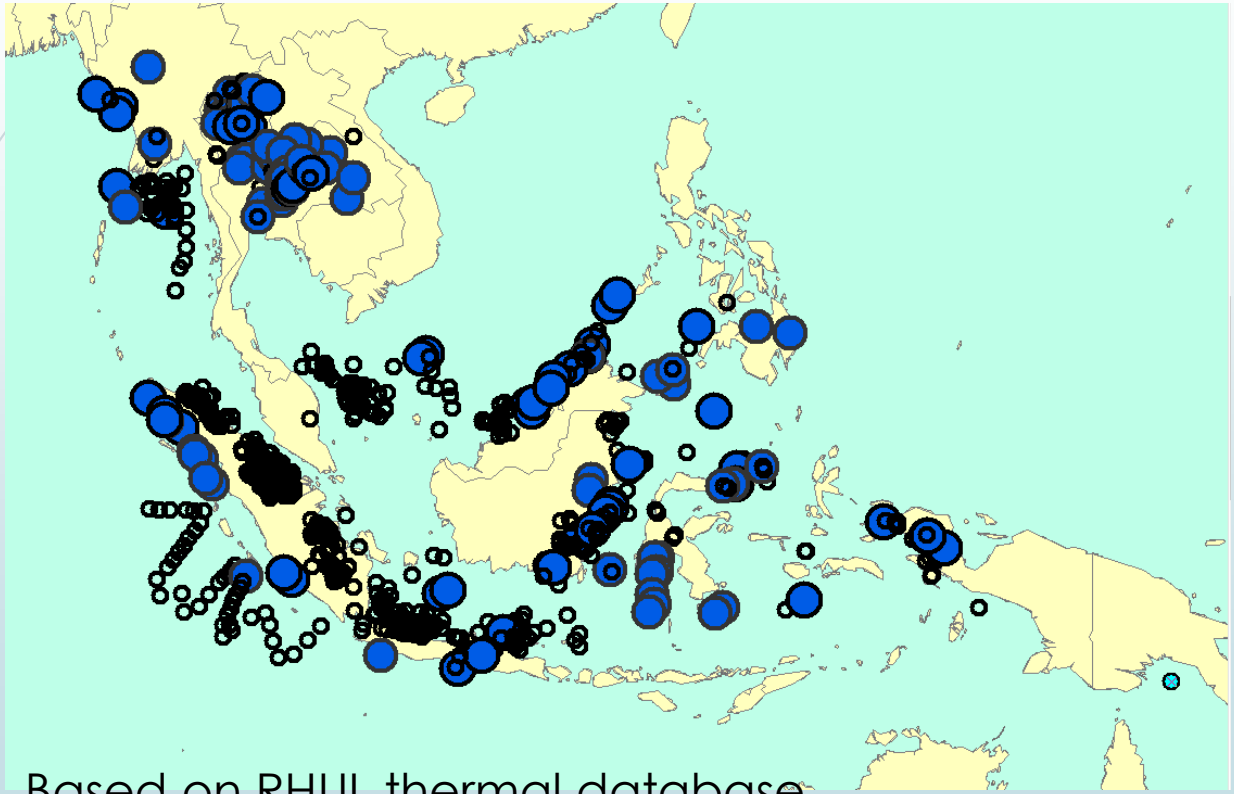
Known Hydrates and BSRs



Largely after Prabhakar 2012 and Lorenson and Kvenvolden 2010

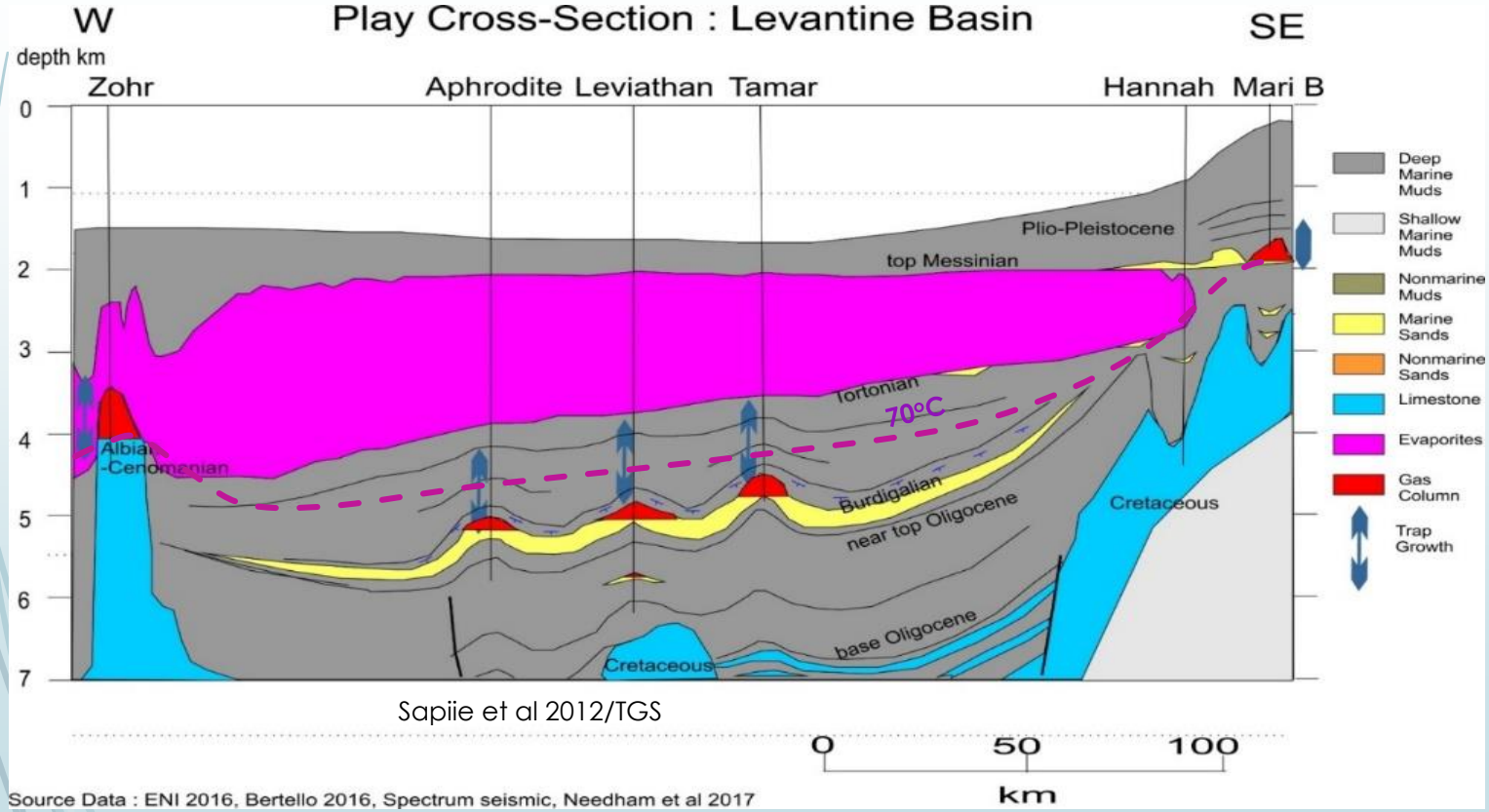
Deep Gulf of Martaban, Wang 2011

Biogenic Screening : Geothermal Gradients below 25°C/km



Based on RHUL thermal database

Biogenic Screening : Timing of Trap Formation



Sapiie et al 2012/TGS

Source Data : ENI 2016, Bertello 2016, Spectrum seismic, Needham et al 2017

Conclusions

- Biogenic Gas may be an underestimated resource in SE Asia
- The potential in deep water is greater than that onshore or on the shelf (cold seabed, seal capacity, gas hydrates, high pressures)
- Significant resources of biogenic gas can lie below the active biogenic generation window
- Screening for biogenic gas should be run independently for that for thermogenic petroleum as success factors are different and sometimes exclusive. These include
  - Very early trap formation, e.g. carbonate buildups and syn-sedimentary anticlines
  - Low thermal gradient – favours e.g. east Indonesian basins
  - Presence of bottom simulating reflectors = gas hydrates
  - High depositional rates and undercompacted sediments