


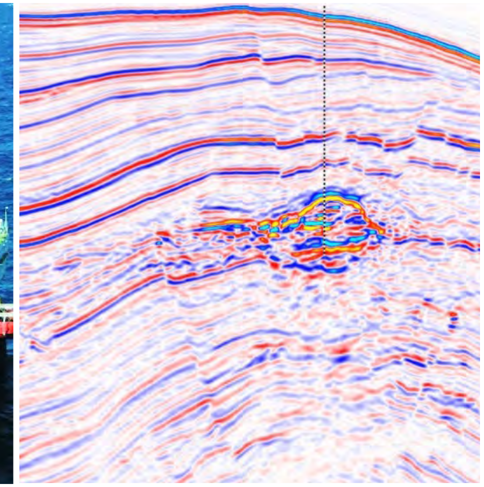


International Gas Hydrate R&D Activities

Timothy S. Collett

U.S. Geological Survey

Colorado School of Mines

Methane Hydrate Advisory Committee Meeting

December 1-2, 2020

USGS

science for a changing world

Briefing Outline

1. Gas hydrate scientific and industry drilling
2. International gas hydrate R&D projects
3. IODP gas hydrate related proposals and expeditions
4. European gas hydrate research and drilling programs
   - CAGE, GEOMAR/SUGAR, MARUM, MIGRATE
5. Gas hydrate production R&D projects - Update
   - India, China, Japan
6. Summary
7. Outreach

Briefing Outline

1. **Gas hydrate scientific and industry drilling**
2. **International gas hydrate R&D projects**
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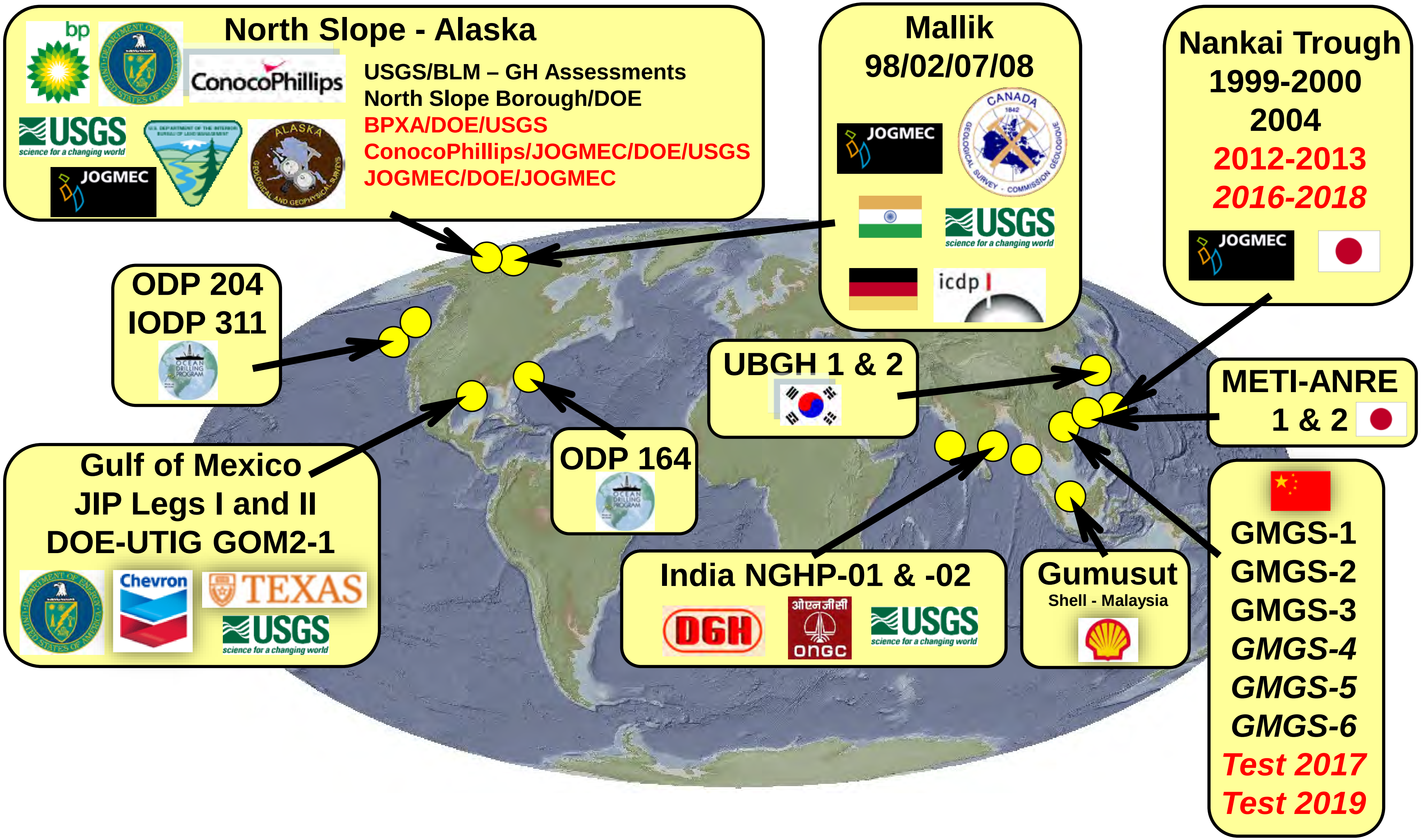
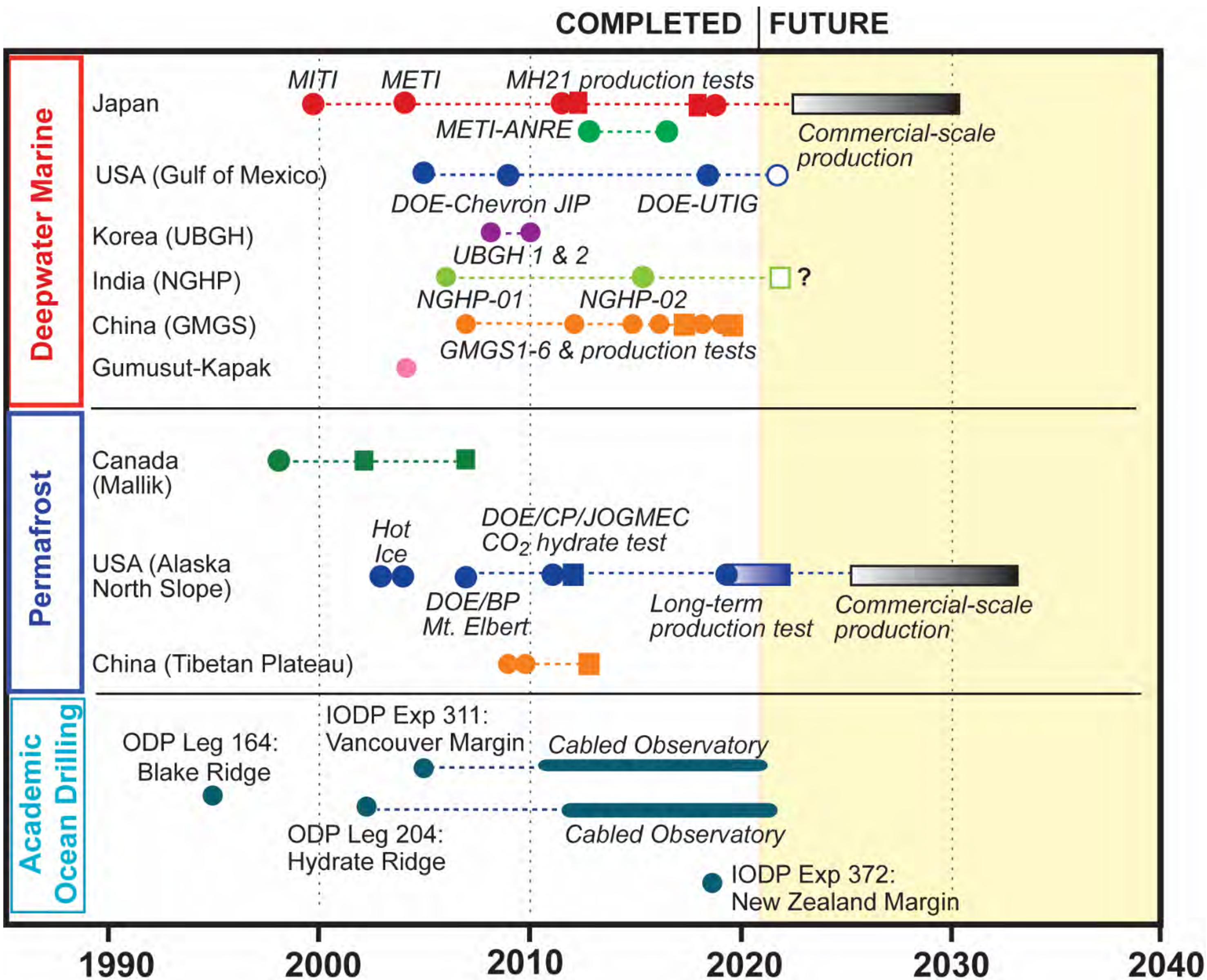
Gas Hydrate Scientific and Industry Drilling

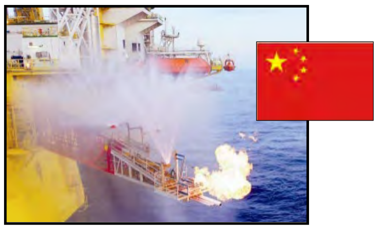


Gas Hydrate Scientific and Industry Drilling



International R&D

- **Japan**
  - *1998-2013: Collaboration on Arctic and marine international projects*
  - *2014/2019: METI-ARNE Japan Sea project*
  - *2016/17: Extended (12 and 24 day) marine production test*
  - *2014/2016-2023: Collaboration USA: Ignik Sikumi & Extended Prod. Test*
  - *April 2019: Three-year extension to MH21*



- **China**
  - *2007 trough 2019: GMGS-1 through GMGS-6 expeditions*
  - *2007 through 2014: Onshore tests*
  - *2017/2019: Geological Survey of China SCS production tests*

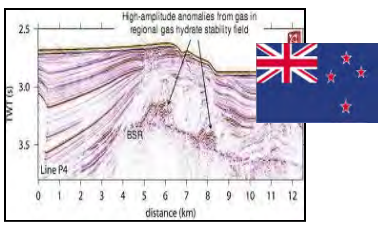
- **USA**
  - *2005 & 2009: Gulf of Mexico JIP Leg I and II Expeditions*
  - *2007: Alaska Mount Elbert Stratigraphic Test Well*
  - *2011-2012: Alaska Ignik Sikumi Methane Hydrate Production Test Well*
  - *2017-2022: University of Texas Gulf of Mexico 2-1 Expedition*
  - *2018-2023: Alaska North Slope Extended Gas Hydrate Production Test*

- **India**
  - *2006: NGHP-01 expedition*
  - *2009-2014: Site review collaboration*
  - *2015: NGHP-02 expedition*
  - *Proposed: NGHP-03 gas hydrate production testing (2-3 months)*

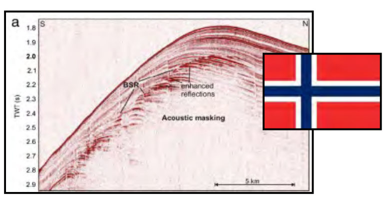
International R&D

- **Korea**
  - *2007 & 2010: UBGH-1 & UBGH-2 expeditions*
  - *2010-2019: Gas hydrate geomechanical lab studies*
  - *2020: Reprogramming - 2nd GHDO R&D master plan for 2020-2028*

- **European Union**
  - *MIGRATE Project – EU research coordination effort*
  - *GEOMAR SUGAR – Submarine Gas Hydrate Reservoirs*
  - *MARUM (Bremen) – MeBo New Zealand (2016)*
  - *MARUM/CAGE (U. Tromsø/Bremen) – MeBo Svalbard (2016)*
  - *MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)*
  - *MARUM/SUGAR(GEOMAR/U.Bremen) – MeBo Taiwan (2018)*



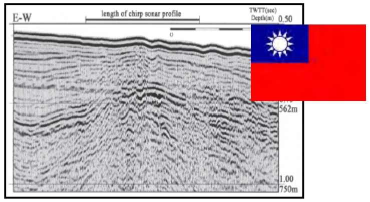
- **New Zealand**
  - *Gas Hydrate on the Hikurangi Margin, GNS, Univ. of Auckland*
  - *NETL support NRL/GNS Co-Op and Stanford Univ (PetroMod)*
  - *20017/18 IODP Expedition 372 Geomechanical deformation*



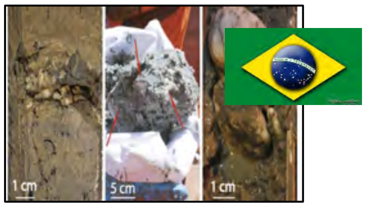
- **Norway**
  - *Gas hydrate global screening & production studies, Statoil/Equinor*
  - *CAGE, Centre for Arctic Gas Hydrate Environment and Climate (Tromsø)*

- **Canada**
  - *Onshore Mallik Project 1998, 2002, 2007-2008*
  - *Beaufort Shelf hazard and climate research*
  - *Pacific and Atlantic marine gas hydrate studies*

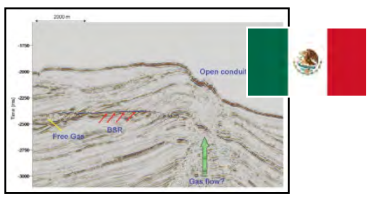
International R&D



- **Taiwan**
  - *Marine gas hydrate research, marine surveys*
  - *Central Geologic Survey and the National Taiwan University*
  - *SUGAR/MARUM (GEOMAR) – Taiwan (2018) MeBo (seeps & BSRs)*

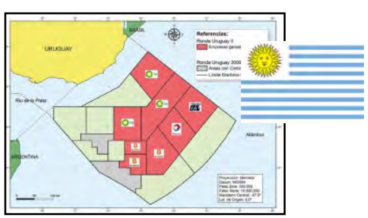


- **Brazil**
  - *Petrobras – Energy and Geohazard focus studies ?*
  - *Academic and related IODP proposals*



- **Mexico**
  - *Pemex, CNH, SENER, IMP, UNAM*
  - *Energy focus studies in the Gulf of Mexico*

- **Columbia**
  - *Ecopetrol SA*
  - *Energy focus studies*



- **Uruguay**
  - *Uruguay's National Oil Company ANCAP*
  - *Energy focus studies*

Others: Ireland, South Africa, Turkey, Vietnam, Malaysia, etc.

International Ocean Discovery Program (IODP)
Gas Hydrate "Related" Proposals/Expeditions

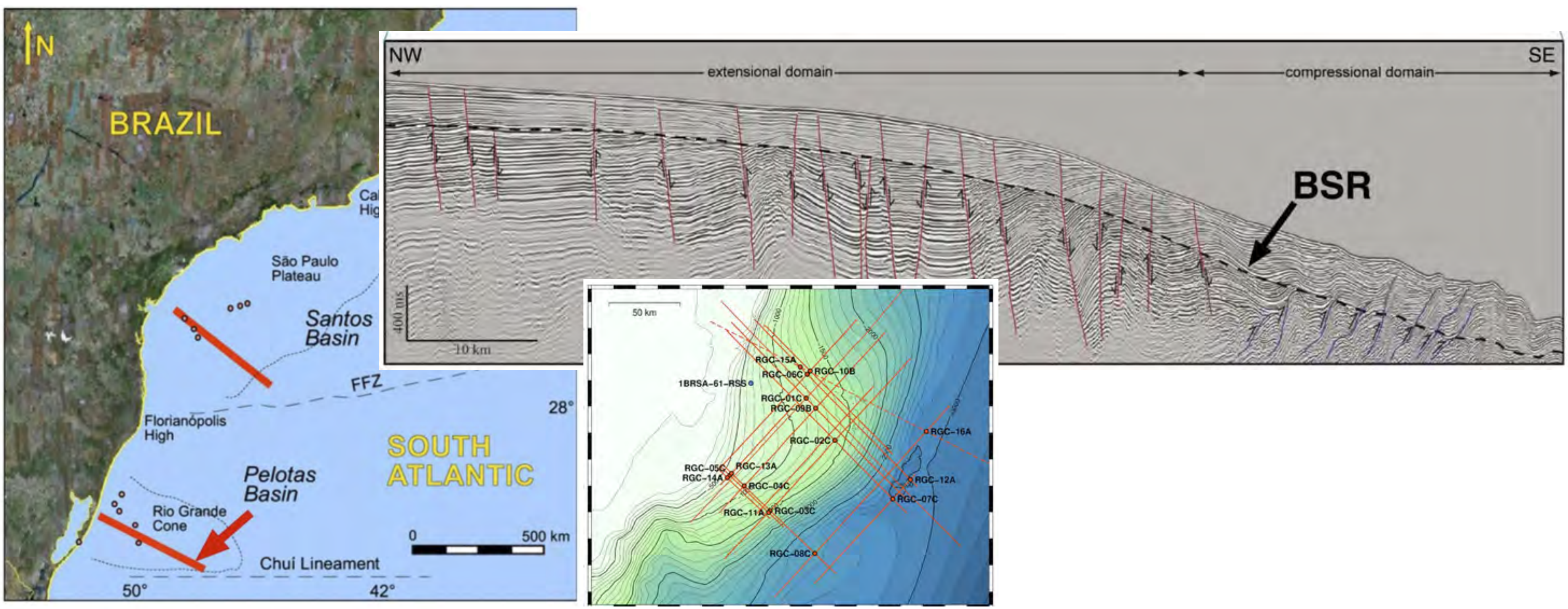
- **791-APL (2012) A. Malinverno**: Constraining methane cycling in continental margins: a combined microbiological: Northern Cascadia continental margin
- **811-Full (2013) P. Flemings:** The impact of recent warming and pore pressure rebound on slope instability; Cape Fear Slide, offshore North Carolina
- **885-Pre (2015) J. Bahk**: Ulleung Basin gas hydrates and submarine landslides: climate-driven hazards; Ulleung Basin, Korea
- **859-Full (2017/2020) P. Baker:** Deep drilling of the Amazon continental margin: The evolution of Cenozoic neotropical biodiversity, climate, and oceanography; Amazon continental margin
Scheduled as IODP Expedition 387 (26-June to 26-August, 2020): Shallow water (289 to 441 m) on the uppermost continental slope to the west of the Amazon Fan Expedition 387 Postponed
- **864-Full2 (2017/2020) T.D. Jones:** The Origin, Evolution and Paleoenvironment of the Equatorial Atlantic Gateway; Pernambuco Plateau, NE Brazil
Scheduled as IODP Expedition 388 (26-April to 26-June, 2020): Target Late Cretaceous and Cenozoic sediments offshore NE Brazil, Water depth 2237-4441 m Expedition 388 Postponed
- **910-Full (2018) Alberto Malinverno:** Carbon cycling in methane-charged continental margin sediments: Rio Grande Cone; Brazil Atlantic margin
Scheduled as IODP Expedition 394 Expedition 394 Postponed
- **935-Full (2019) Stefan Bünz**: Pleistocene evolution of Arctic gas hydrates and fluid flow Systems – POLARIS; Fram Strait
- ***961-APL (2019) A. Cook***: Linking Sediment Deposition During Glacial Cycles and Methane Hydrate Occurrence, Gulf of Mexico WR313
Scheduled as IODP Expedition 961 Status ?

IODP Expedition 394 - IODP Proposal 910-Full: Carbon cycling in methane-charged continental margin sediments: Rio Grande Cone; Brazil Atlantic margin

Proponents: Alberto Malinverno, Joao Marcelo Ketzer, Gerald Dickens, Caroline Thaís Martinho, Adolpho Augustin, Frederick Colwell, Verena Heuer, Fumio Inagaki, Adriana Leonhardt, Renata Medina da Silva, Yuki Morono, Vivian Helena Pellizari, Maria Alejandra Pivel, John Pohlman, Brandi Reese, Luiz Frederico Rodrigues, Volkhard Spiess, Marta Torres, Adriano Vian

Scientific Objectives

The overall scientific goal of the proposed expedition is to substantially improve our understanding of biogeochemical and physical processes that lead to widespread methane occurrence in continental margin sediments and that couple to the overlying ocean over time. The planned measurements of in situ methane concentration from pressure core sampling will provide key constraints to the modeling and the estimated methanogenesis rates will inform the quantification of methane amounts in continental margin sediments.



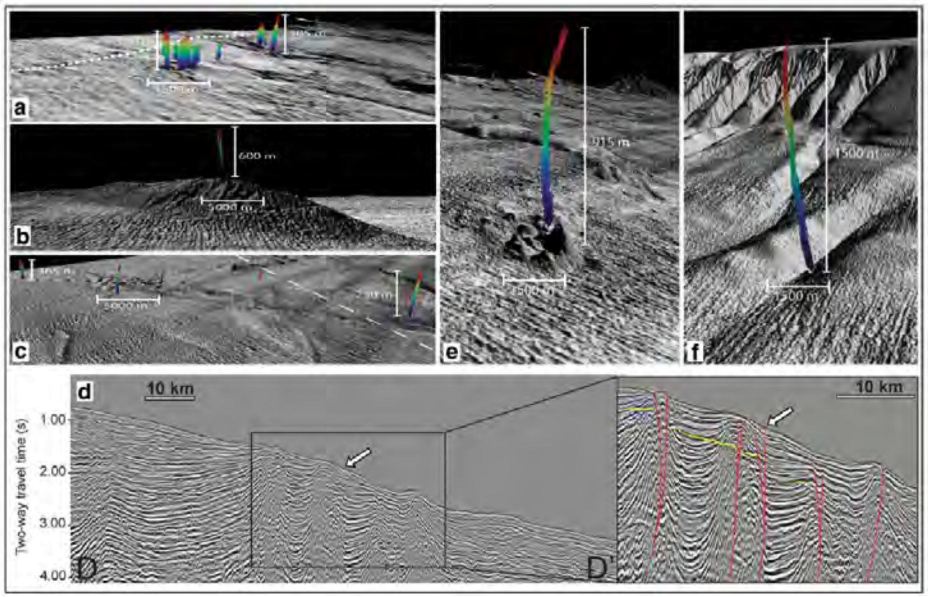
Geo-Marine Letters
https://doi.org/10.1007/s00367-018-0546-6

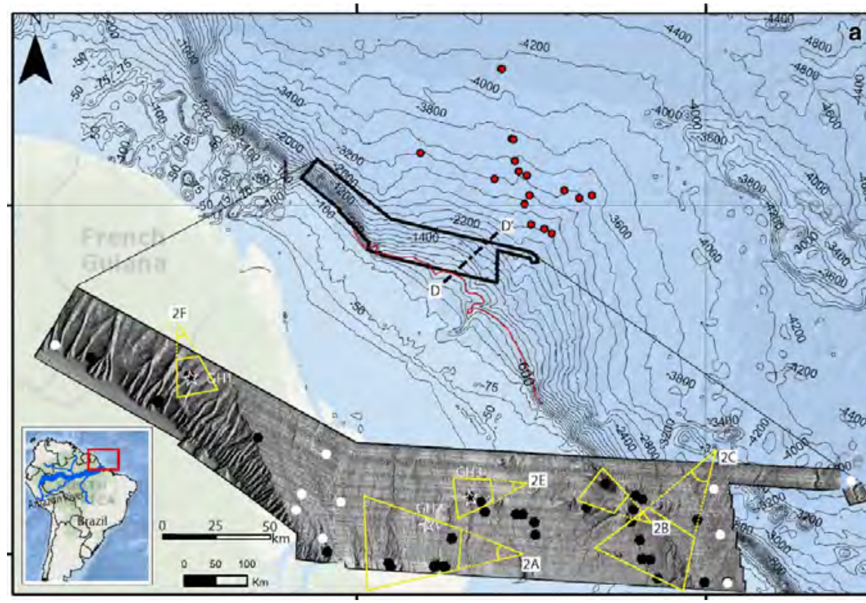
ORIGINAL

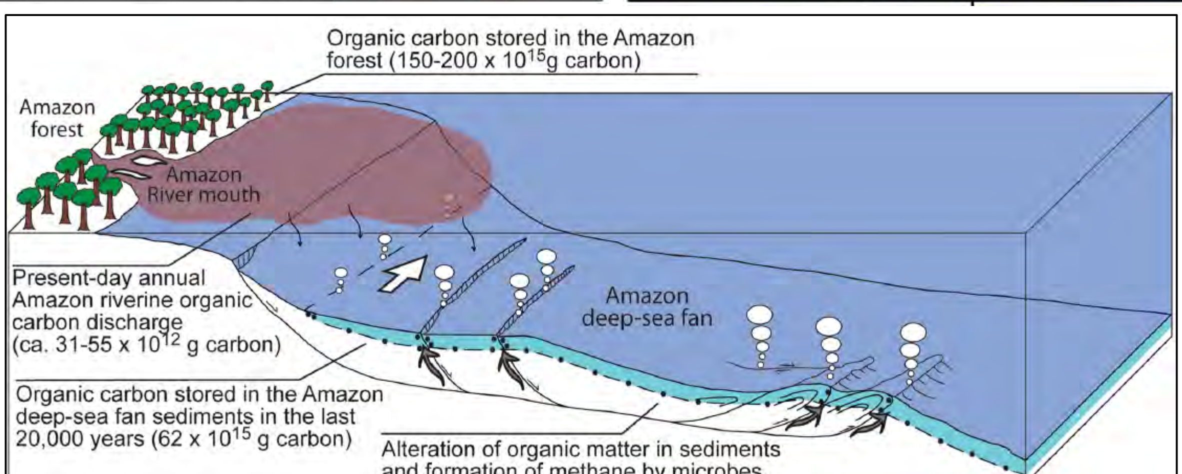
Gas seeps and gas hydrates in the Amazon deep-sea fan

Joao Marcelo Ketzer[1,2] · Adolpho Augustin[1] · Luiz Frederico Rodrigues[1] · Rafael Oliveira[1] · Daniel Praeg[1,3] · Maria Alejandra Gomez Pivel[4] · Antonio Tadeu dos Reis[5] · Cleverson Silva[6] · Bruno Leonel[7]

Ketzer et al., 2018







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- ***IODP, EU and EFTA Countries***

  EU MIGRATE Project

  CAGE: Centre for Arctic Gas Hydrate, Environment and Climate; Tromsø Univ

  GEOMAR: GEOMAR Helmholtz Centre for Ocean Research Kiel

  MARUM: Center for Marine Environmental Sciences; University of Bremen

EU-EFTA

European Union and Other Major European Gas Hydrate Research Programs

CAGE: Centre for Arctic Gas Hydrate, Environment and Climate; Tromsø Univ

- CAGE marine expeditions (geophysics, seafloor coring, monitoring, etc.)
- IODP 935-Full: Pleistocene evolution of Arctic gas hydrates and fluid flow Systems – POLARIS; Fram Strait

GEOMAR: GEOMAR Helmholtz Centre for Ocean Research Kiel

- SUGAR: Submarine Gas Hydrate Reservoirs (SUGAR I-III 2008-2018)
- Core-Log-Seismic Integration Center - Helmholtz Centres: GEOMAR, AWI and GFZ

MARUM
Center for Marine Environnemental Sciences (MARUM); University of Bremen

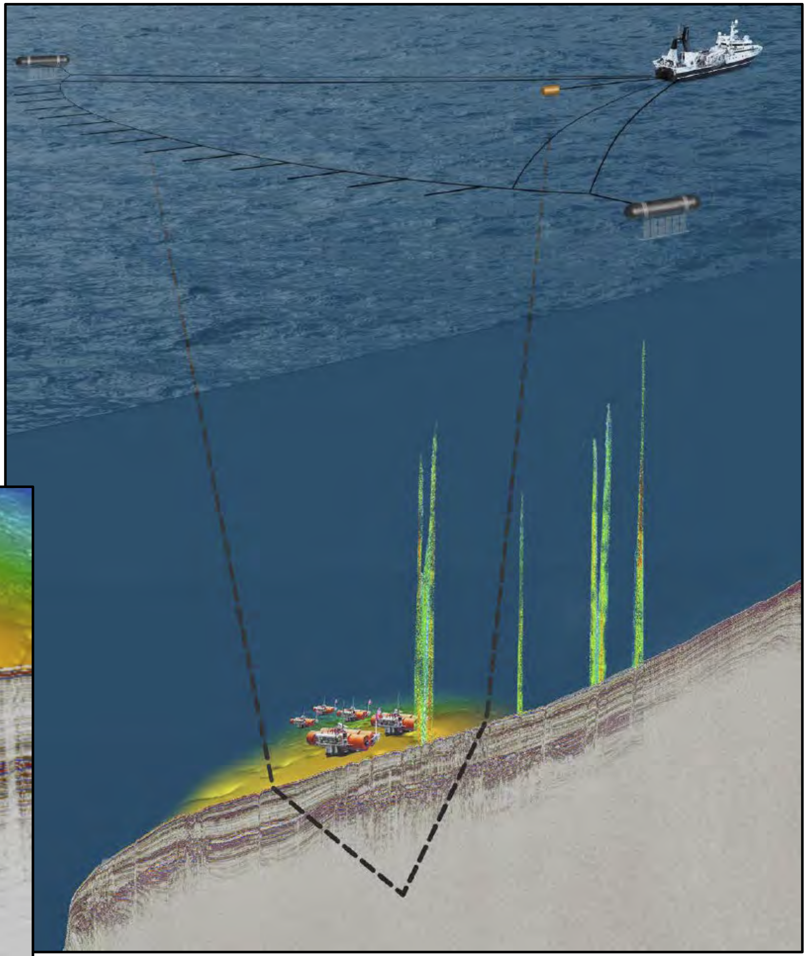
- MARUM (Bremen) – MeBo New Zealand (2016)
- MARUM/CAGE (U. Tromsø/Bremen) – MeBo Svalbard (2016)
- MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)
- MARUM/SUGAR(GEOMAR/U.Bremen) – MeBo Taiwan (2018)

CAGE: Centre for Arctic Gas Hydrate Environment and Climate

CAGE investigates methane release, a greenhouse gas far stronger than CO_2, from the Arctic seafloor. Vast amounts of methane are trapped at shallow depths below the seafloor as gas hydrates, ice-like mixtures of gas and water. Current ocean warming makes these shallow greenhouse gas reservoirs particularly vulnerable to thawing. CAGE investigates the implications of this to the Arctic climate and environment.

<u>CAGE Research Groups</u>

Gas hydrate and free gas reservoirs
The role of ice ages
Cold loving microbes in a warming Arctic
Gas in the water column
Methane seepage history
Methane, CO_2 and ocean acidification
Methane emissions to the atmosphere



Submarine Gas Hydrate Reservoirs
SUGAR

SUGAR I: August 2008 – July 2011
SUGAR II: August 2011 – July 2014
SUGAR III: October 2014 – March 2018

Phase III is focusing on characterizing the gas hydrate reservoir in the Black Sea (the Danube deep-sea fan), addressing relevant environmental challenges, and developing appropriate production scenarios and monitoring strategies. The goal of the project is to realize a field test which takes place in autumn 2018.

SUGAR Working Groups
WP1 - Geophysical Exploration und Data Processing
WP2 - Exploration Drilling Technique
WP3 - Natural Gas Production from Gas Hydrates
WP4 - Environmental Monitoring

SUGAR is funded by the Federal Ministry of Economy and Technology (BMWi) and the Federal Ministry of Education and Research (BMBF). Additional financial and R&D support is provided by the company RWE Dea AG. All participating SME partners finance 50% of their project budget.

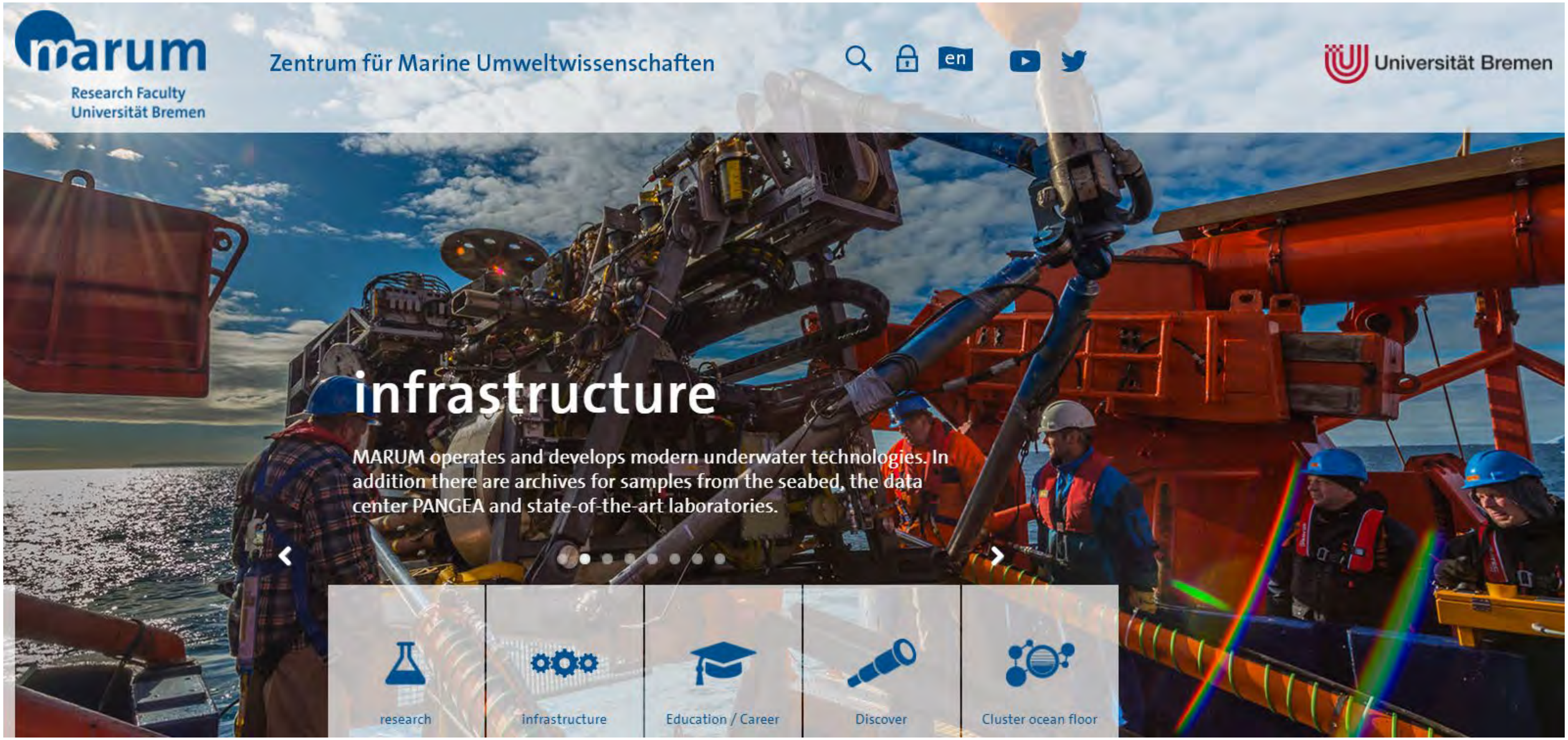
CORE LOG SEISMIC
INTEGRATION CENTER

Inaugural Workshop, April 15-16, 2021, GEOMAR Helmholtz Centre for Ocean Research Kiel

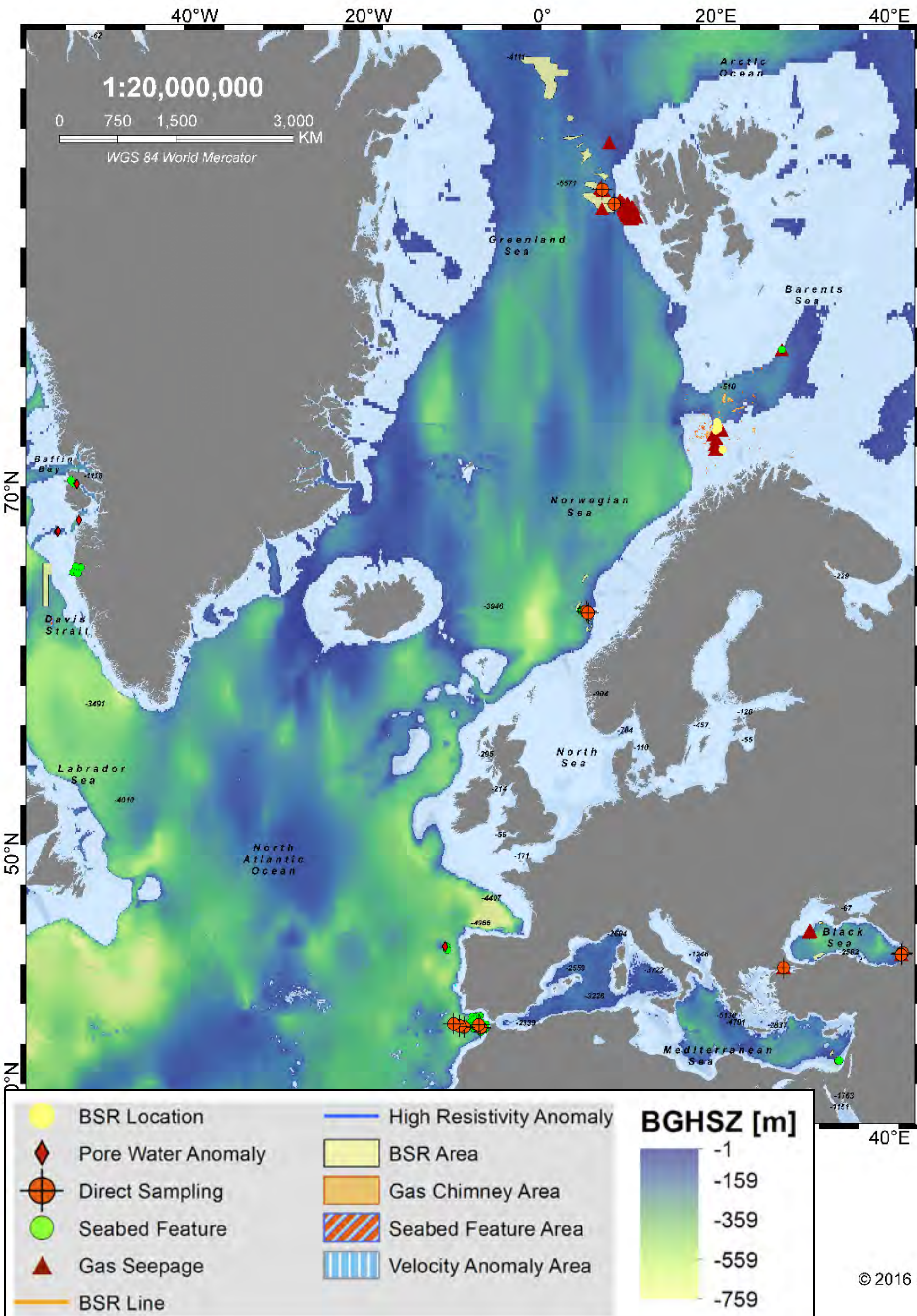
The Helmholtz research centres GEOMAR, AWI and GFZ are planning an inaugural workshop (April 15-16, 2021, at GEOMAR in Kiel) to open a new virtual research centre for core-log-seismic integration. ***Our vision is to establish a collaborative network of experts in the various fields of core-log-seismic integration, with the central aim of developing new research projects across academia and industry.***

Dr. Gareth Crutchley	Marine Geologist GEOMAR Helmholtz Centre for Ocean Research Kiel E: gcrutchley@geomar.de T: +49 (0) 431 600-2337
Prof. Christian Berndt	Professor of Marine Geophysics GEOMAR Helmholtz Centre for Ocean Research Kiel E: cberndt@geomar.de T: +49 431 600-2273
Dr. Ulrich Harms	Head of Scientific Drilling Working Group Helmholtz Research Centre for Geosciences (GFZ) Potsdam E: ulrich.harms@gfz-potsdam.de T: +49 331 288-1085
Dr. Karsten Gohl	Head of Geophysics Section Alfred Wegener Institute Helmholtz-Centre for Polar and Marine Research (AWI), Bremerhaven E: karsten.gohl@awi.de T: +49 471 4831-1361
Dr. Simona Pierdominici	Research Scientist Helmholtz Research Centre for Geosciences (GFZ) Potsdam E: simona.pierdominici@gfz-potsdam.de T: +49 331 288-1083

University of Bremen
Center for Marine Environmennental Sciences (MARUM)



MeBo Drilling/Coring Systems
MARUM (Bremen) – MeBo New Zealand (2016)
MARUM/CAGE (U. Tromsø/Bremen) – MeBo Svalbard (2016)
MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)
MARUM/SUGAR(GEOMAR/U.Bremen) – MeBo Taiwan (2018)



GAS HYDRATE DISTRIBUTION EUROPE

MIGRATE
marine gas hydrate

This map was developed as part of the COST-MIGRATE project "Marine gas hydrate - an indigenous resource of natural gas for Europe" The data was obtained from members of the MIGRATE project and scientific papers.

For further information regarding the COST-MIGRATE project please visit https://www.migrate-cost.eu.

This map was created by Adi Neuman (University of Haifa) with the collaboration of WG1 members. Please see the supporting file for detailed information.

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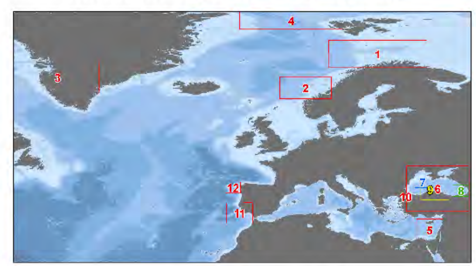
Addtional Maps for Gas Hydrate



Additional maps available in a larger scale. Map extent and index number are in red, blue, green and yellow.

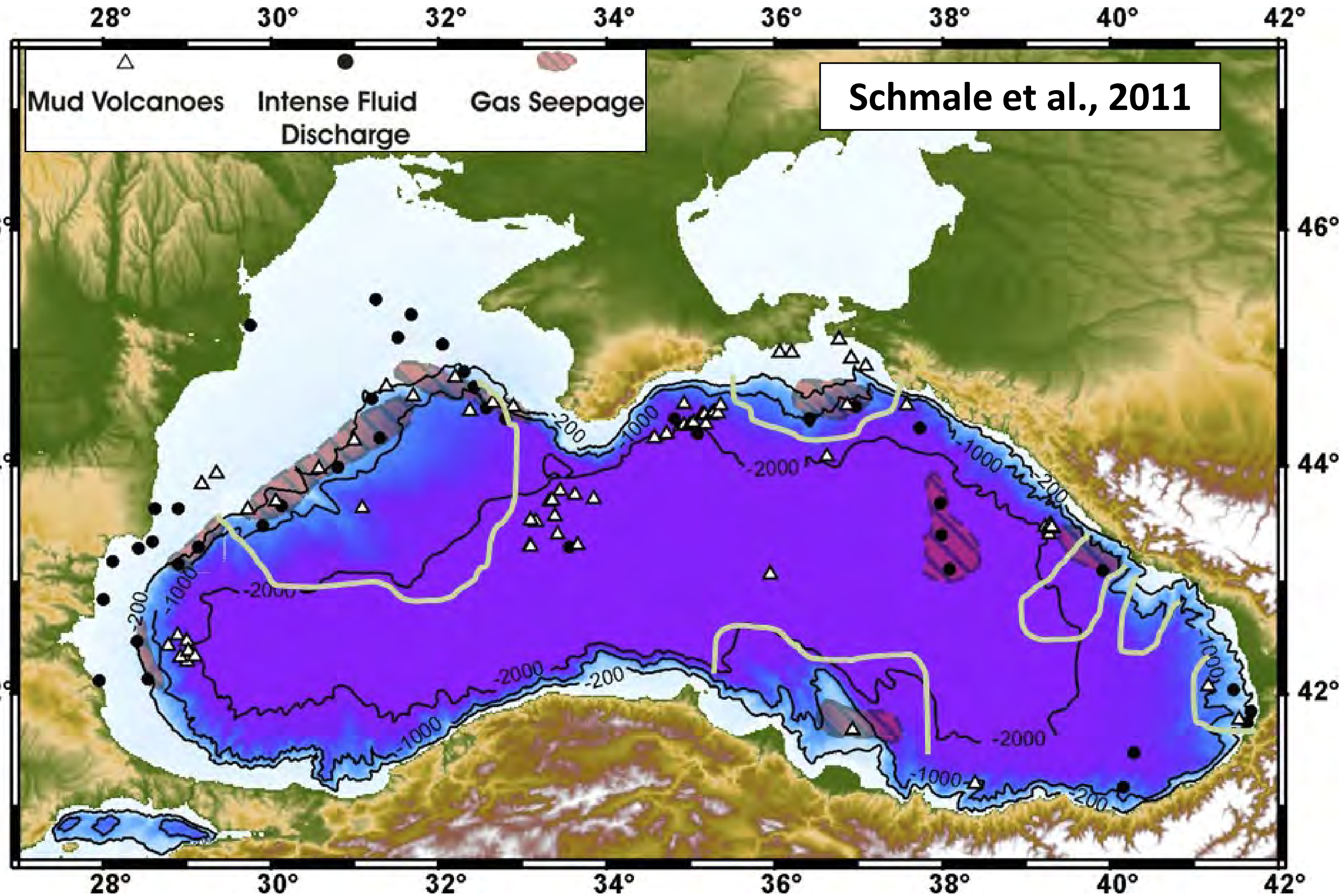
https://www.migrate-cost.eu/wg-1-resource-assessment

COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

European Gas Hydrate Occurrences

Black Sea

- Northwest Margin - Danube and Dniepr Fan (Romania-Bulgaria border)
- Offshore İğneada (Bulgaria)
- Zonguldak-Amasra and Samsun (Turkey)
- Hopa-Rize-Trabzon-Giresun (Turkey)

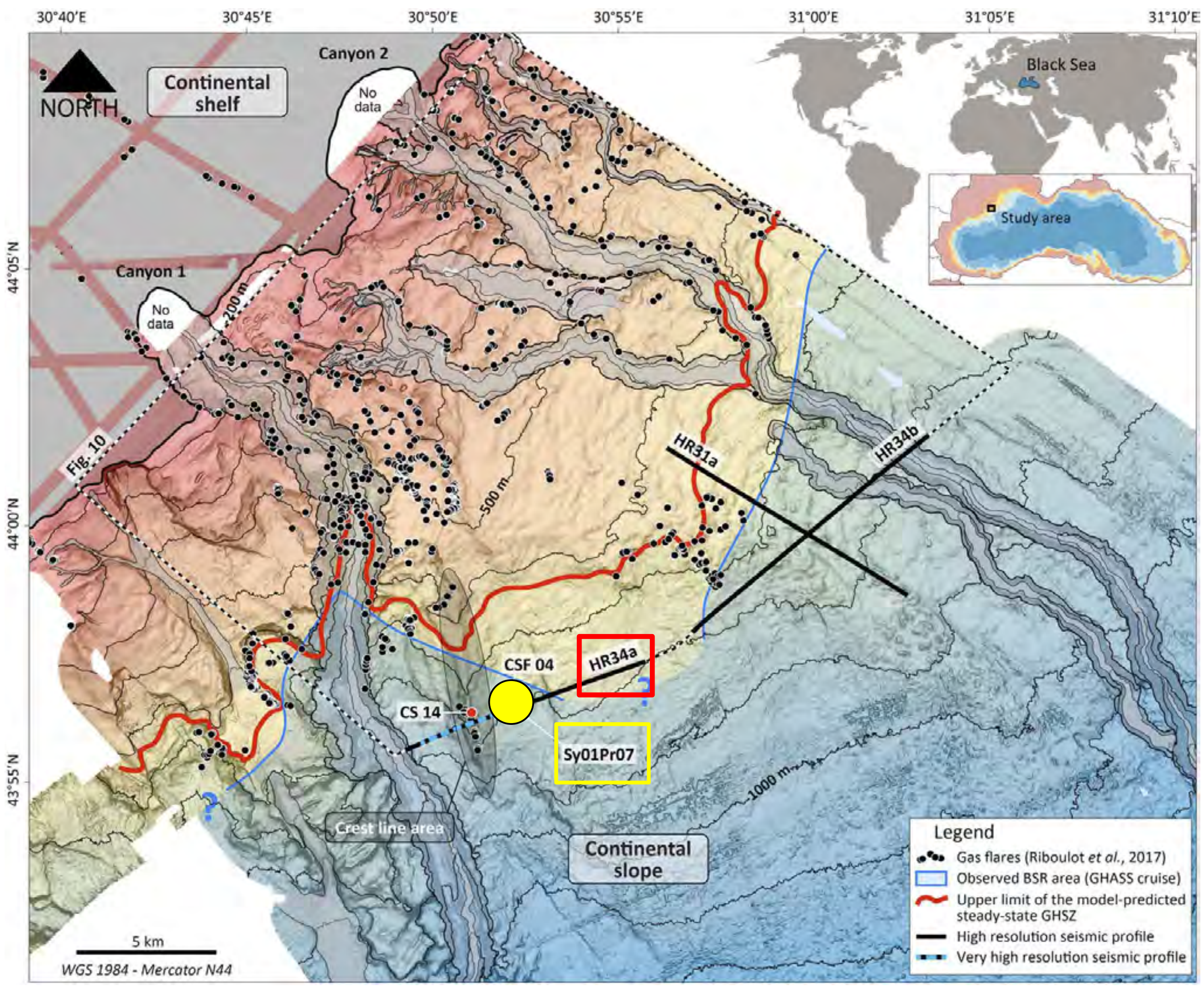


European Gas Hydrate Occurrences

Ker et al., 2019
Ifremer

Black Sea

The presence of gas hydrates in the Danube Fan, located in the western part of the Black Sea, is inferred from the identification of a hydrate related BSRs. Gas seeps and gas-related seismic evidences have been also reported in the Danube Fan.



European Gas Hydrate Occurrences

Black Sea

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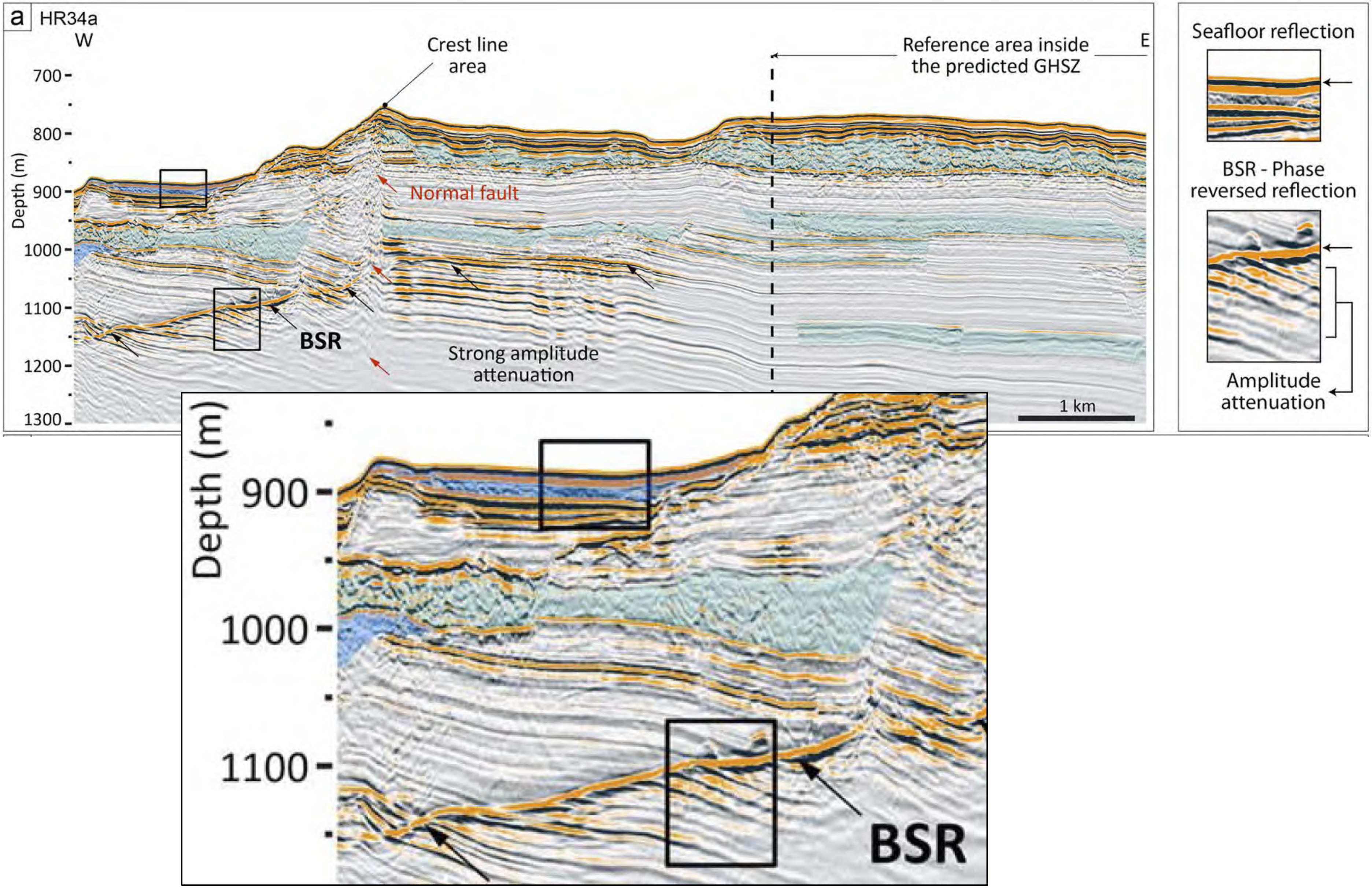
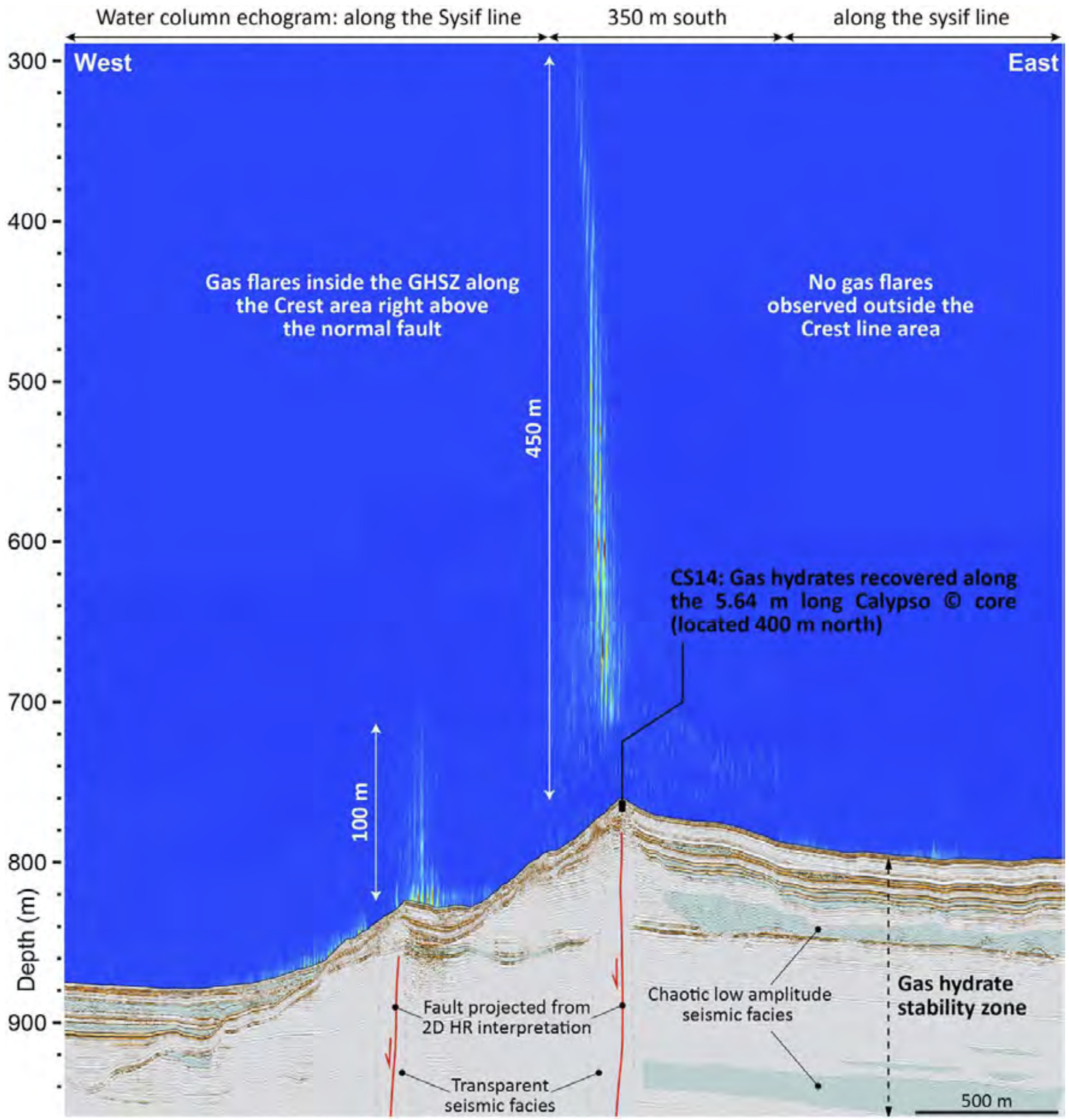


European Gas Hydrate Occurrences

Ker et al., 2019
Ifremer

Black Sea

Sysif line PL01PR07 shows the location of two gas flares.



Geochemical measurements performed on gas hydrate samples, which were collected for the first time in the Romanian sector of the Black Sea, confirmed that the gas entrapped is biogenic methane with a concentration of 99.6% (Riboulot et al., 2018).

MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)

Center for Marine Environnemental Sciences (MARUM)

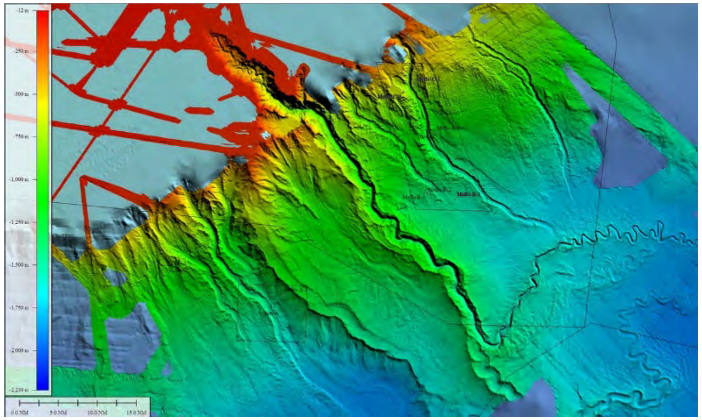
Submarine Gas Hydrate Reservoirs (SUGAR)

M142: R/V METEOR Cruise; 04.11.2017- 09.12.2017; Varna (Bulgaria) - Varna - Varna

Drilling gas hydrates in sandy channel deposits in the Danube deep-sea fan, Black Sea (Romanian and Bulgarian sector)

Objective

Within the framework of the joint research project SUGAR III, which is financed by BMWi and BMBF, the FS METEOR-cruise M142 will be carried out in the Danube deep-sea fan of the Black Sea. The primary objective of the proposed cruise is to drill into the gas hydrate accumulations in the Danube paleodelta with the mobile drilling device MeBo200 of MARUM. Based on geophysical data acquired on previous cruises, MSM 34 & 35, two working areas were selected, where (1) gas hydrates and free gas co-exist in the upper 50-150 m of the gas hydrate stability zone, and (2) sediment slumping and gas seepage occur above the upward-bending base of the gas hydrate stability zone.



https://www.marum.de/en/Research/M142.html

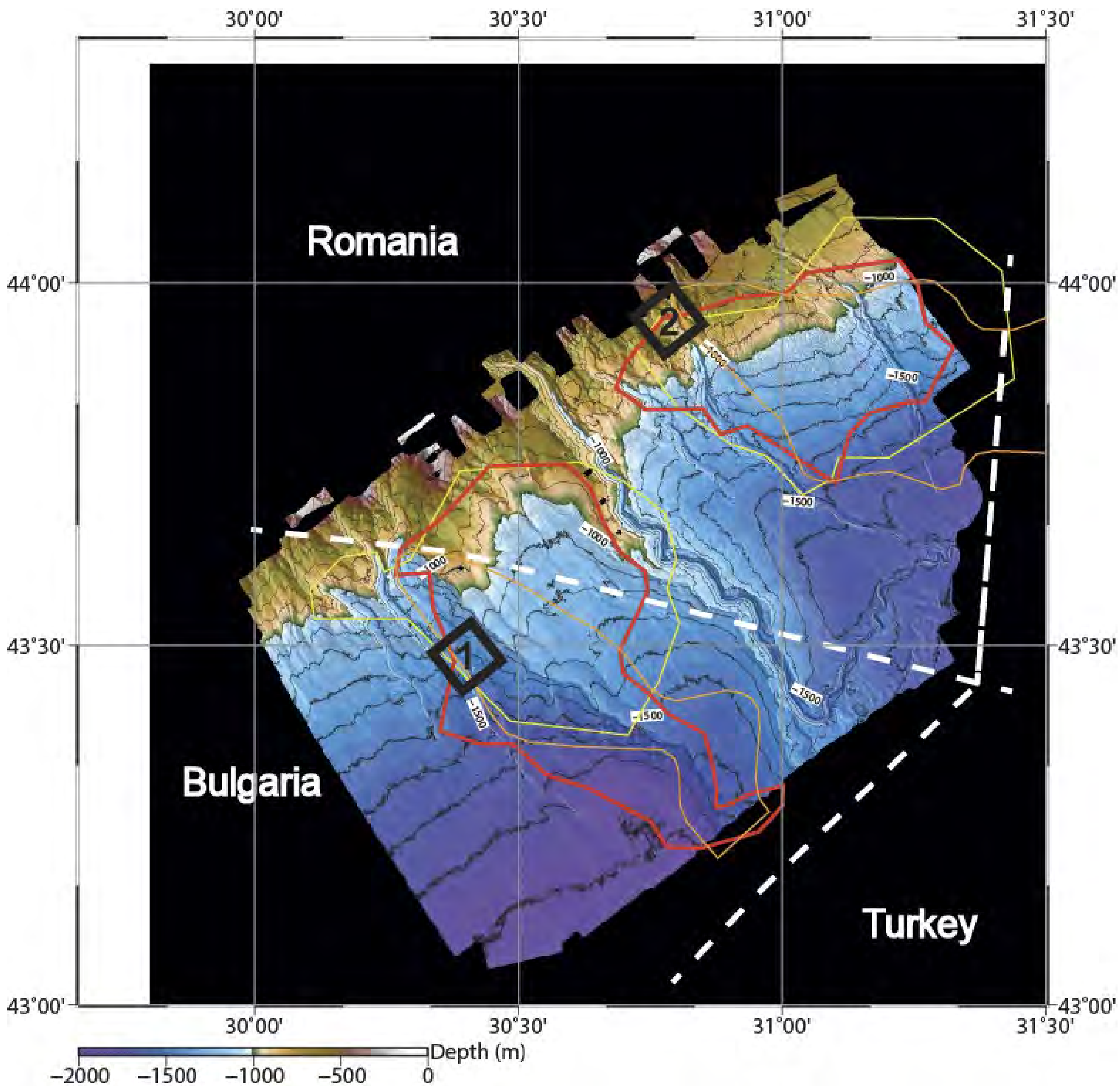
MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)

Center for Marine Environnemental Sciences (MARUM)

Submarine Gas Hydrate Reservoirs (SUGAR)

M142: R/V METEOR Cruise; 04.11.2017- 09.12.2017; Varna (Bulgaria) - Varna - Varna

Drilling gas hydrates in sandy channel deposits in the Danube deep-sea fan, Black Sea



Danube deep-sea fan indicating the proposed working areas 1 & 2, located in the Bulgarian and Romanian sector of the Black Sea.

However, all research activities were concentrated to the Romanian sector of the Black Sea.

MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)

Center for Marine Environnemental Sciences (MARUM)

Submarine Gas Hydrate Reservoirs (SUGAR)

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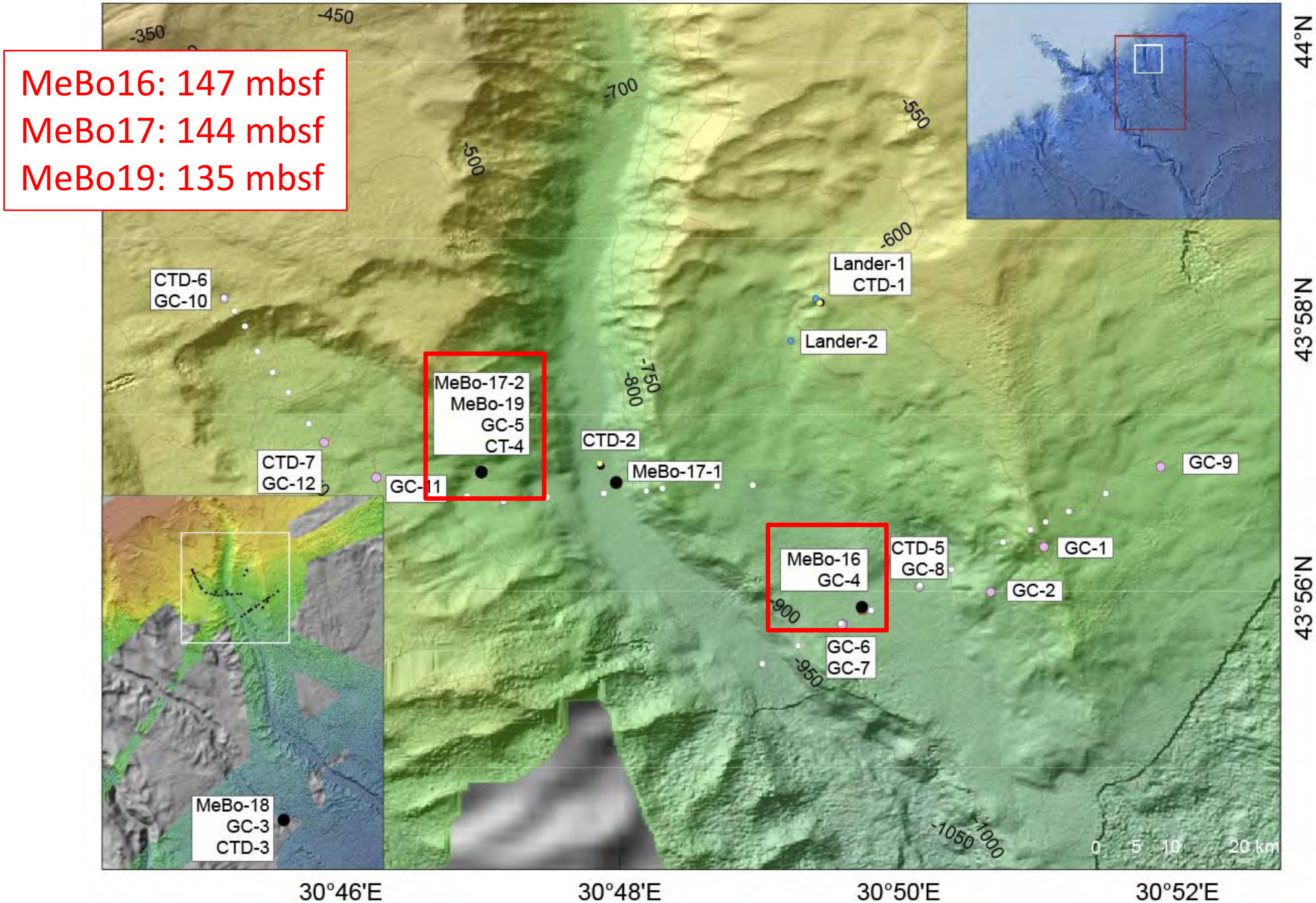
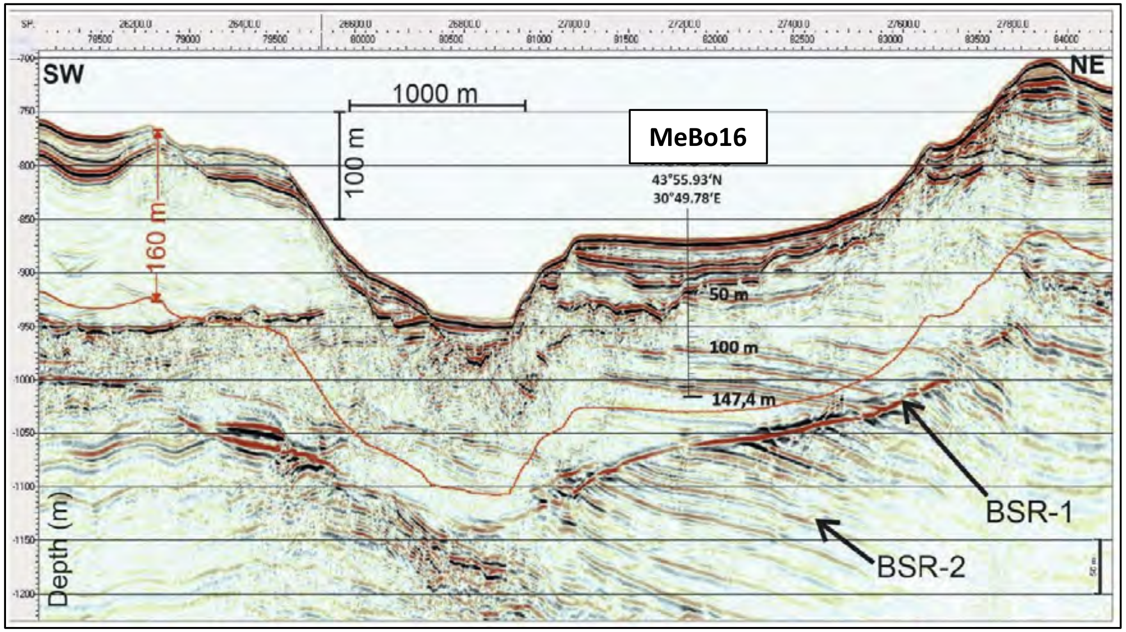
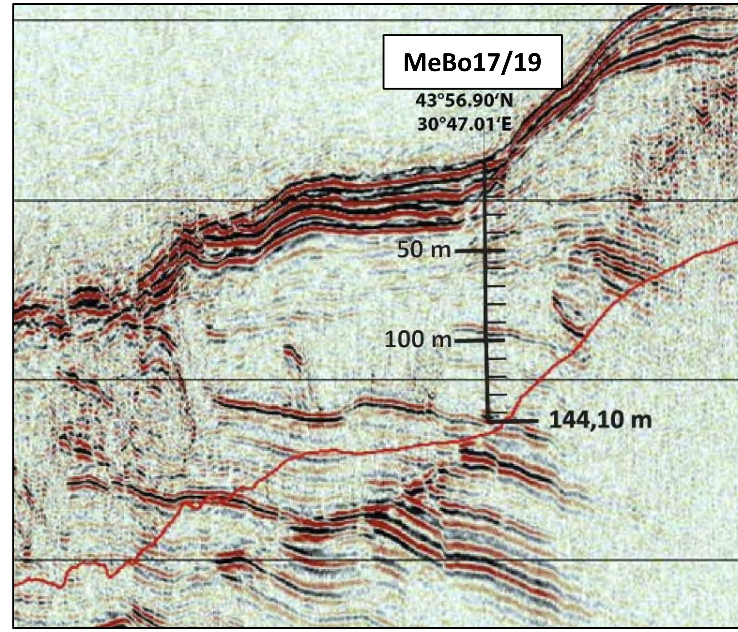


MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)





GeoB No. Station	Deployment duration [hrs:min]	Latitude [N]	Longitude [E]	Water depth m	Drill depth m	Coring length m	Recovery	Tool deployments
22603-1 MeBo16	96:40	43°55.95	30°49.75	860	147.4	147.3	124,9 m 85%	
22605-1 MeBo17	95:29	43°56.90	30°47.01	765	144.1	123.2	103,2 m 84%	SGR, Acoustic T, Pressure core barrels
22609-2 MeBo18	21:30	43°52.83	30°52.67	1400	17.9	7.2	4,5 m 63%	T
22620-1 MeBo19	58:15	43°56,90	30°47,01	780	134.7	46.8	34,3 m 73%	SGR; DI Pressure core barrels

MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)

Station No.	Location	Neg. temp. anomalies	Observation
MeBo16	Eastern S2 canyon shoulder	No	Gas voids present through whole core.
MeBo17	Western S2 canyon shoulder	Yes	15 cm thick interval with ΔT = -1°C in core barrel 29 (81–87.8 m).
MeBo19	MeBo17 site	Yes	Top 3 - 5 cm section of almost every liner with up to ΔT = -3°C. Core Barrel 07 and 15 contained further anomalies in the top 50 cm.

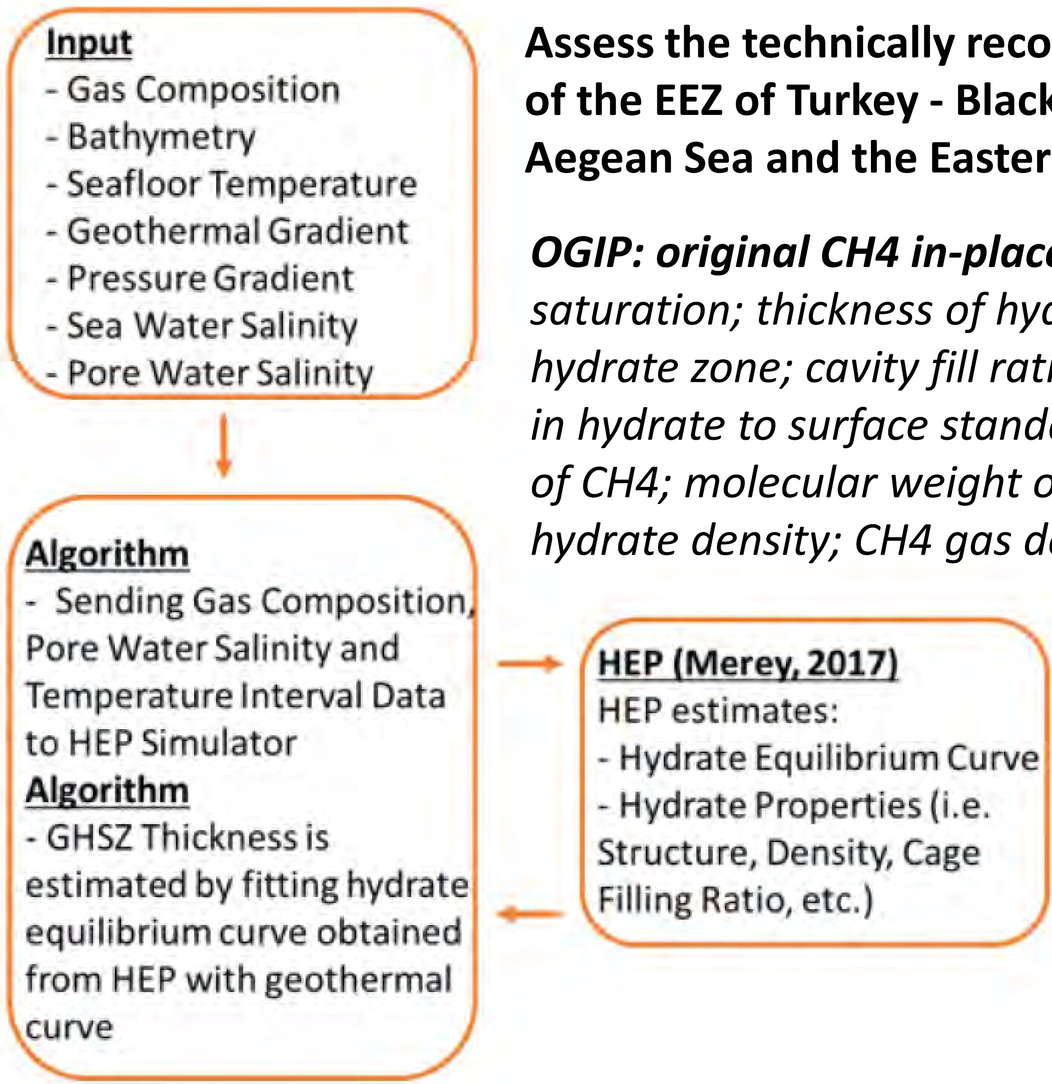
Station/ Device	GeoB No.	Area	Ex-situ con-centration of dissolved CH_4	Stable C and H isotopic composition of CH_4
MeBo16	22603-1	S2 canyon, E shoulder	40	74
MeBo17	22605-1	S2 canyon W slump	35	70

MeBo16: Gas voids have been observed in almost every core liner, which appeared as positive temperature anomalies. Besides this, no negative anomalies were present. The imaging process required almost 4 hours, resulting in smaller differences between voids and sediment over time or possible negative temperature anomalies.
MeBo17: A negative anomaly with ΔT = -1°C has been observed in core barrel 29 with a thickness of about 15 cm, which was seen as dissociated gas hydrate. The liner has been on deck for one hour before the IR imaging was conducted. Gas voids were present in nearly all of the cores with positive temperature anomalies.
MeBo19: Negative temperature anomalies up to ΔT = -3°C have been observed in the top 3 - 5 cm of most of the core liner, often together with soupy sediments. Core liner 7 and 15 appear with larger cold spot intervals: A temperature anomaly of ΔT = -1.5°C was measured in the intervals of 0 - 10 cm and 30 - 40 cm in core liner 7. Core liner 15 showed in addition to the top 3 - 5 cm anomaly a ΔT = -1.3°C in the interval of 30 - 45 cm.

Technically recoverable methane hydrate potential of the marine regions in the exclusive economic zones of Turkey (2020)

IV INTERNATIONAL SCIENTIFIC AND TECHNICAL CONFERENCE – GAS HYDRATE TECHNOLOGIES: GLOBAL TRENDS, CHALLENGES AND HORIZONS, NOVEMBER 11-13, 2020, DNIPRO, UKRAINE

Sukru Merey, Batman University



Assess the technically recoverable methane hydrate potential of the EEZ of Turkey - Black Sea, the Sea of Marmara, the Aegean Sea and the Eastern Mediterranean Sea

OGIP: original CH4 in-place in hydrates *= porosity; hydrate saturation; thickness of hydrate zone; cross-sectional area of hydrate zone; cavity fill ratio of CH4; Expansion factor of CH4 in hydrate to surface standard conditions; molecular weight of CH4; molecular weight of H2O, Hydration number; CH4 hydrate density; CH4 gas density at standard conditions*

Technically recoverable methane hydrate potential of the marine regions in the exclusive economic zones of Turkey (2020)

IV INTERNATIONAL SCIENTIFIC AND TECHNICAL CONFERENCE – GAS HYDRATE TECHNOLOGIES: GLOBAL TRENDS, CHALLENGES AND HORIZONS, NOVEMBER 11-13, 2020, DNIPRO, UKRAINE

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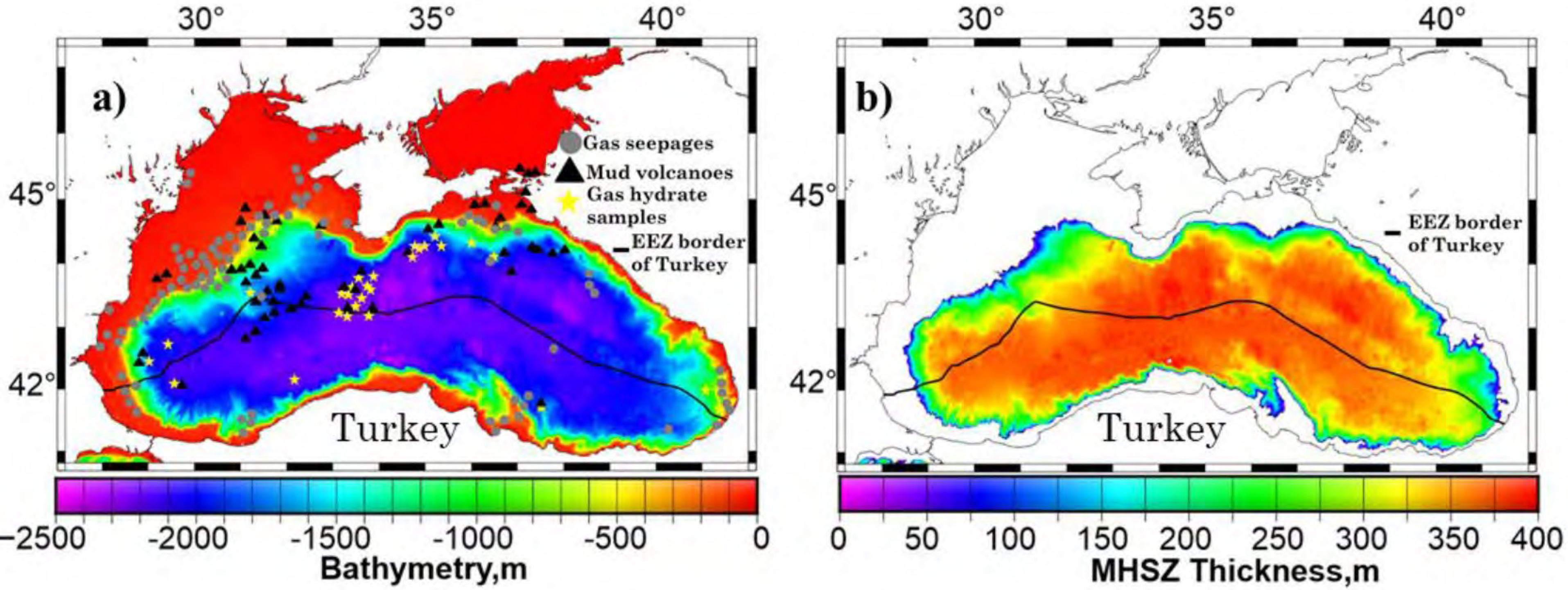
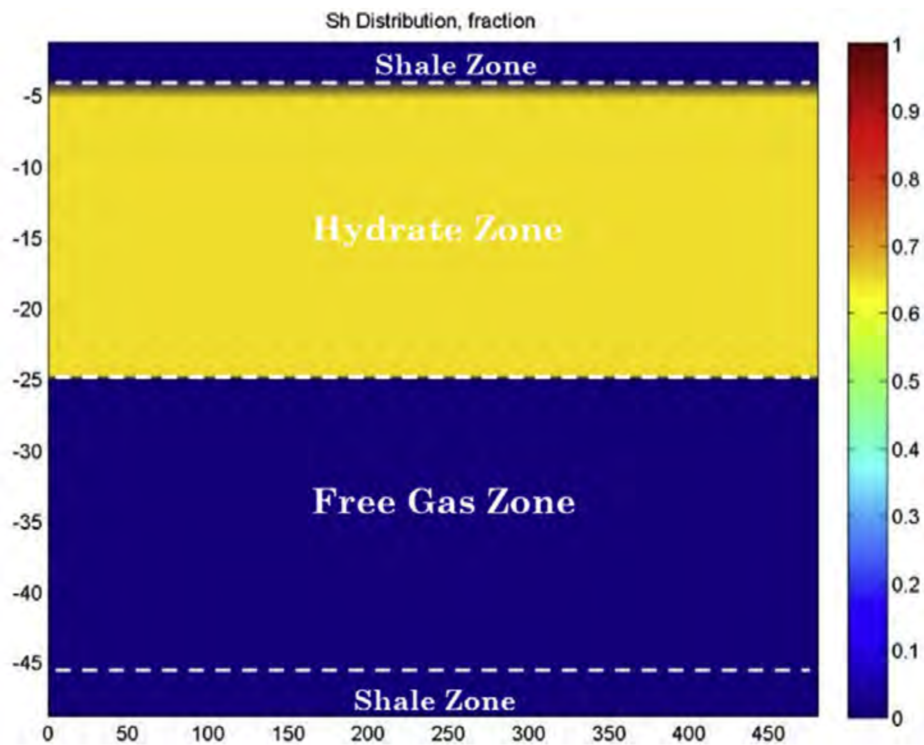
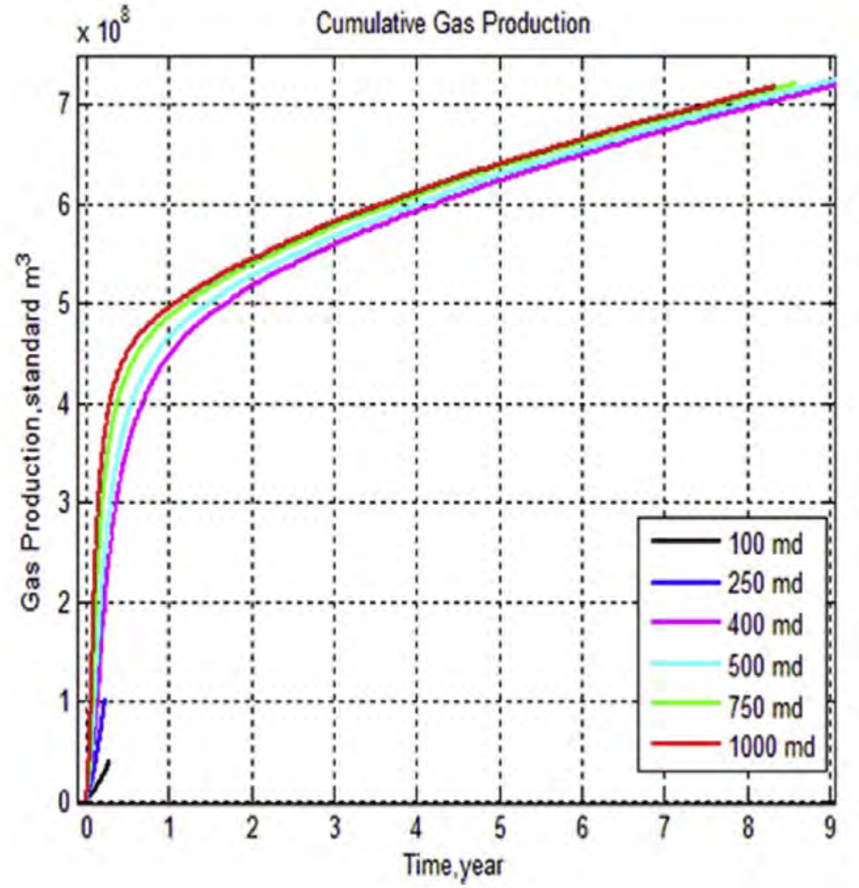


EEZ of Turkey in the Black Sea: The total expected methane in methane hydrates deposited inside all sediments is approximately 114.2 tcm (ranging from 3.73 to 411.55 tcm). The methane amount in methane hydrate-bearing sands (which are considered as technically recoverable gas hydrates) in the EEZ of Turkey in the Black Sea was found as 4.63 tcm (varying from 0.114 to 16.87 tcm).

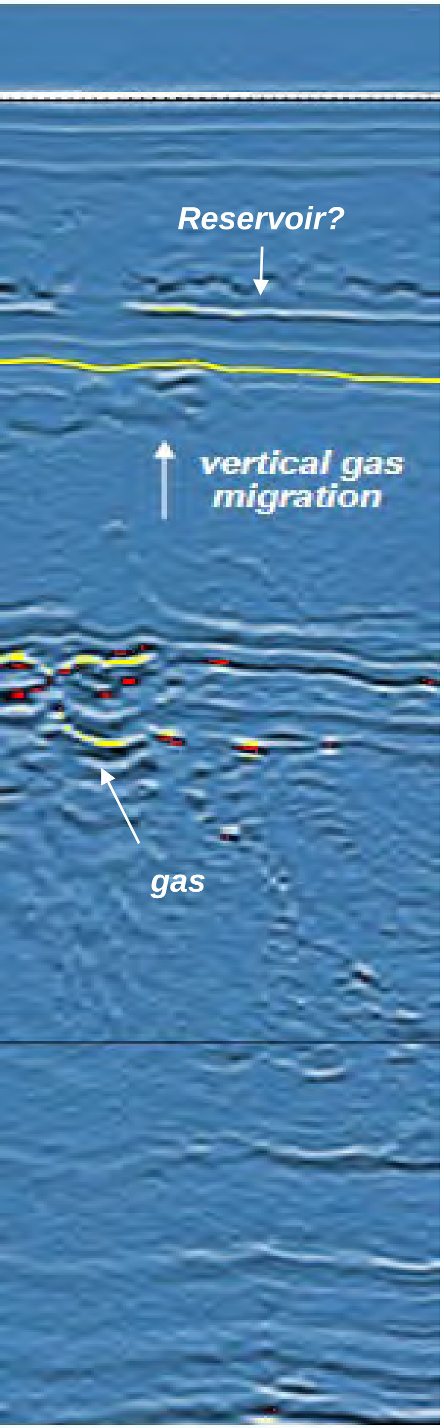
Investigation of Gas Hydrate Potential of the Black Sea and Modelling of Gas Production from a Hypothetical Class 1 Methane Hydrate Reservoir in the Black Sea Conditions *(2016)*

Sukru Merey and Caglar Sinayuc, Batman University





HydrateResSim numerical simulator, gas production potentials from a hypothetical Class 1 hydrate reservoir in the Black Sea conditions by depressurization (at different production pressures) and depressurization combined with wellbore heating were simulated.

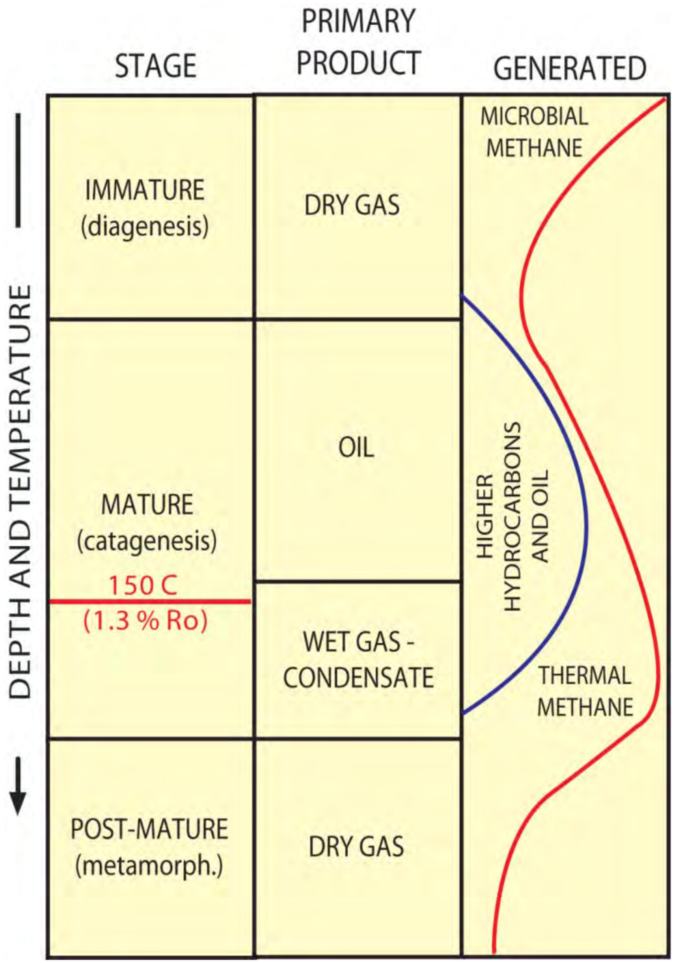


Gas Hydrate (Petroleum) System

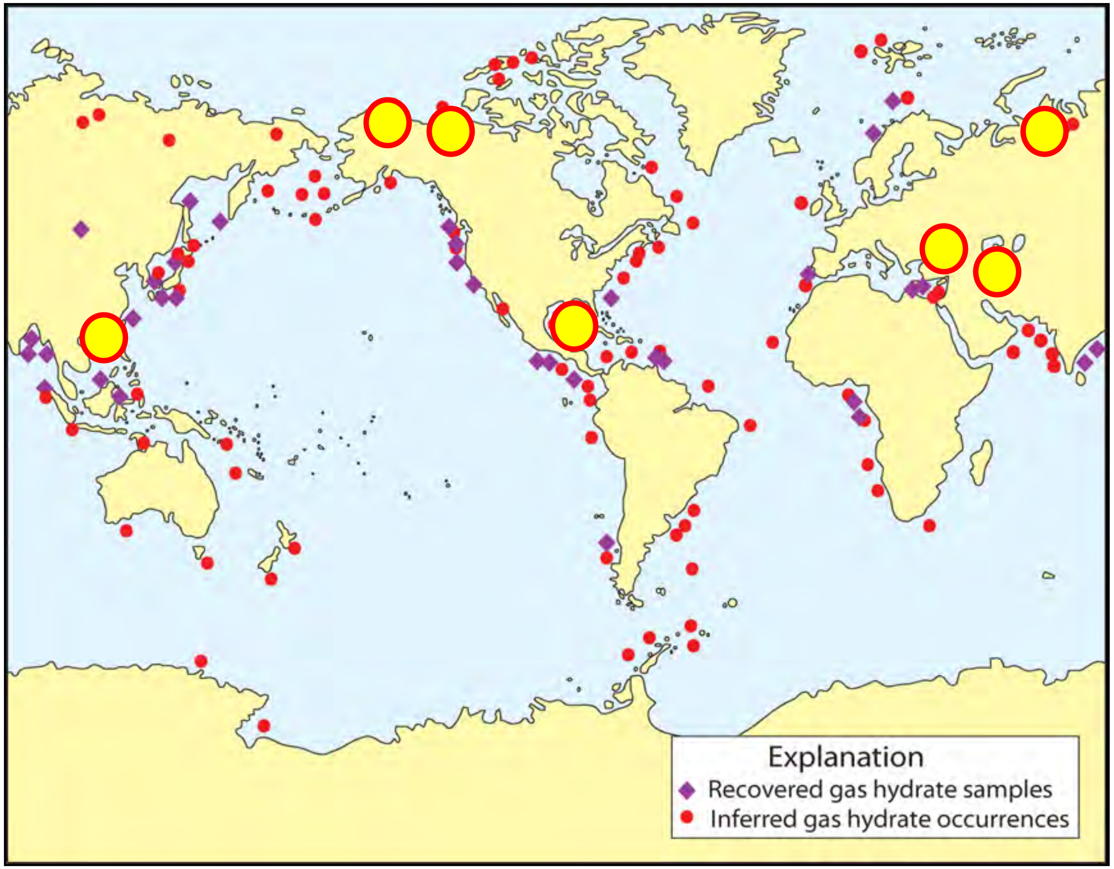
- **Extent of GH Stability Zone**
  - Formation temperature
  - Formation pressure
  - Pore water salinity
  - Gas chemistry
- **Gas Source and Migration - Charge**
  - Availability of gas and water (source)
  - Gas and water migration pathways
- **Reservoir**
  - Presence of reservoir rocks
  - Trap and seals

Gas Hydrate Petroleum System

-Gas Source and Migration-



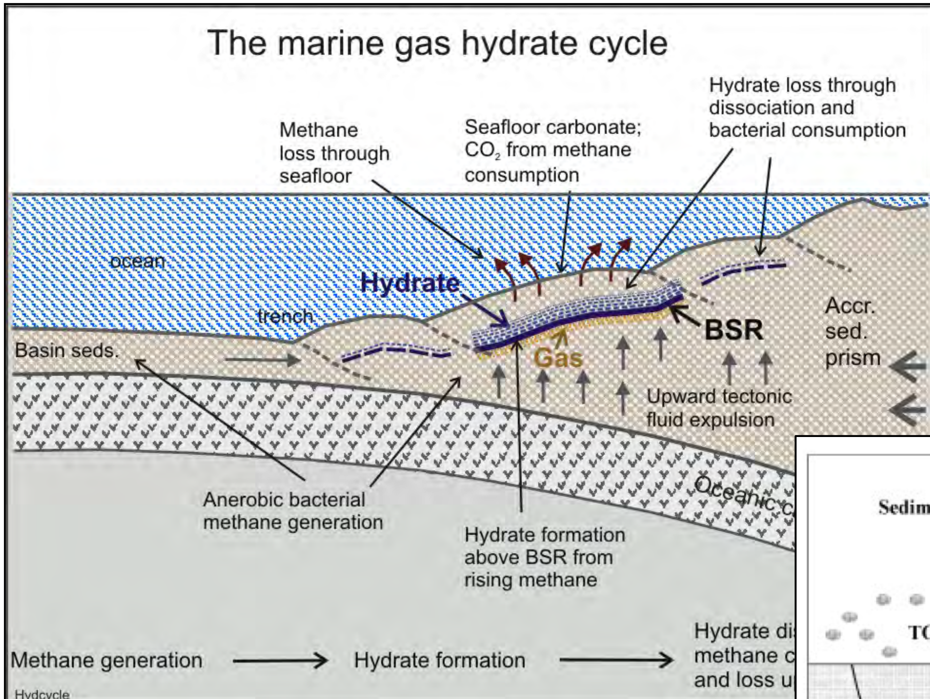
THERMOGENIC SOURCED GAS HYDRATES



Microbial vs. Thermogenic Gas Systems

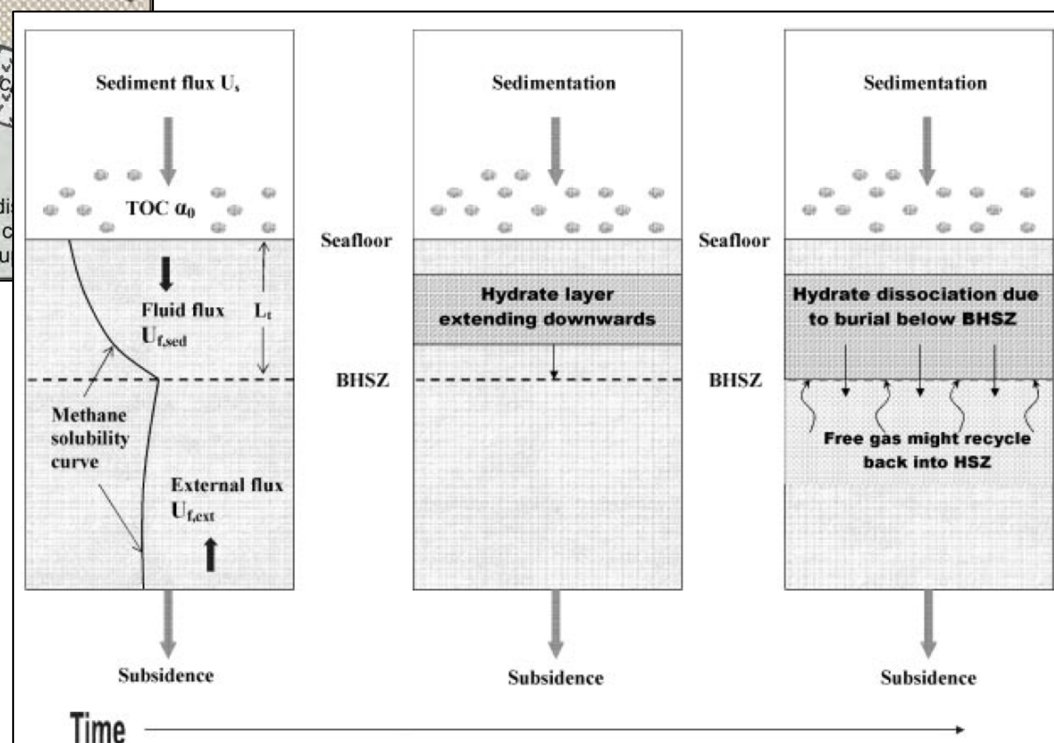
Gas Hydrate Petroleum System

-Evolution Through Time-



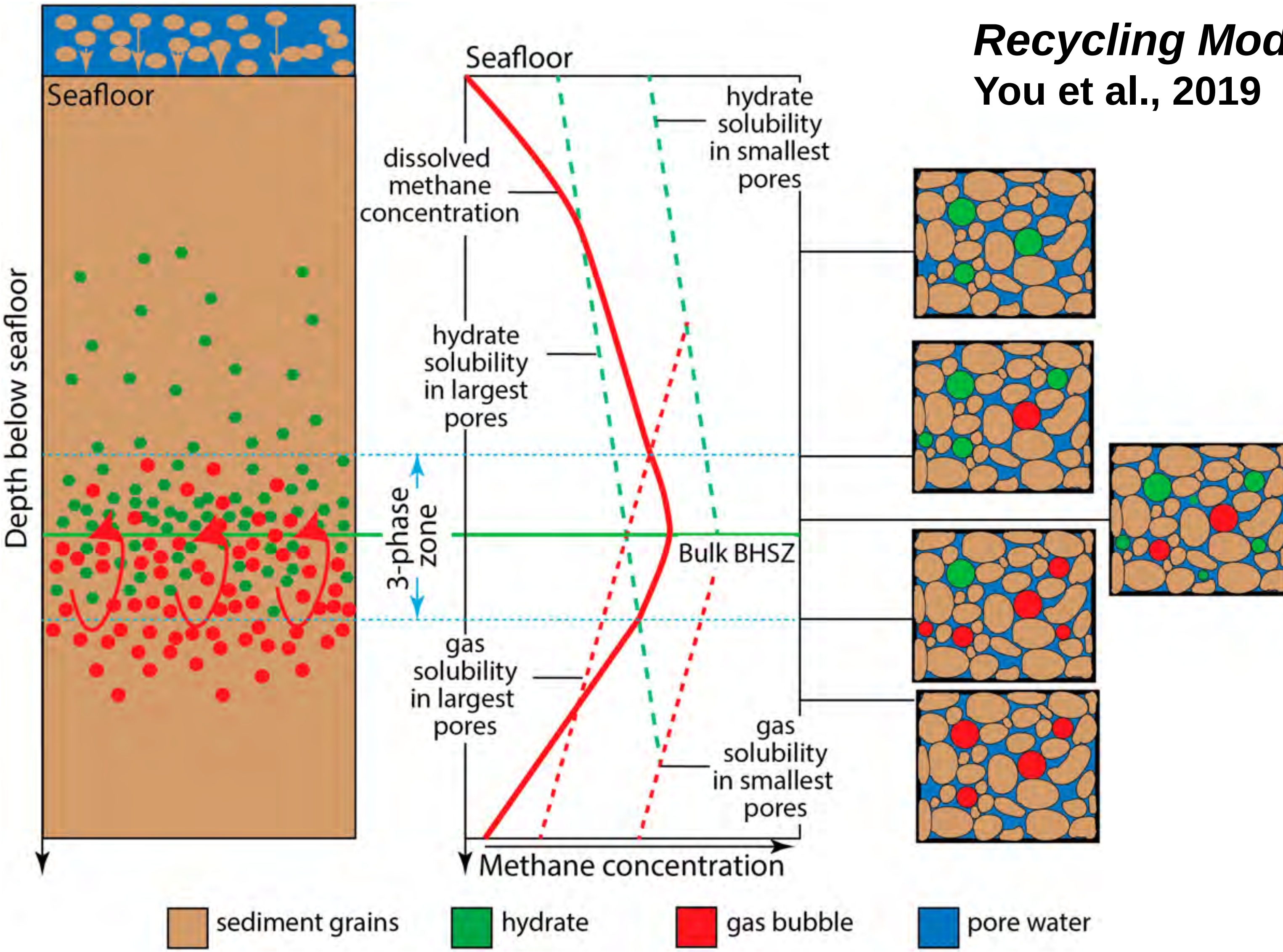
Solubility Driven Diffusion Model
Hyndman and Davis, 1992

Recycling Model
Modified from Paull, 1996

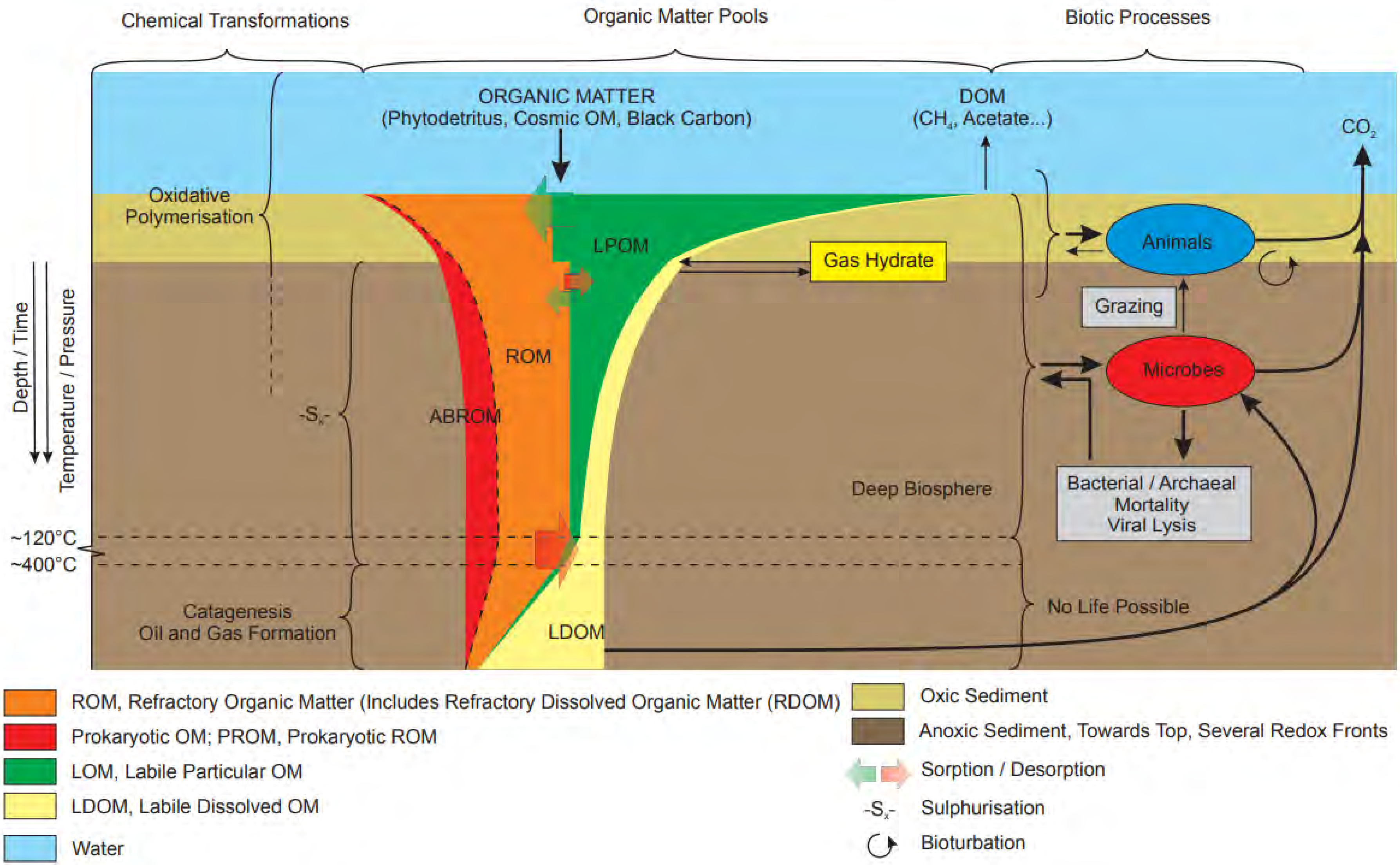


Gas Hydrate Petroleum System
-Evolution Through Time-

Recycling Model
You et al., 2019



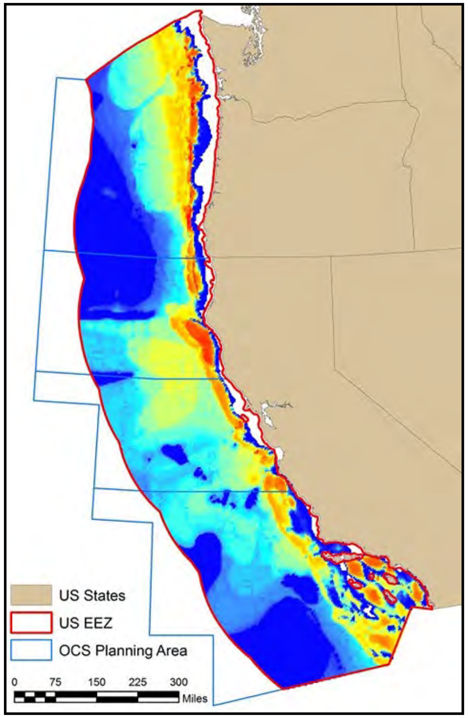
Biogenic Gas Generation

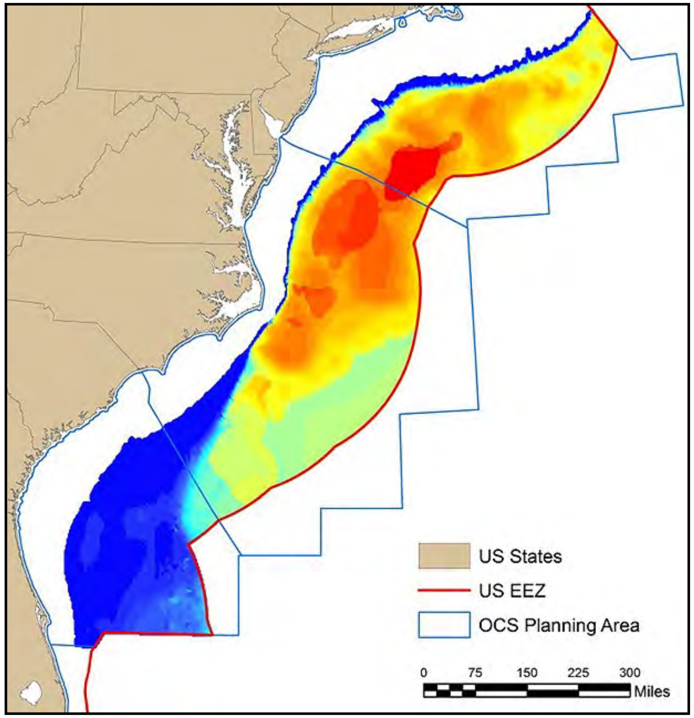


Degradation and transformation of organic matter (OM) in sediments

In-Place Gas Hydrate Resources of the Lower 48 United States Outer Continental Shelf

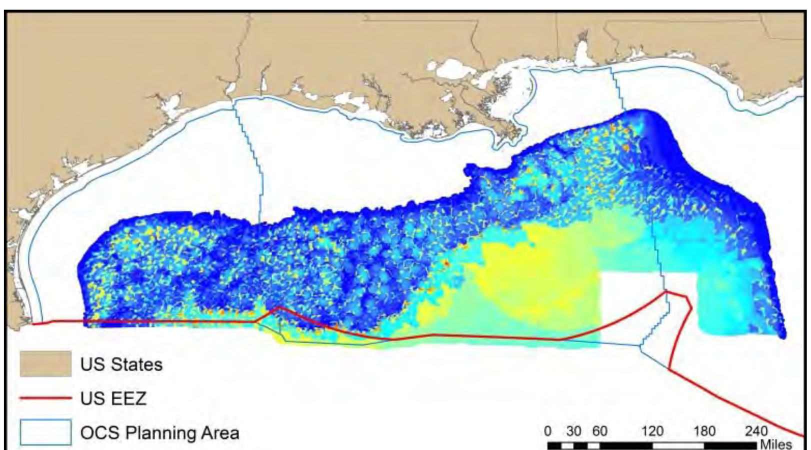
Bureau of Ocean Energy Management (BOEM)





Mean in-place gas hydrate resource volume for the Gulf of Mexico, Atlantic, and Pacific OCS

BOEM
BUREAU OF OCEAN ENERGY MANAGEMENT



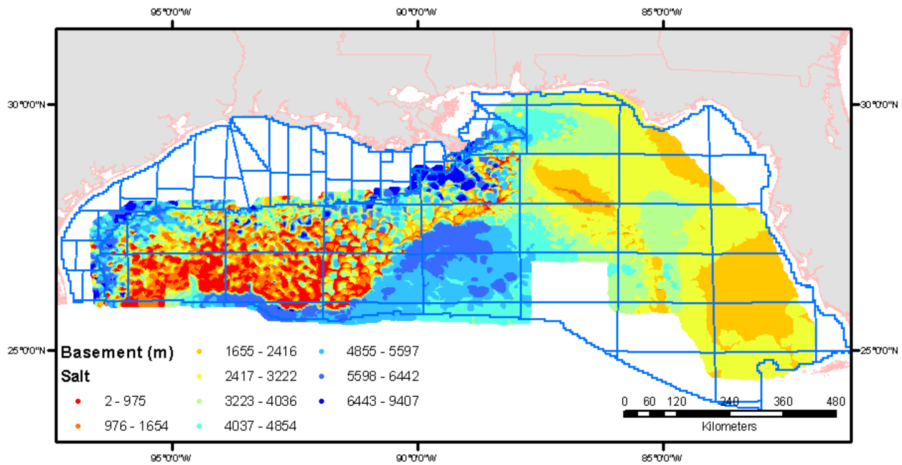
Region	In-Place Gas Hydrate Resources Gas (Tcfg)		
	95%	Mean	5%
Atlantic OCS	2,056	21,702	52,401
Pacific OCS	2,209	8,192	16,846
Gulf of Mexico OCS	11,112	21,444	34,423

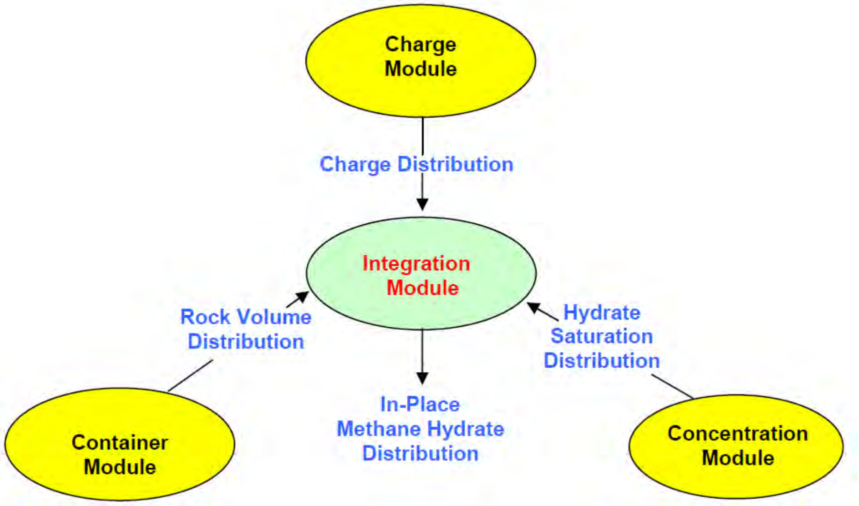
Gas Hydrate Resource Evaluation

Map-based inputs (for example):
bathymetry, sand %,
depth to salt, surficial anomalies

Empirical data draw:
Stratigraphic thickness
Geothermal gradient
Conversion efficiency
Gas composition
Temperature
TOC

Modules:
Container (HSZ thick, sed type)
Concentration (Sh)
Charge (generation, migration)
Integration



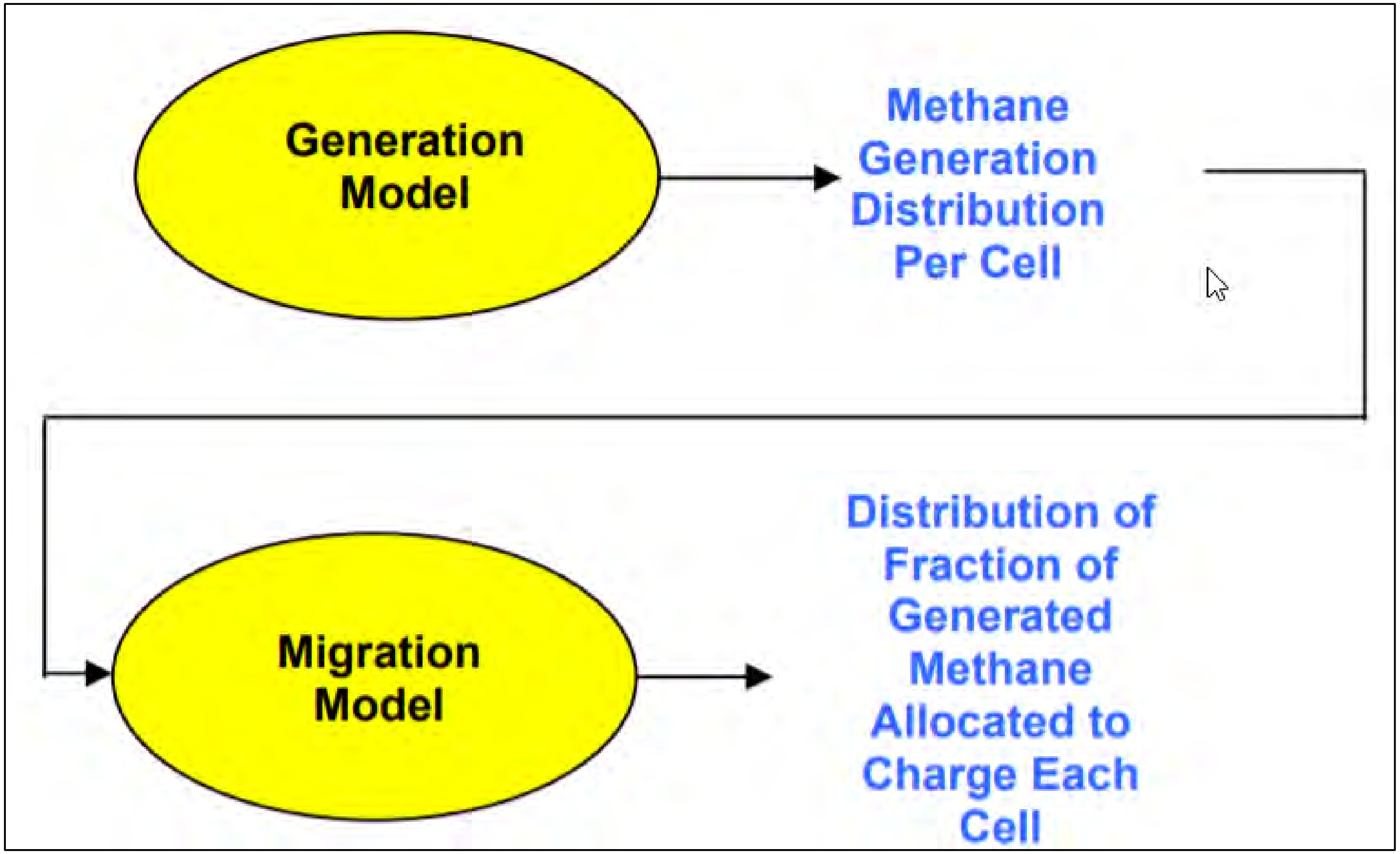


MMS Report 2008-004
Preliminary Evaluation of In-Place Gas Hydrate Resources: Gulf of Mexico Outer Continental Shelf. MMS Report 2008-004

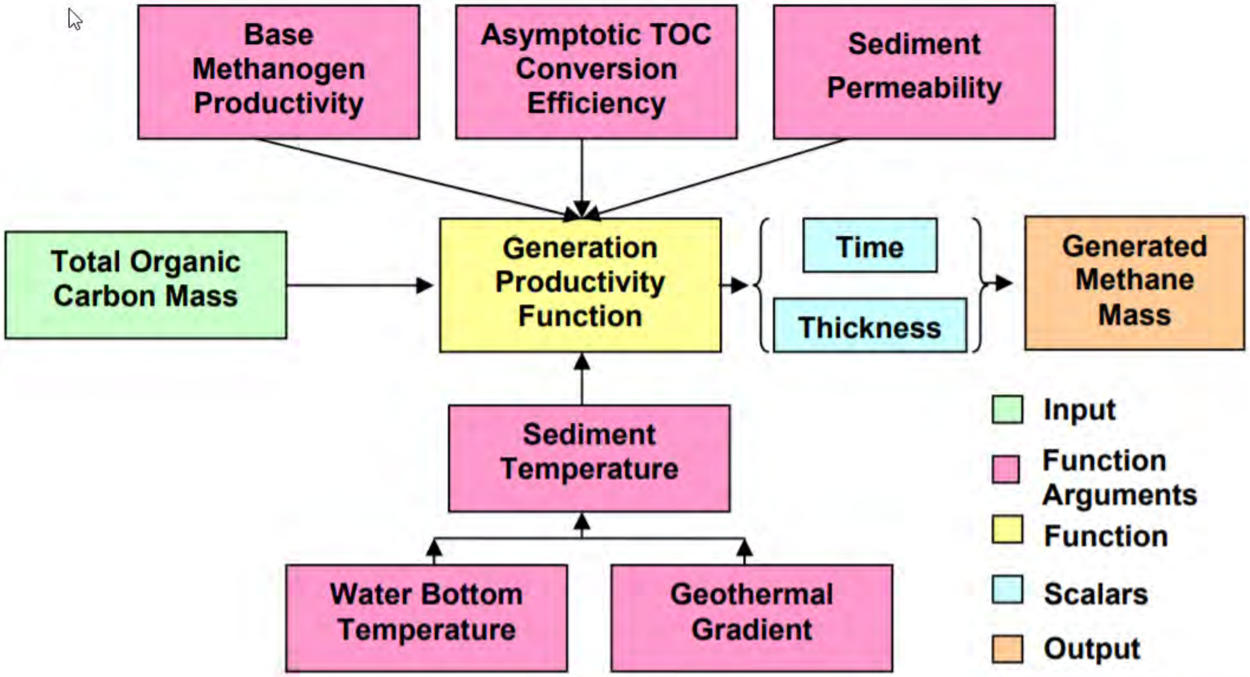
Assessment Modules

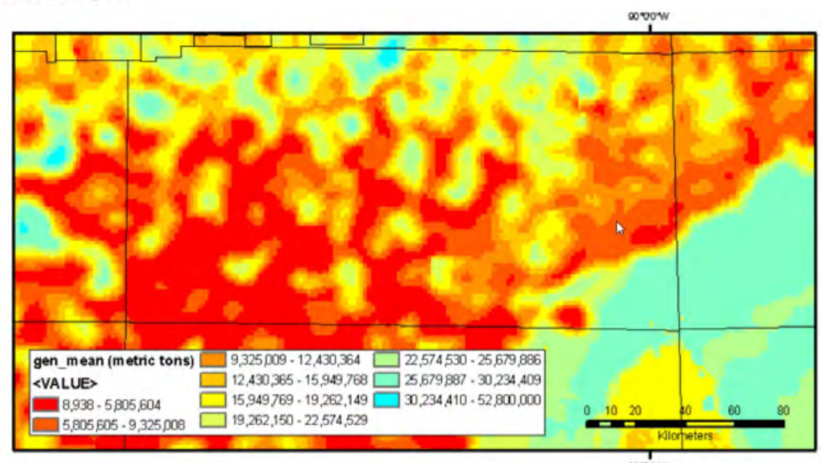
1. Container: The container module determines the bulk volume of rock that can contain hydrates.
2. Concentration: The concentration module provides a probability distribution of volume of hydrates per unit of bulk rock volume in the net HSZ.
3. Charge: The charge module contains a generation model and a migration model. A Monte Carlo trial of the generation model produces the amount of biogenic methane produced in each cell at that trial. The migration model aggregates generation into hydrodynamic catchment areas and then spatially redistributes a fraction of the catchment's generated gas at that trial to each cell within it.
4. Integration: At each Monte Carlo trial, the charge module's output and the volume of candidate void space generated by the container and concentration modules are compared (1,000 trials).

Charge Module



Charge Module – Biogenic Generation

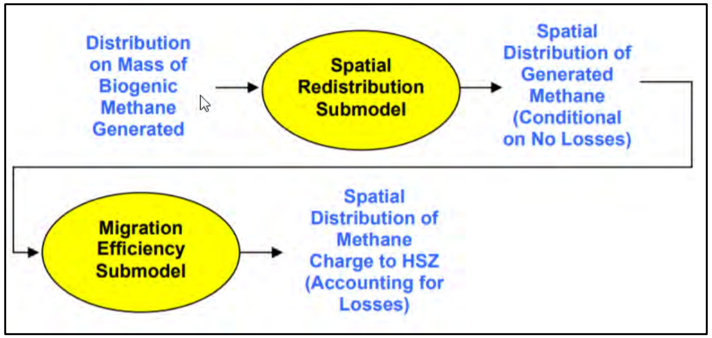


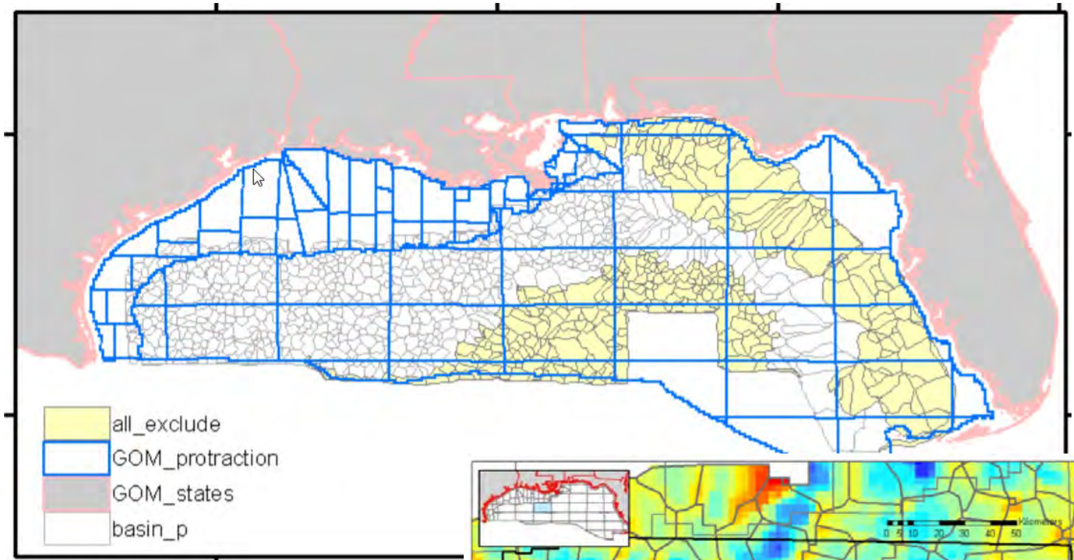


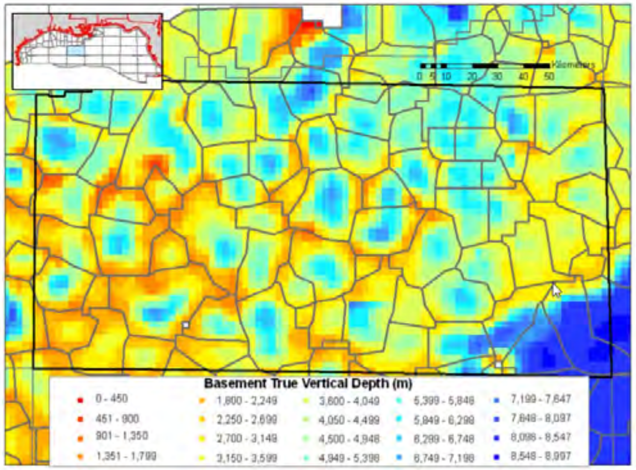
Mean volume of generated biogenic methane in GC

Charge Module – Gas Migration

1. No lateral movement. In this case 100 percent of migration is completely vertical kin that cell.
2. 100 percent of the generated gas is available for lateral migration out of the cell where it is generated. The directions and magnitudes of gas transport are completely controlled by a function of stratal dip.



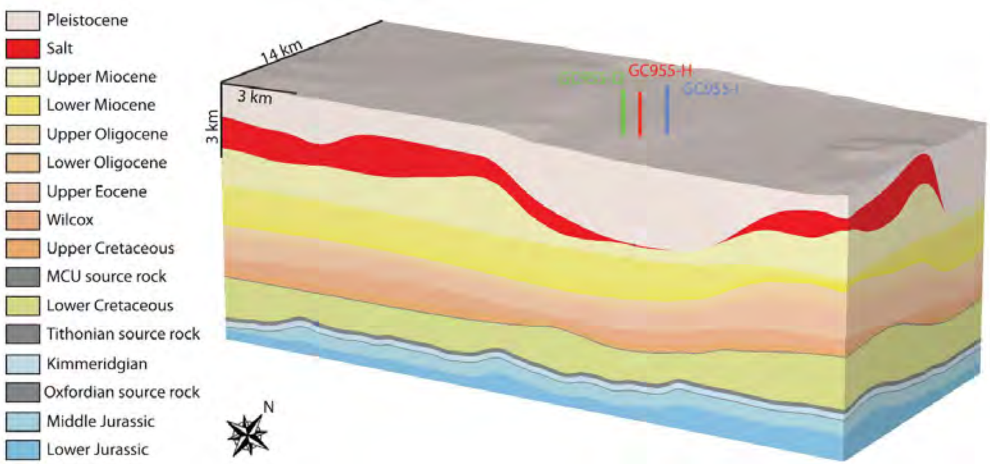




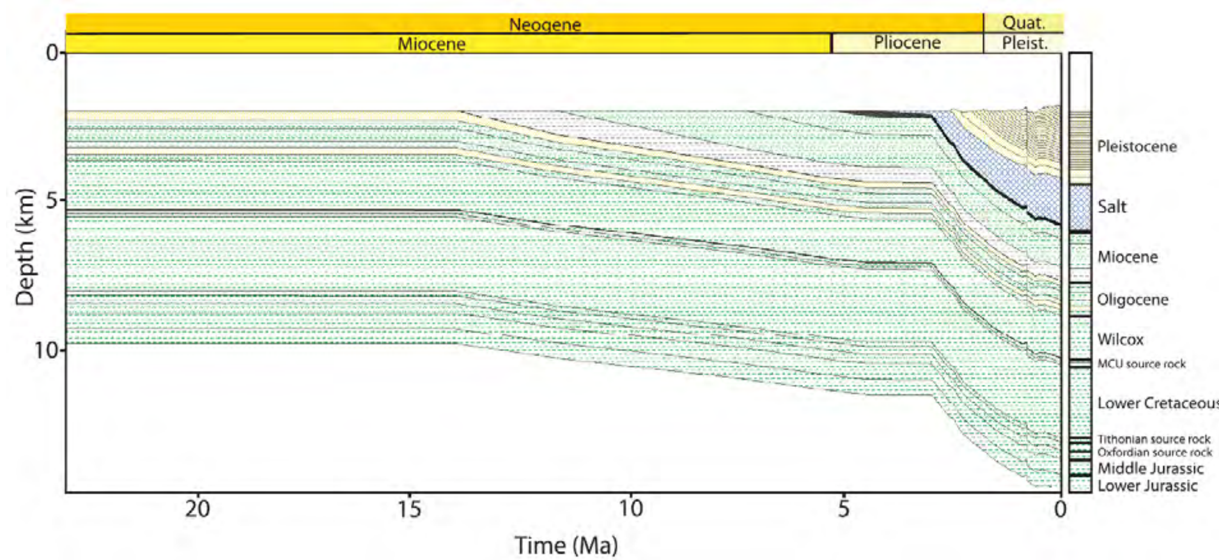
Catchment basins used to analyze the migration of gas in the basin

3-D Basin-Scale Reconstruction of Natural Gas Hydrate System of the Green Canyon, Gulf of Mexico – Ewa Burwicz et al. (2017)

PetroMod reconstruction, accounting for depositional and transient thermal history of the basin, source rock maturation, petroleum components generation, expulsion and migration, salt tectonics, and associated multistage fault development; which yielded a 3-D gas hydrate distribution in the Green Canyon area.



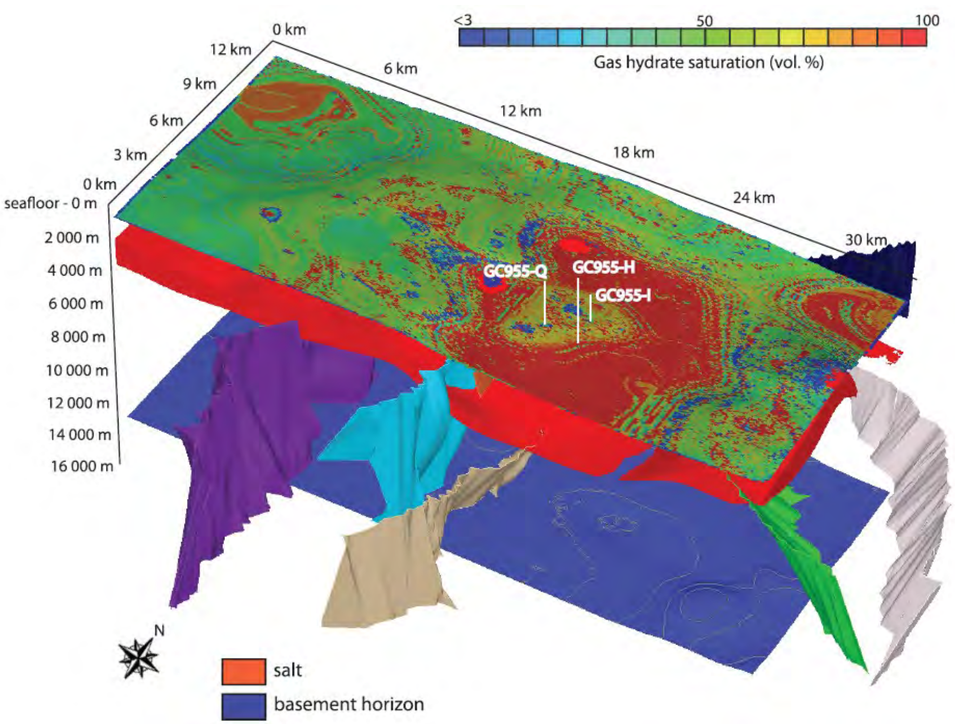
Large amounts of gas hydrates located in the deepest parts of the basin dissociate and the released free methane gas migrates upward to recharge the GHSZ

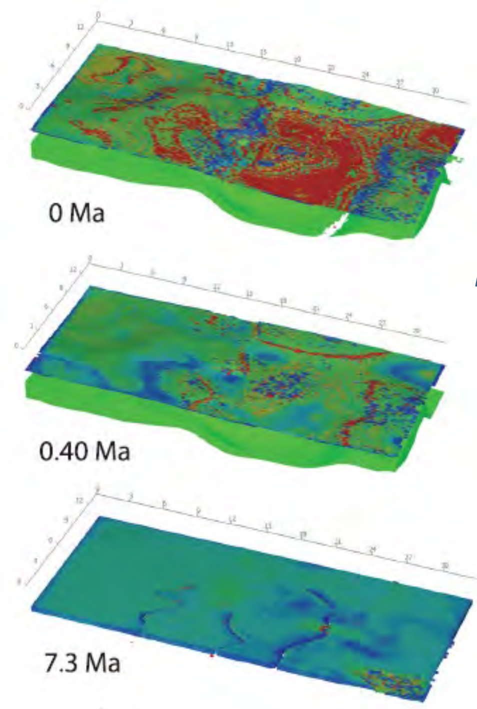


3-D Basin-Scale Reconstruction of Natural Gas Hydrate System of the Green Canyon, Gulf of Mexico – Ewa Burwicz et al. (2017)

Generation masses and migration balance of biogenic and thermogenic methane, and the total amount of present-day gas hydrate deposits as predicted in the Green Canyon area.

	Biogenic Methane	Thermogenic Methane
Total generation in the model	13,483 Mt	2075 Mt
Total amount migrated out of the model across the top boundary	8328 Mt	1164 Mt
Total amount migrated out of the model across the sides	2669 Mt	314 Mt
Total amount trapped during migration (stagnant phase in shales)	68 Mt	63 Mt
Total amount of gas hydrate present in the model	~3256 Mt of gas hydrate (equals to ~434 Mt of CH_4, ~340 Mt of carbon or, alternatively, ~7×10^{11} m^3 of CH_4 at STP conditions)	

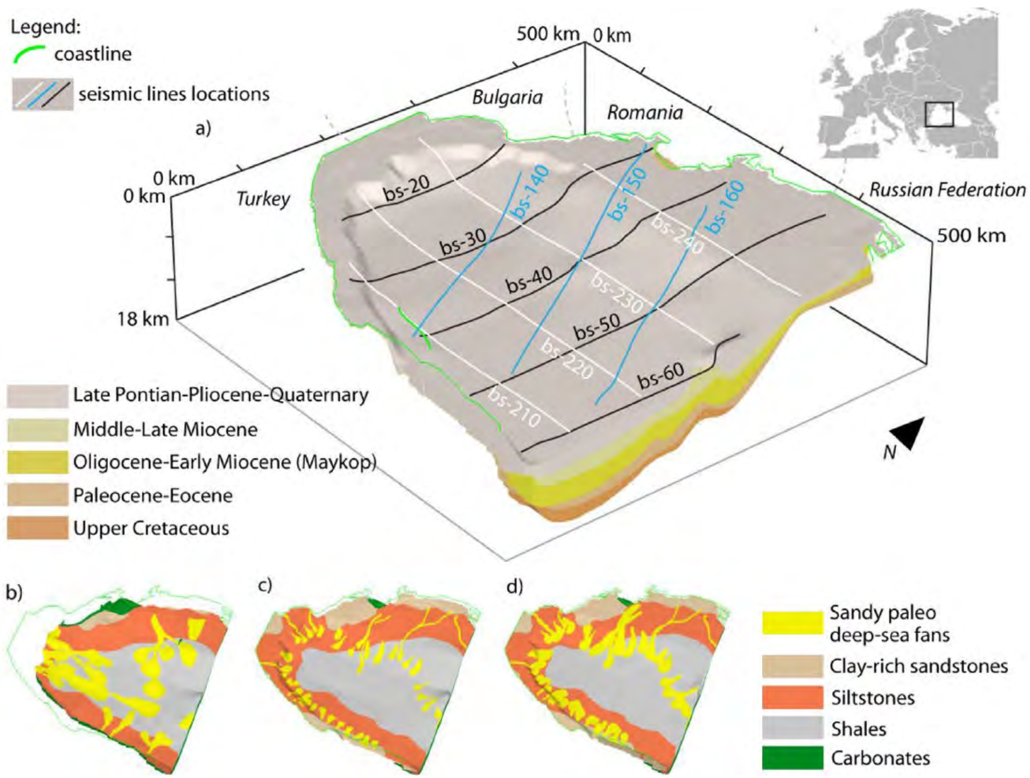


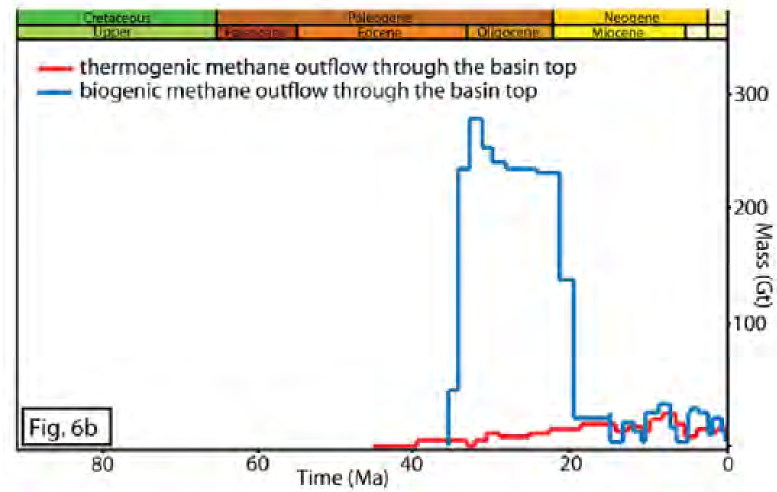


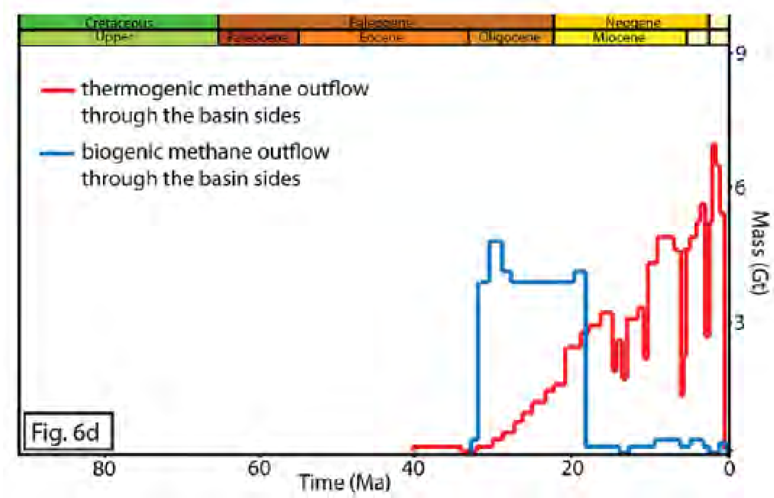
Temporal evolution of gas hydrate deposits at the BGHS

Basin-Scale Estimates on Petroleum Components Generation in the Western Black Sea Basin Based on 3-D Numerical Modelling – Ewa Burwicz and Matthias Haeckel (2020)

PetroMod numerical model reconstructing the depositional history (98–0 Ma) of the Western Black Sea sub-basin. The model estimates the rates and total amounts of the in-situ biogenic methane generation and thermally-driven organic matter maturation in the source rocks.



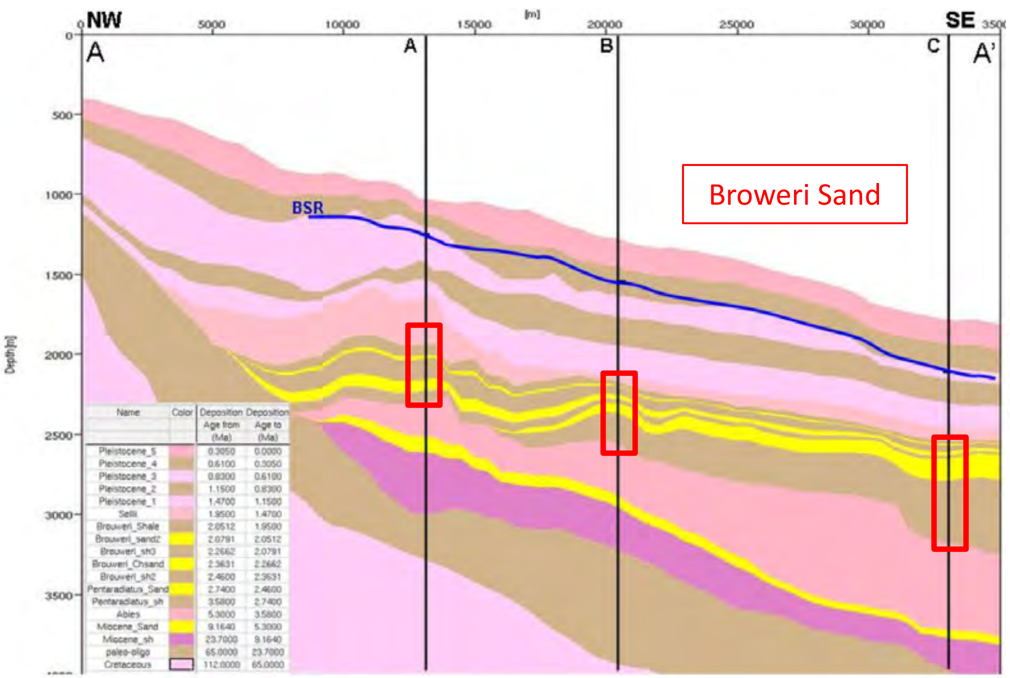


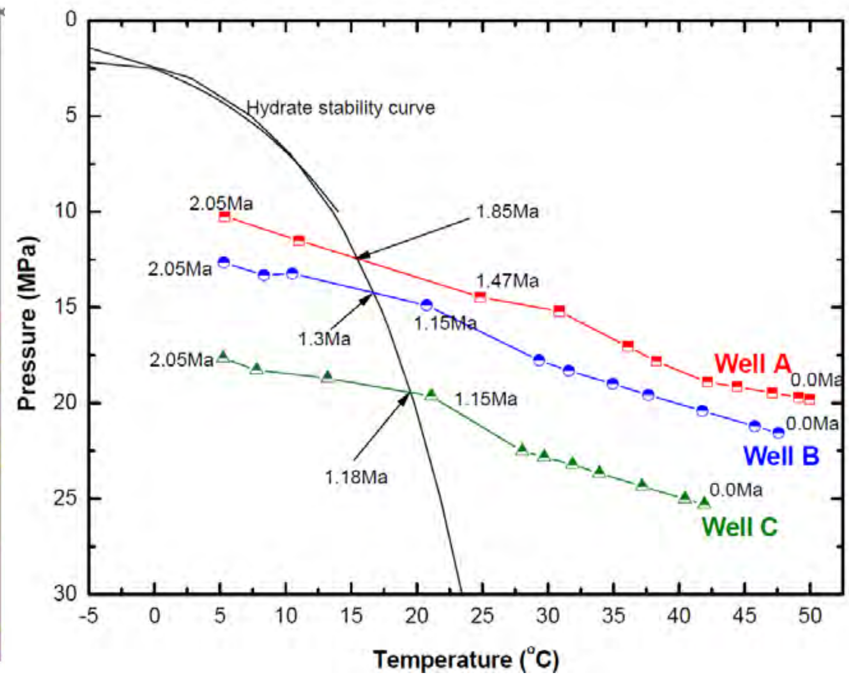


Thermogenic (red line) and biogenic (blue line) methane migration over time intervals

Paleo Hydrate and its Role in Deep Water Plio-Pleistocene Gas Reservoirs in Krishna-Godavari Basin, India - Nishikanta Knudu et al. (2008) -- *Reliance*

The gas in the deep water Plio-Pleistocene channel-levee complex in the Krishna-Godavari Basin has been derived from biogenic (microbicidal) sources. Possible explanation of these large gas accumulations can be attributed to the destabilization of paleo hydrate. The following sequence of geological events can account for the generation of the discovered conventional and hydrate accumulations on the Krishna-Godavari Basin: Deposition of organic rich sediments in deep water → Bacterial activity at reducing environment (methanogenesis) → Formation of gas hydrate → Increase of temperature leading to melting of hydrate and release of gas (associated with sediment deposition) → Migration and subsequent entrapment in porous and permeable sand bodies.





P-T history of reservoir sand (Broweri) encountered in 3 wells. The reservoir sand was within the hydrate stability zone (GHSZ) till 1.85 Ma, 1.3 Ma and 1.18 Ma in well A, B and in C respectively.

Do Paleo Hydrates Play a Major Role in Deepwater Biogenic Gas Reservoirs in Krishna-Godavari Basin?

- Nishikanta Knudu et al. (2008)

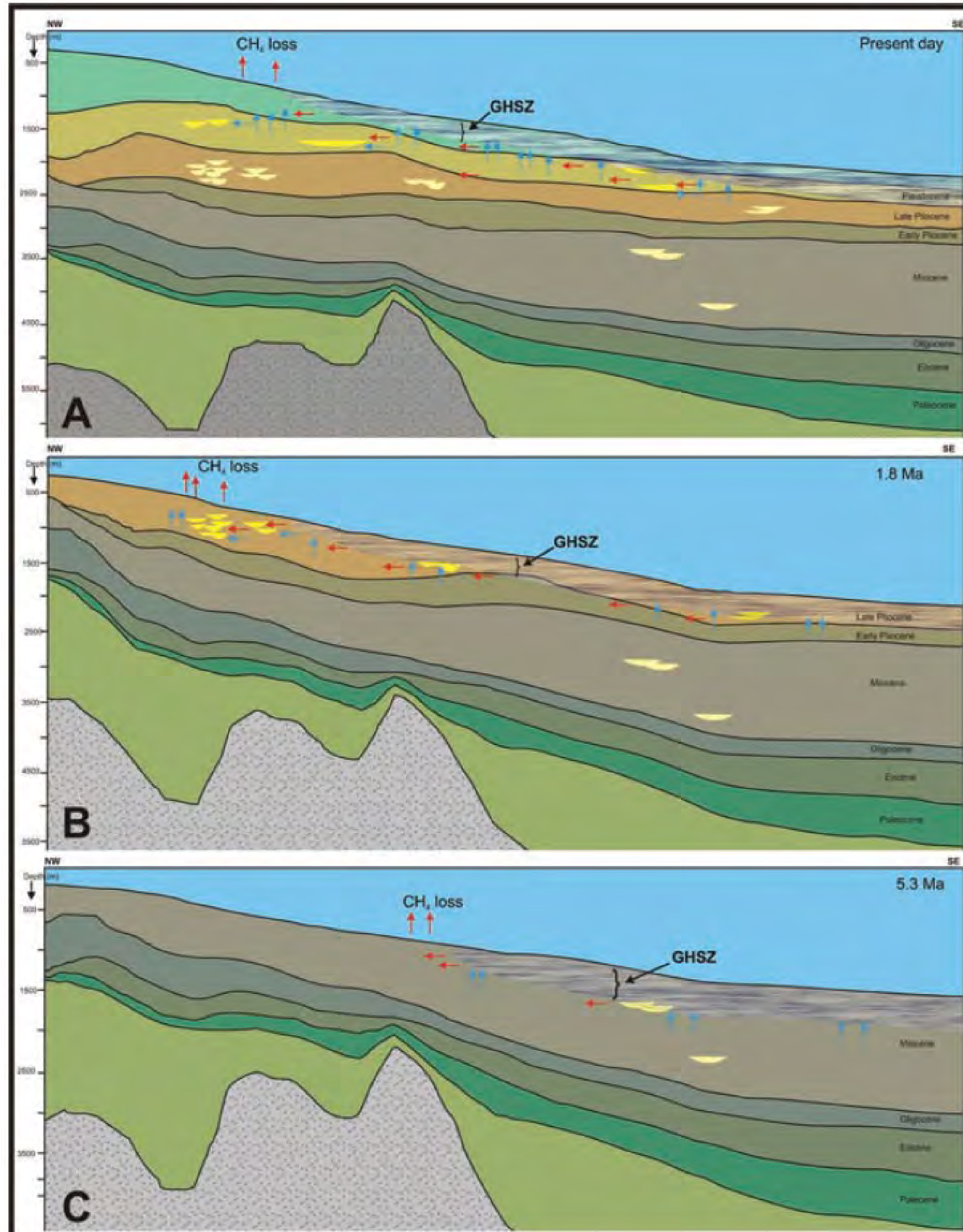
2-D Paleo-hydrate and conventional gas fields in Krishna-Godavari Basin at different geological times.

A - Geological section showing GHSZ and conventional gas filled channel sand systems.

B - Pliocene GHSZ with growing number of gas hydrate and conventional gas channel sand systems.

C - GHSZ during the Miocene.

Dark yellow color sands depict active charging from gas hydrate destabilization and methanogenesis (migration) at respective times. Light yellow color channel sands were charged previously. Red arrows indicate gas released from hydrate destabilization. Blue arrows indicate methanogenesis (migration).

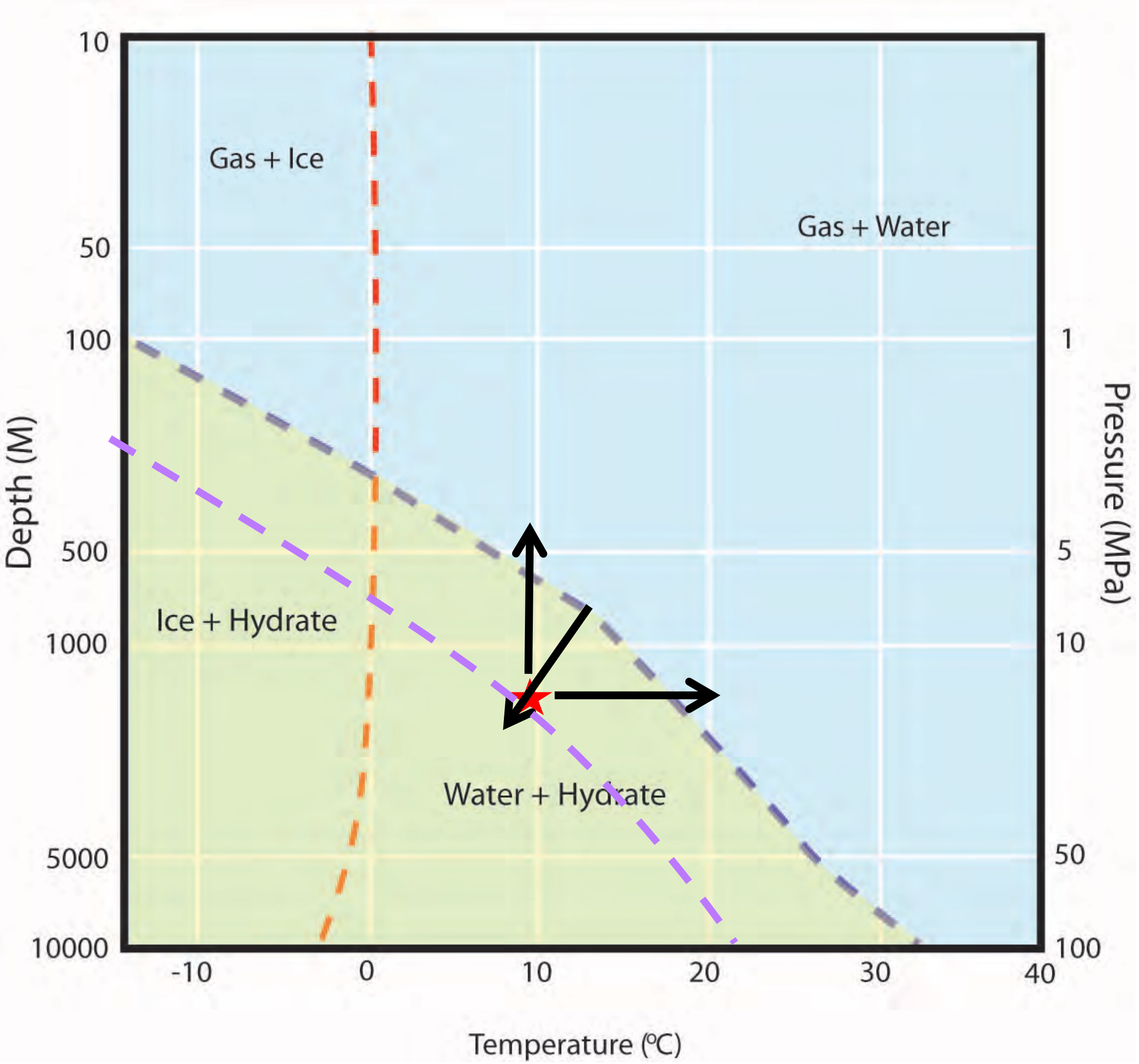


Briefing Outline

1. Gas hydrate scientific and industry drilling
2. International gas hydrate R&D projects
3. IODP gas hydrate related proposals and expeditions
4. European gas hydrate research and drilling programs
   - CAGE, GEOMAR/SUGAR, MARUM, MIGRATE
5. **Gas hydrate production R&D projects - Update**
   - **India, China, Japan**
6. Summary
7. Outreach

Gas Hydrate Production Concepts

- **Depressurization**
- **Heating**
- **Inhibitor Injection**
- **Chemical Exchange**
  - CO_2 sequestration



Gas Hydrate Production R&D

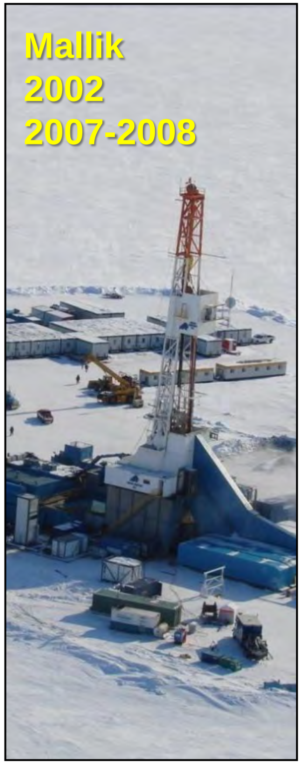
Global Gas Hydrate Production Testing

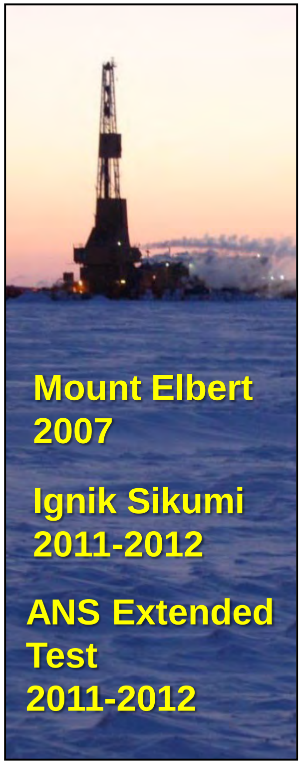
- **Messoyakha (Russia) in the 1970s**
  - Hydrate supported gas production (?)
- **Industry Drill-Stem Tests in the 1970s**
  - NW Eileen St 2; Mallik 1L-38
- **1998, 2002 Mallik (Canada)**
  - Thermal and formation pressure testing
- **2007 BP-DOE-USGS Alaska**
  - Formation pressure testing
- **2007 & 2008 Mallik (Canada)**
  - Depressurization test (6-days)
- **2011-2102 ConocoPhillips-DOE Alaska**
  - CH_4-CO_2 exchange and depressure test (25-days)
- **2013 Nankai Trough Offshore Test (Japan)**
  - 1st Marine GH production test (6-days)
- **2017 South China Sea Test (China)**
  - Marine GH production test (60-days)
- **2017 Nankai Trough Test (Japan)**
  - Marine GH production test (2-test 10 & 30 days)
- **2019 South China Sea Test (China)**
  - Marine GH production test (31-days)
- ***2018-2023 DOE-JOGMEC-USGS Alaska***
  - *Extended depressurization testing*

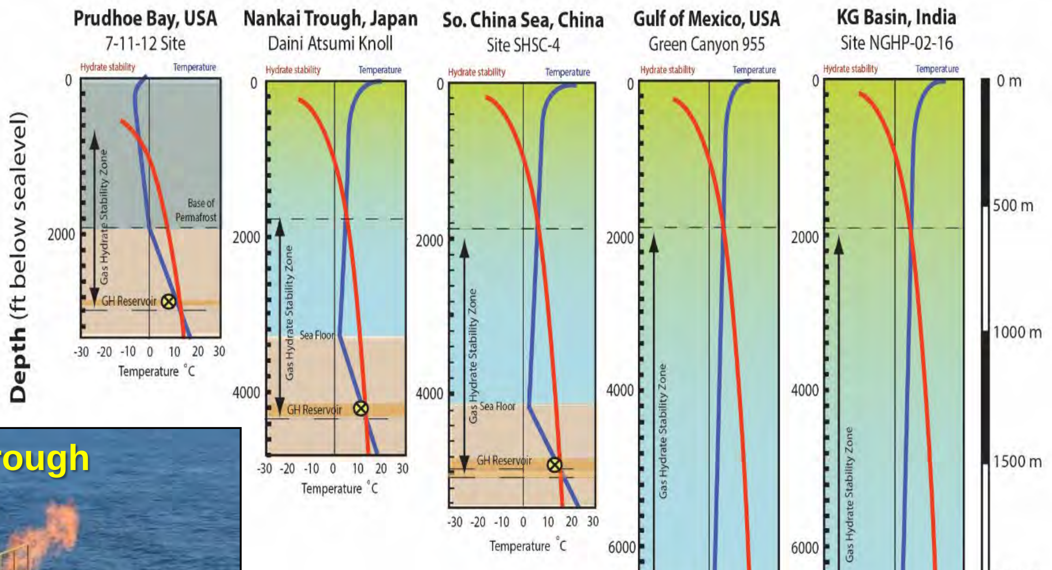
USGS
science for a changing world

Gas Hydrate Production R&D

Global Gas Hydrate Production Testing

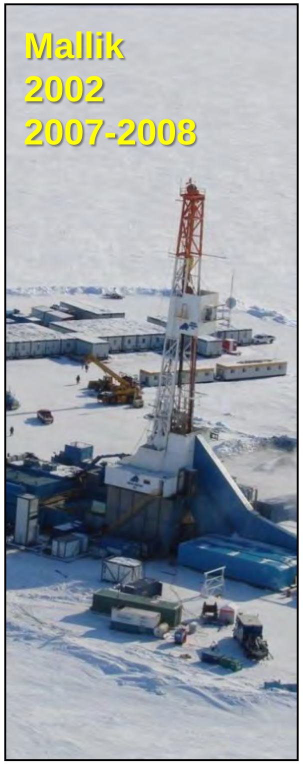


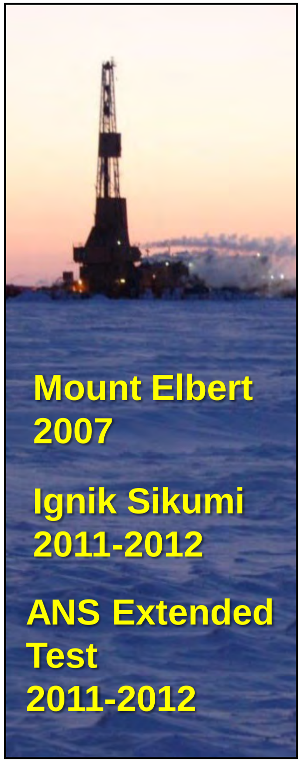


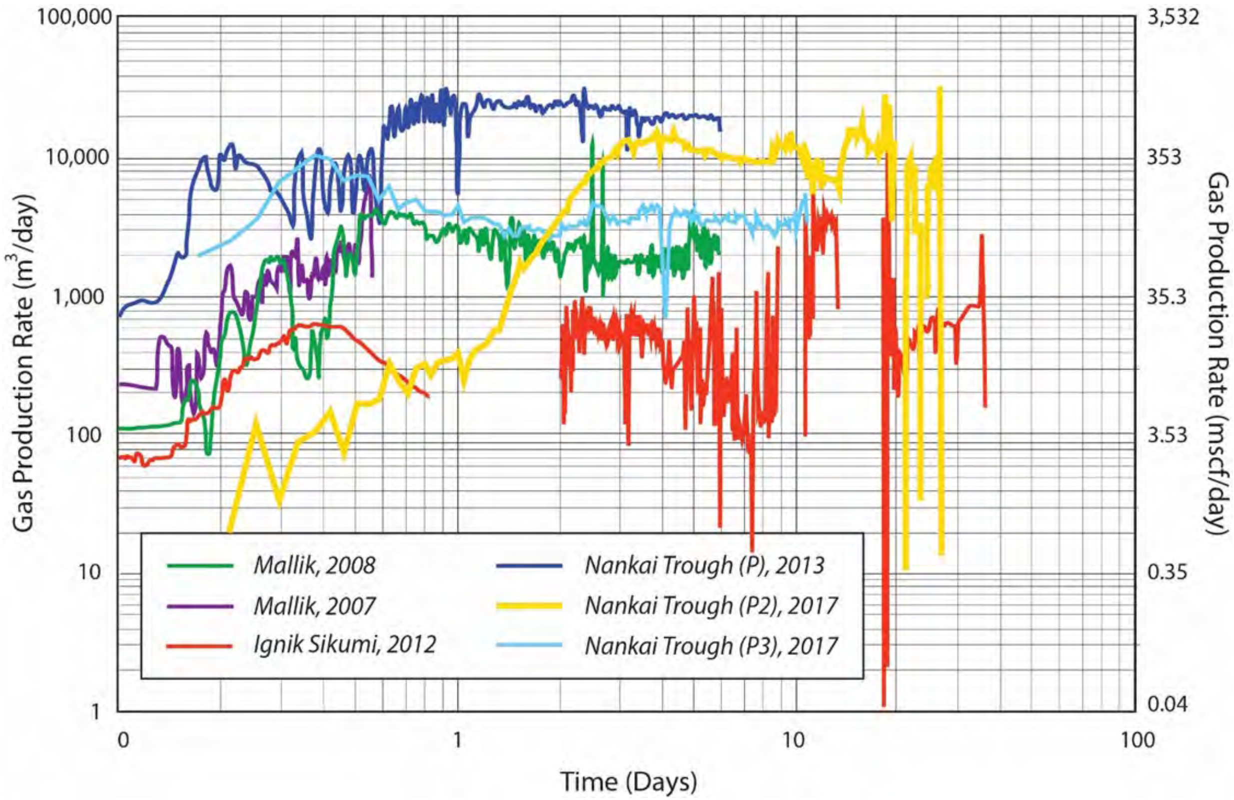


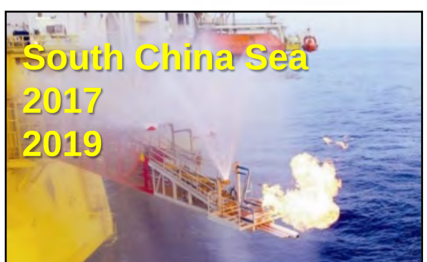
Boswell et al., (2019)

Gas Hydrate Production R&D
Global Gas Hydrate Production Testing





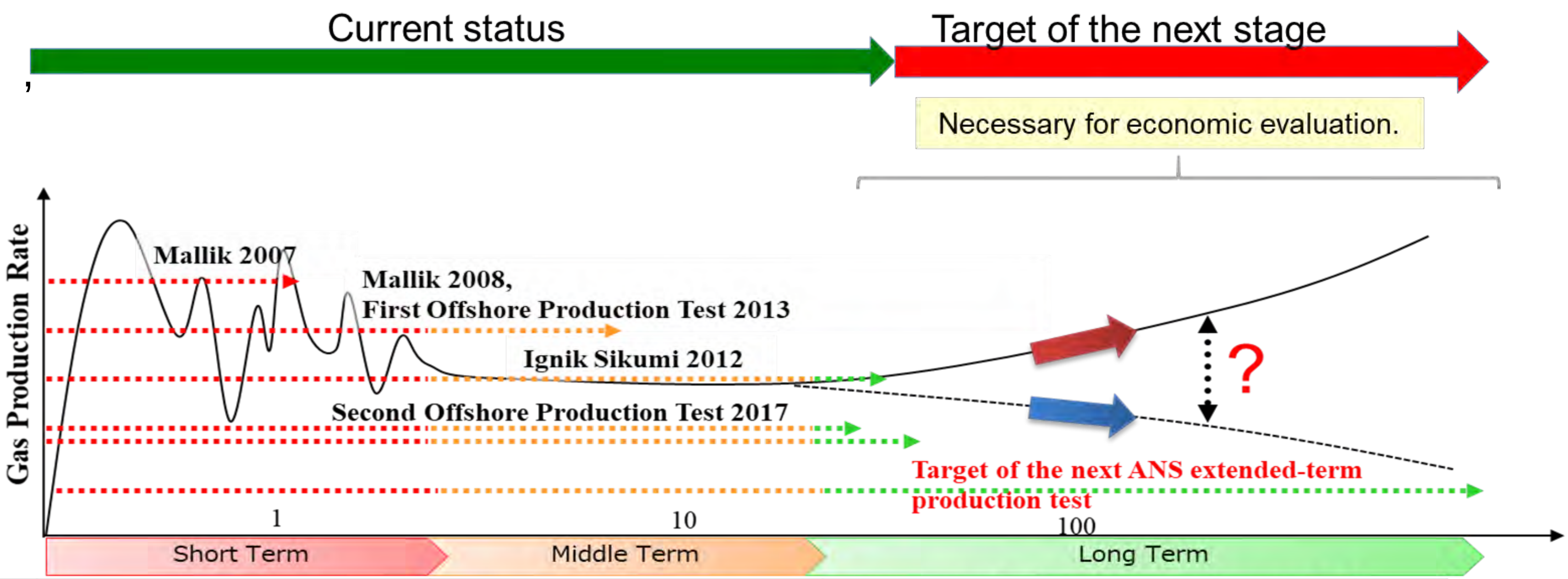




Boswell et al., (2019)

JOGMEC Alaska Pre-Bid Meeting

Purpose of the Project



Production	Unstable, Fluctuate Production	Stable pressure, quasi-static flow	Increase in production rate due to the expand of dissociation front? Decrease in production rate due to formation damage?
Dissociation	Effect of wellbore is not neglected.	Effect of wellbore is neglected, equilibrium of heat influx and dissociation heat is established.	Formation property change cause long-term and slow but dynamic effects of gas hydrate dissociation.
Objectives	Clarification of test device. No firm information of reservoir response.	Basic reservoir response and thermal/fluid transport properties are known.	Economics, long-term reliability of the production systems

Modified from Yamamoto, 2019

- ***Bay of Bengal KG-Basin, India***

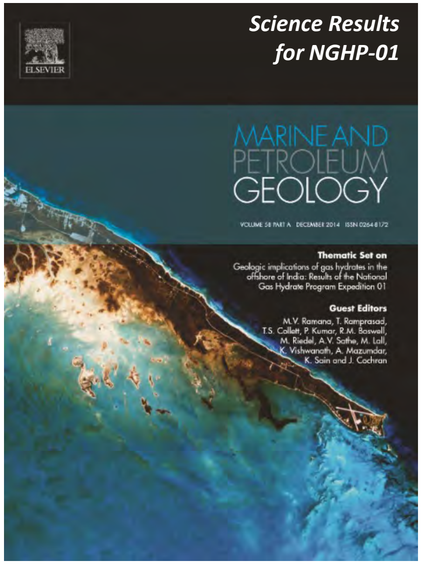
  NGHP-01 & NGHP-02 GH Systems

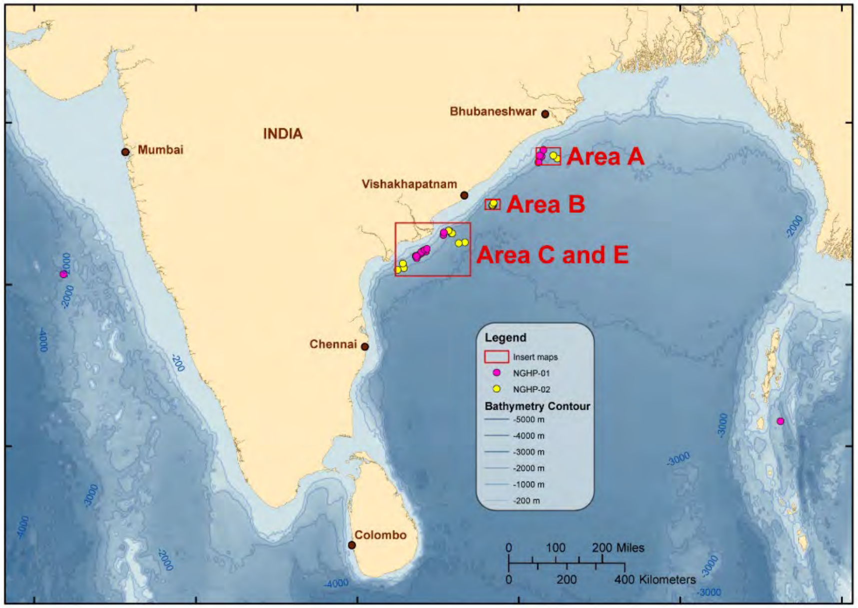
India

India National Gas Hydrate Program

India NGHP-01 & NGHP-02

- Geophysical site review for NGHP-01 and NGHP-02 exploratory drilling
- Planning and execution of NGHP-01 and NGHP-02
- Evaluation and publication of Scientific Results from NGHP-01 and NGHP-02
- Scientific and operational planning for NGHP-03





सत्यमेव जयते
DGH
ओएनजीसी ONGC
ऑयल इंडिया लिमिटेड Oil India Limited
गेल GAIL
JDC
JAMSTEC
GEO TEK CORING
Schlumberger
USGS science for a changing world
AIST
NETL

India NGHP-02: Area B Gas Hydrate System

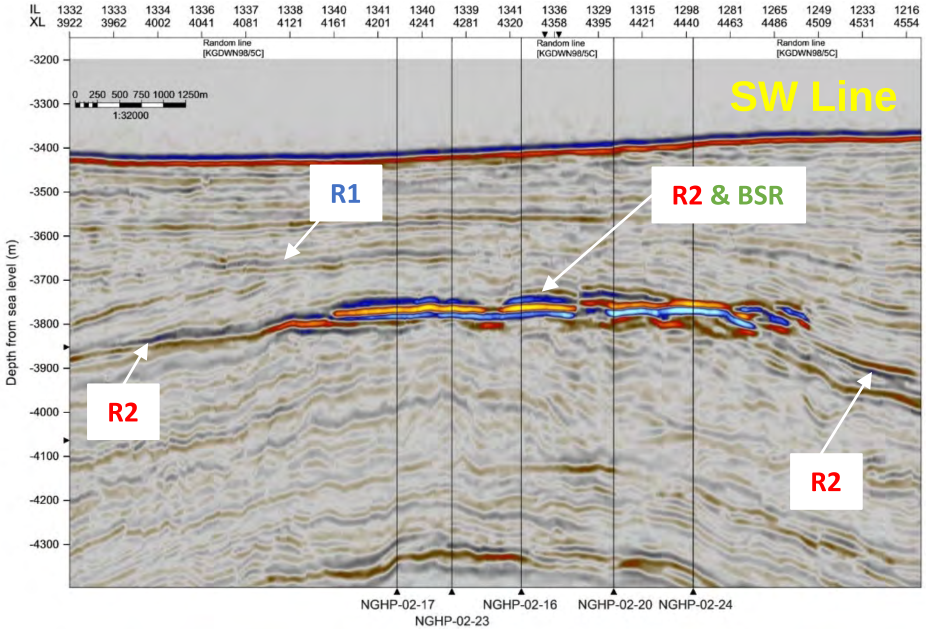
The main feature of Area-B is a large regional elongated anticlinal structure (the L1 Block structure) that is aligned perpendicular to the slope.

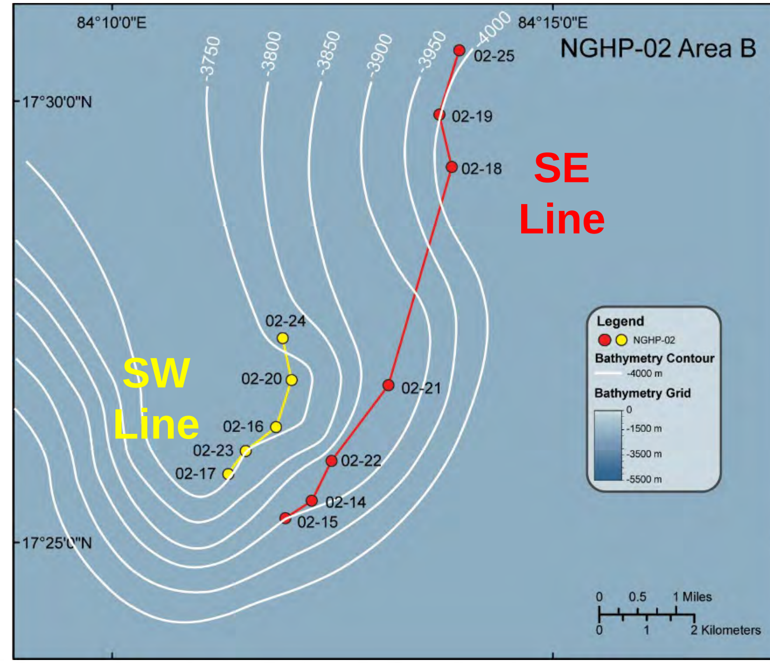
Two potential reservoir systems were identified in Area-B, including an “upper” reservoir faces (R1) and a second “lower” (R2) reservoir section with both reservoir faces characterized by apparent peak-leading seismic events above the BSR.

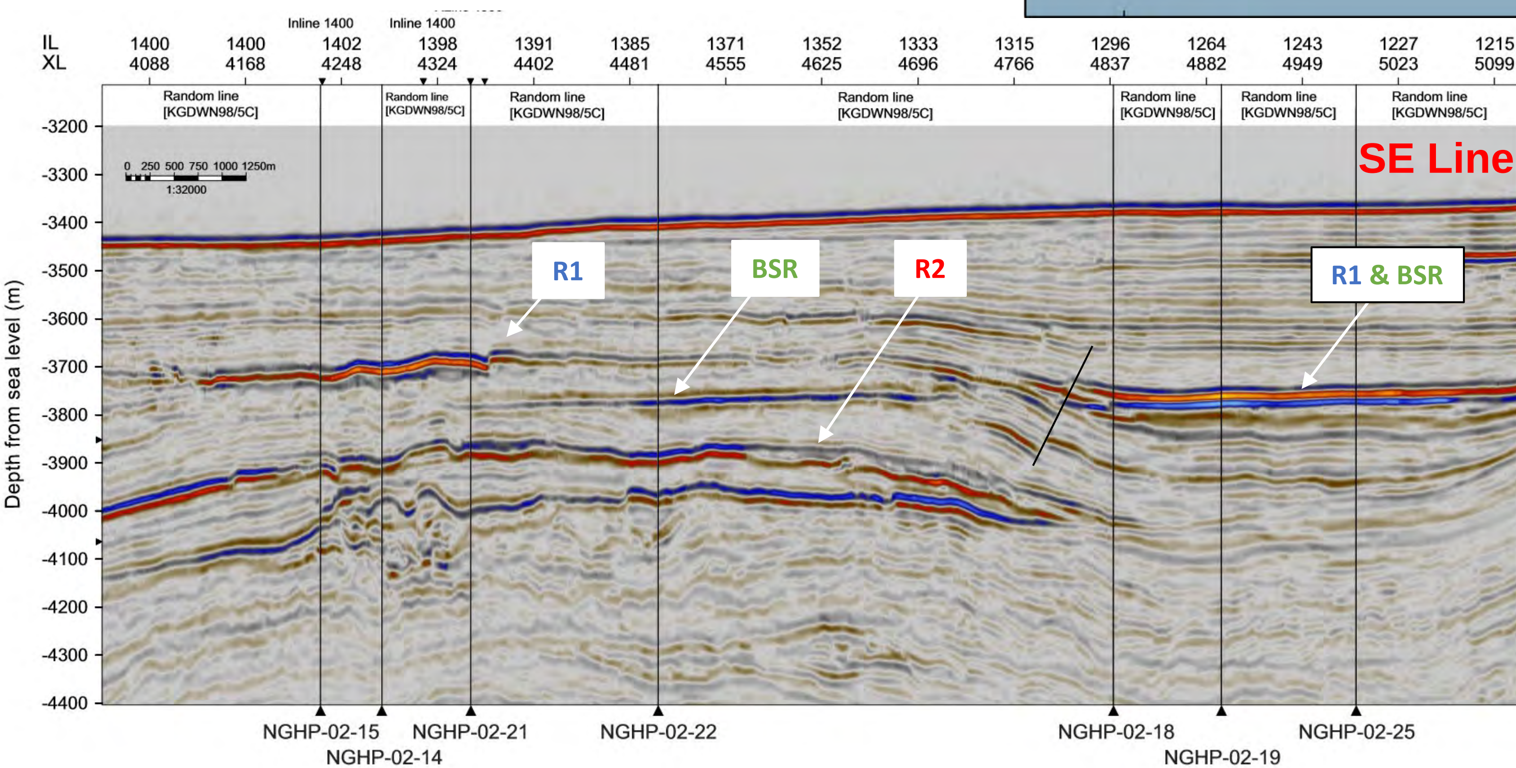
The “upper” reservoir faces (R1) is characterized by a relatively complex occurrence of both pore-filling and fracture-filling gas hydrates.

The “lower” reservoir faces has proven to be more perspective for highly saturated and thick gas hydrate occurrences. The LWD data from Holes NGHP-02-16-A and -17-A that were drilled to test the “lower” reservoir faces just above the BSR, have shown the presence of 18 and 19 m, respectively, of highly concentrated gas-hydrate occurrences.

The unprecedented opportunity to drill 12 LWD penetrations through in the L1 Block gas hydrate accumulation and to core the gas hydrate system at five sites have provided one of the most complete three-dimensional petrophysical-based view of any known gas hydrate reservoir system in the world.

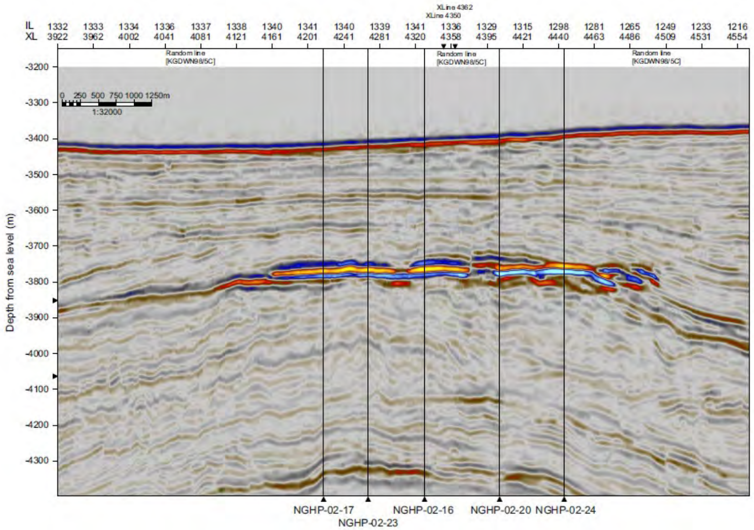


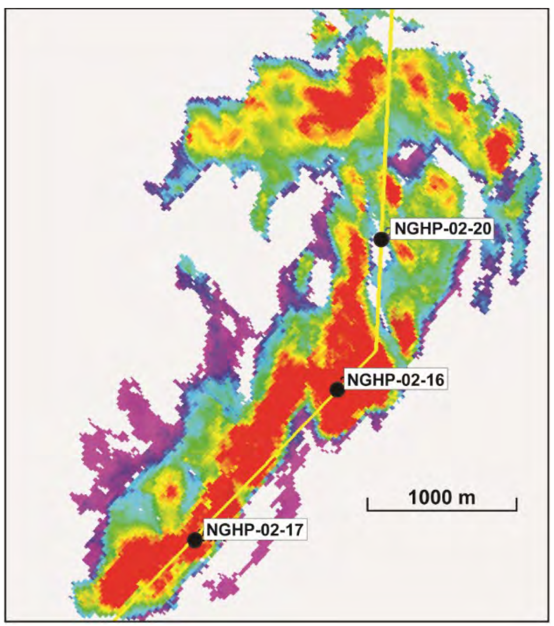


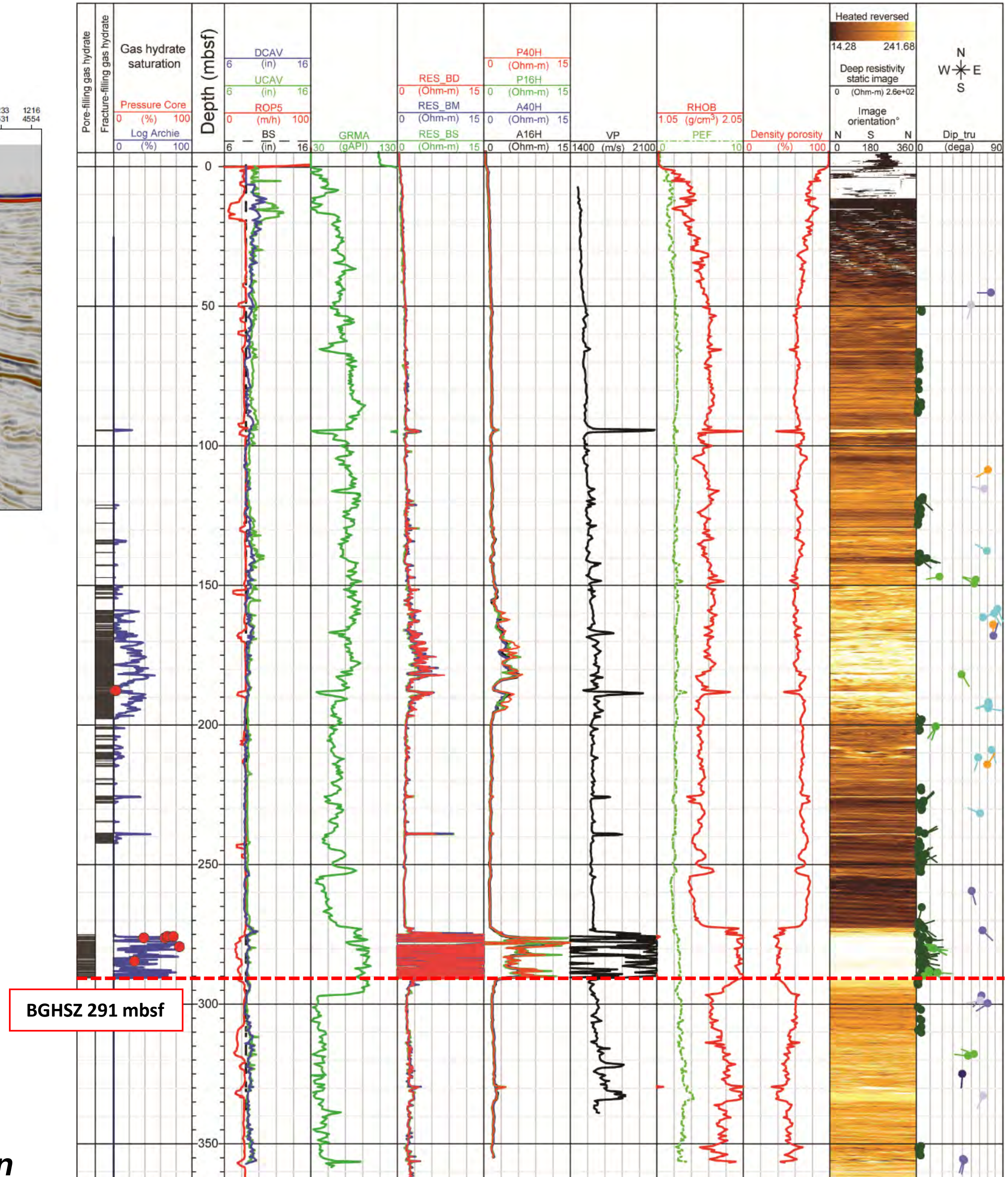


NGHP-02
Area B
L1 Anticline

NGHP-02-16



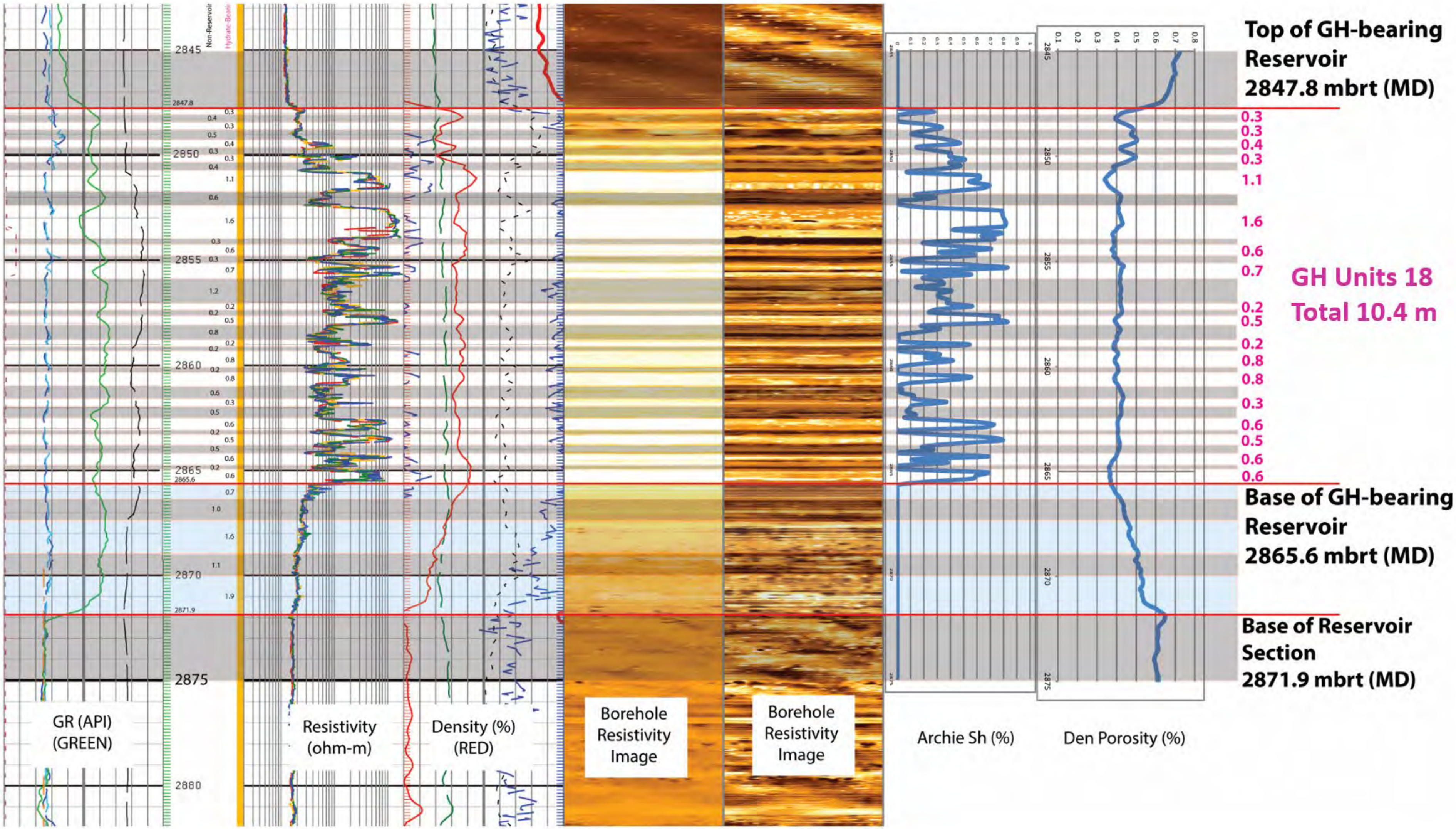




Area B Krishna-Godavari GH System

Toe-of-Slope to Outer Basin Floor Fan

Area B: Site NGHP-02-16 Reservoir Model



Gas Hydrate Units: **Reservoir total porosity (40%); Gas Hydrate Saturation (80%); Effective permeability (two assumed cases 10 mD and 0.1 mD)**

India NGHP-02: Area C Gas Hydrate System

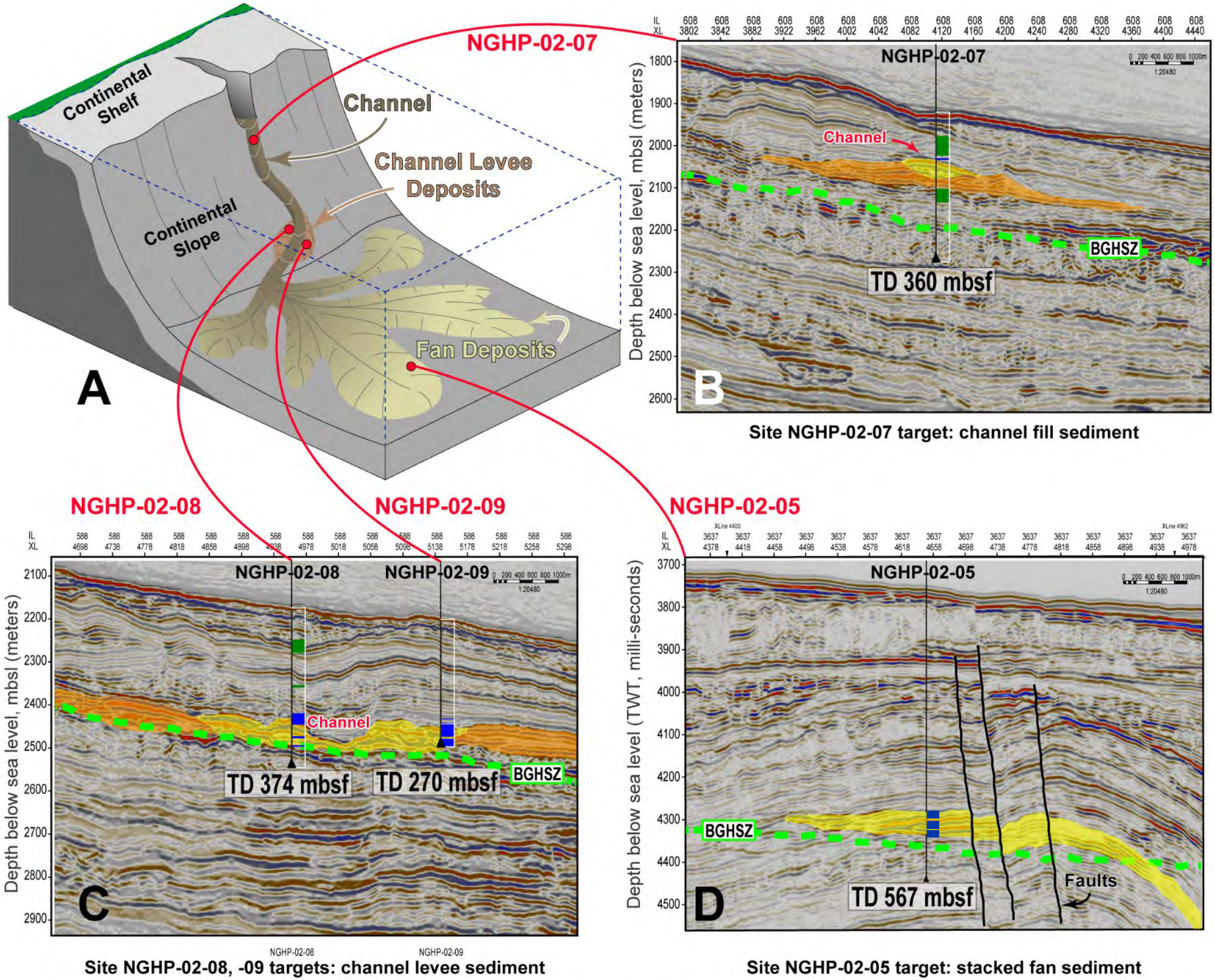
Analysis LWD data from the Area-C along with the available 3-D seismic data volumes, reveals a fully developed gas hydrate system along the outer continental slope margin of the D6 and D9 Blocks in the Krishna-Godavari Basin.

Prominent channel features drilled in Holes NGHP-02-07-A and -10A, appears to be linked to the down slope deep-sea channel levee system targeted by Holes NGHP-02-08-A and -09-A and the more distal middle to outer fan sequences drilled in Holes NGHP-02-05-A and -06-A.

Hole NGHP-02-08-A appears to have penetrated a 26-m-thick interval of what appears to be a sand-rich levee deposit with high gas hydrate saturations over about 20 m of the drilled reservoir section. Hole NGHP-02-09-A, selected to test the same levee system on the opposite bank of the same channel drilled a 53 m thick reservoir section that appears to be mostly gas-hydrate-bearing.

Holes NGHP-02-05-A and -06-A both encountered a relative thick succession of middle to outer fan deposits with individual well log inferred sand reservoir sections measuring more than 50 m in thickness. Hole NGHP-02-05-A encountered a relatively thick section of thinly bedded gas hydrate-bearing turbidite sands just above the BSR at this site.

Krishna-Godavari Gas Hydrate System
Channel-Levee and Fan Systems



Seismic profile legend

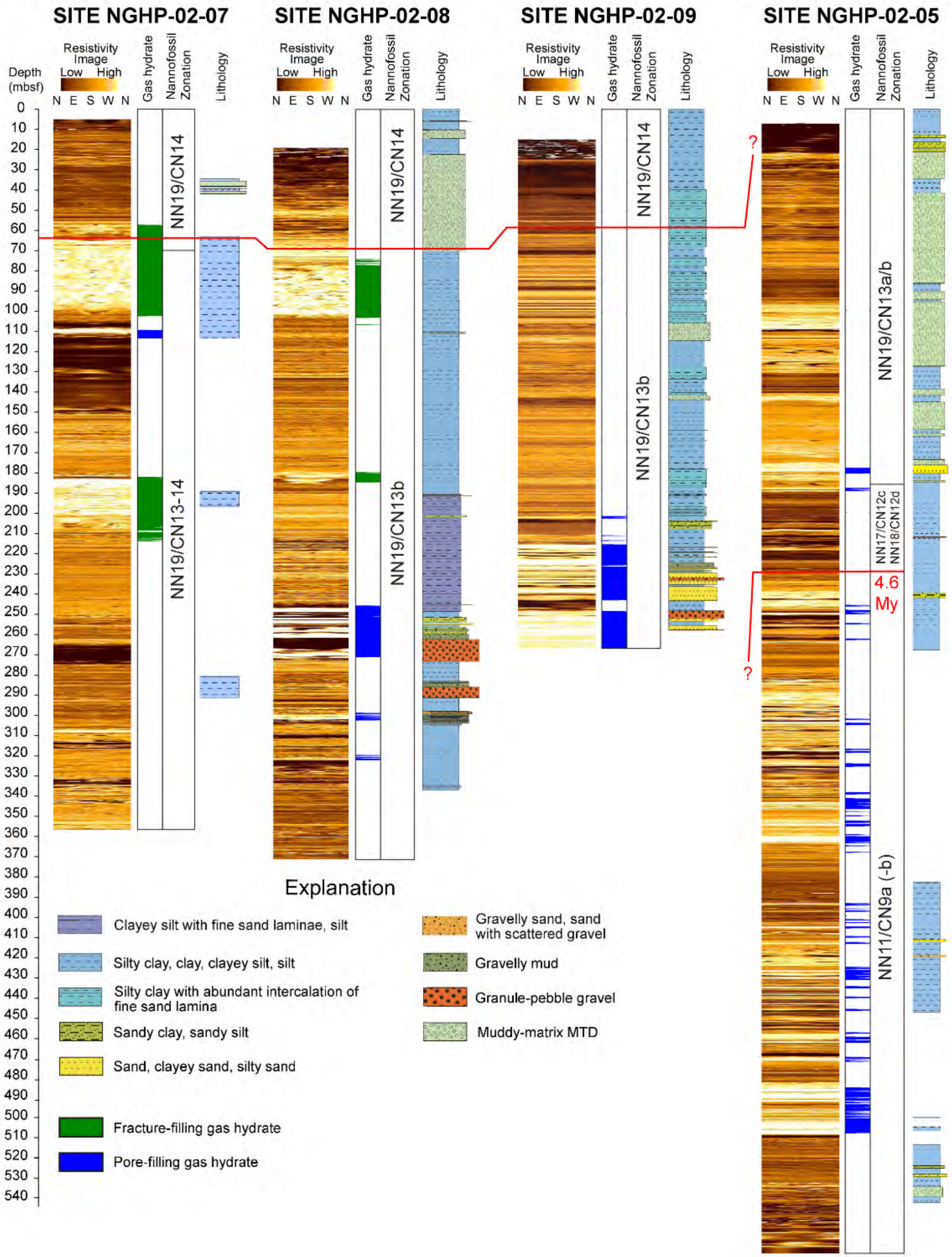
- Coarse-grained, sand-rich sediment
- Coarse-grained, silt-rich sediment

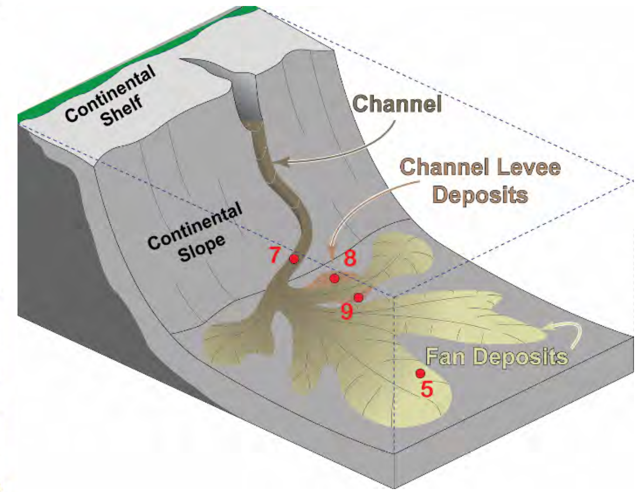
Archie-inferred downhole gas hydrate distribution

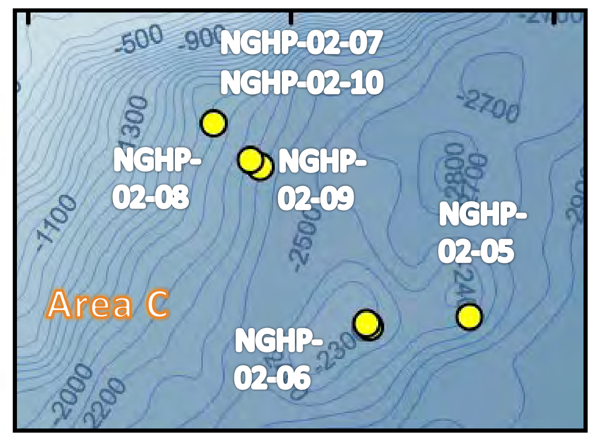
- Gas hydrate-filled fractures (grain displacing)
- Gas hydrate in existing pore space (pore-occupying)

Krishna-Godavari Gas Hydrate System

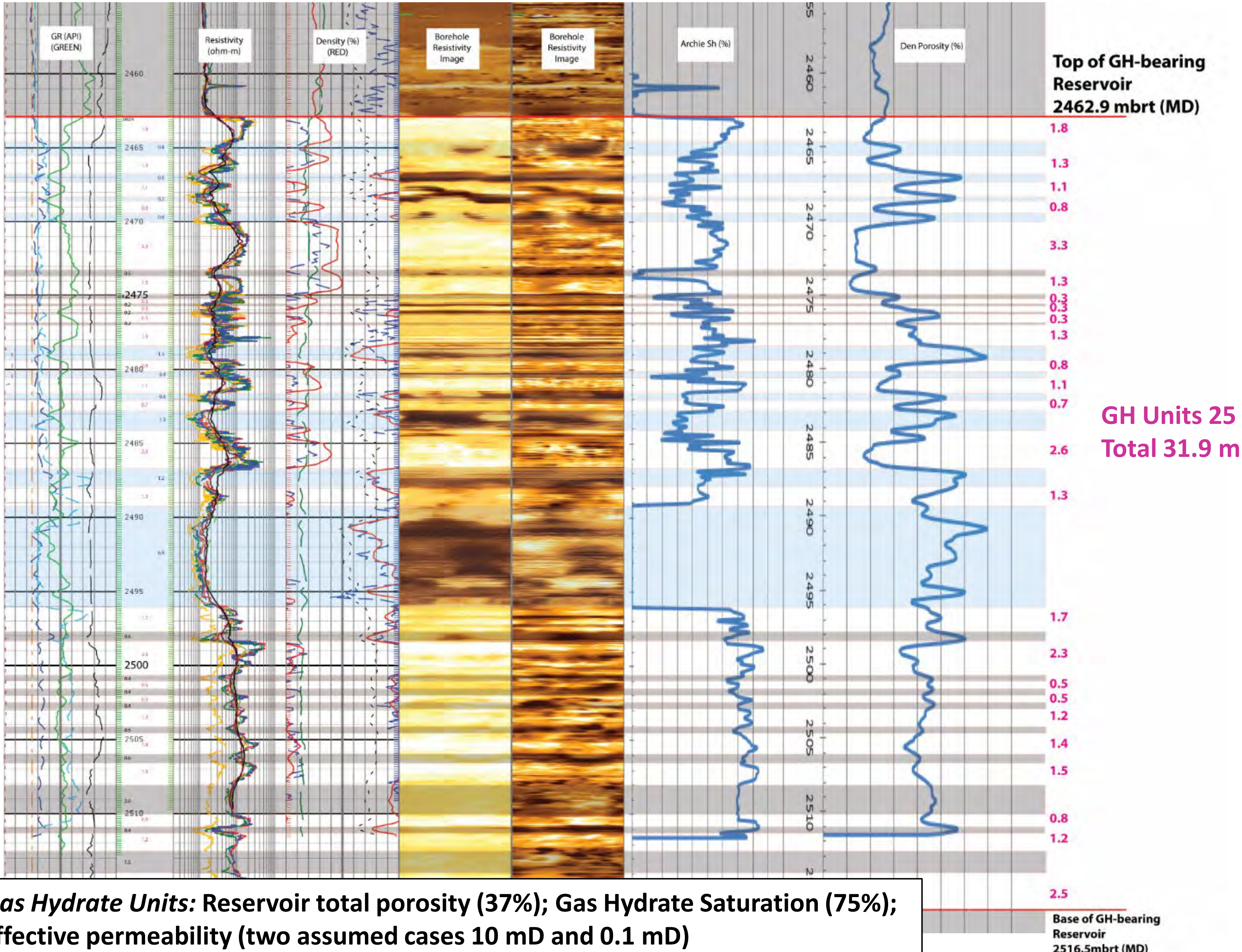
Channel-Levee and Fan Systems







Area C: Site NGHP-02-09 Reservoir Model



Gas Hydrate Units: Reservoir total porosity (37%); Gas Hydrate Saturation (75%); Effective permeability (two assumed cases 10 mD and 0.1 mD)

JOURNAL OF MARINE AND PETROLEUM GEOLOGY SPECIAL ISSUE

Title: Marine Gas Hydrate Reservoir Systems Along the Eastern Continental Margin of India: Results of the National Gas Hydrate Program Expedition 02

Guest Editors: T.S. Collett, M. Pratap, S.K. Singh, K.K. Chopra, P. Kumar, Y. Yamada, N. Tenma, K. Sain, U.S. Sahay, R. Boswell, W. Waite

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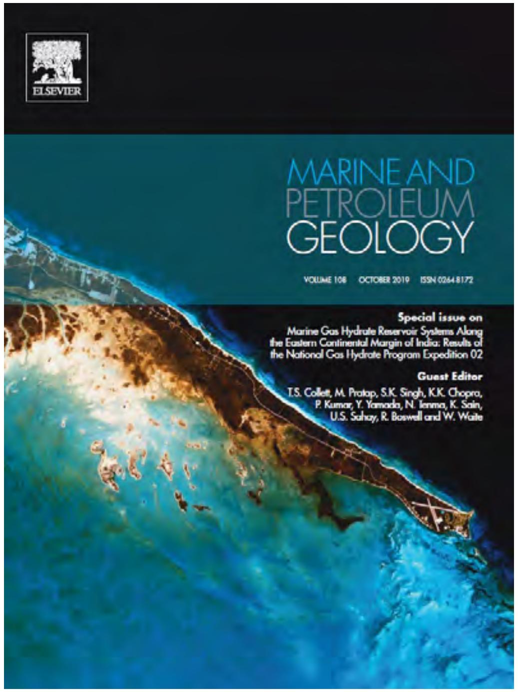
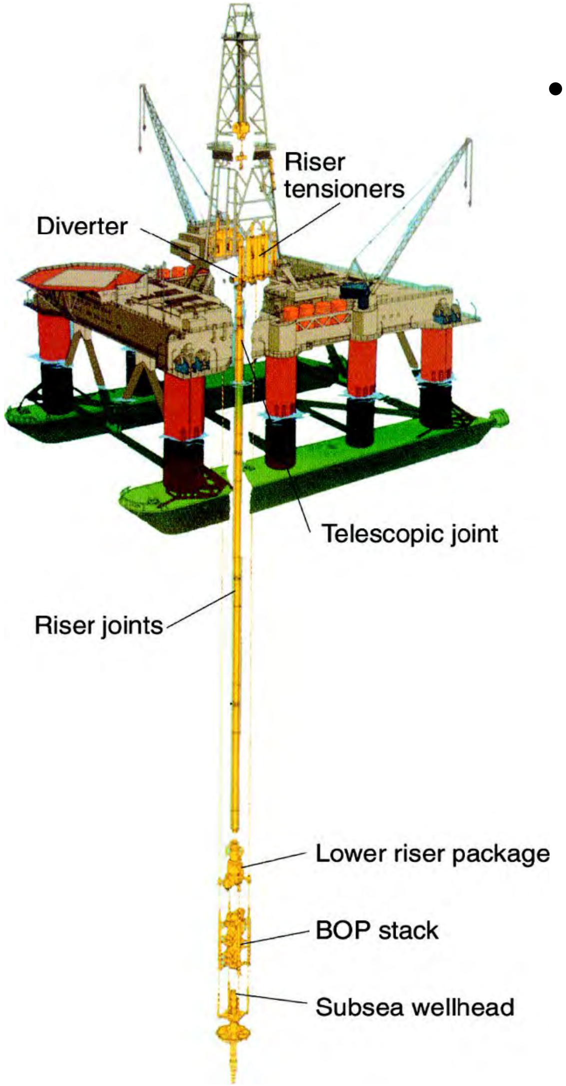


Science Results for NGHP-02



NGHP-03 Test Planning

- Operational Planning
  - Establish observation (monitoring) holes; drilling considerations, logging operations (LWD and advanced wireline logs), and instrumentation including T&P gages, distributed systems (DTS, DSS, DAS), etc.
  - Pressure coring operations in support of site characterization studies and acquiring reservoir/petrophysical data needed for production/mechanical modeling and test design.
  - Establish, instrument, and complete main production test hole.
  - Deploy seafloor monitoring system.
  - Conduct pre-test and post-test 3D/4D VSP.
  - Conduct pre-test and post-test 3D/4D seismic survey.
  - Conduct 60 or 90 days of flow testing.
  - Conduct production test monitoring (before, during, and after testing operations).
  - Suspend and/or abandon test wells.

- ***South China Sea, China***

  GMGS 1 through 6

  Production Testing 2017 & 2019

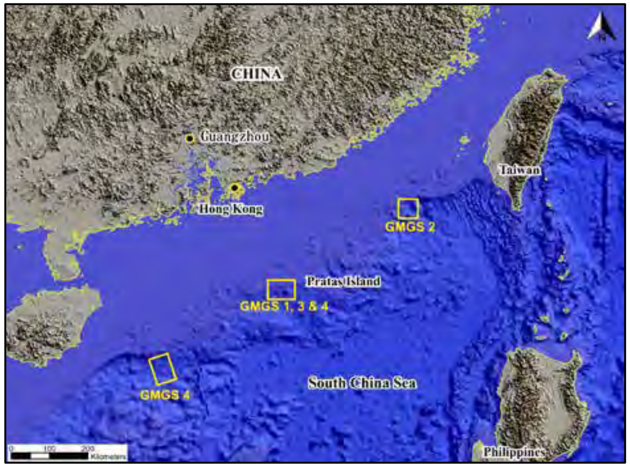
China

China

Very Active Program

GMGS-1 (2007), GMGS-2 (2013), GMGS-3 (2015), GMGS-4 (2016), GMGS-5 (2018), GMGS-6 (2019)

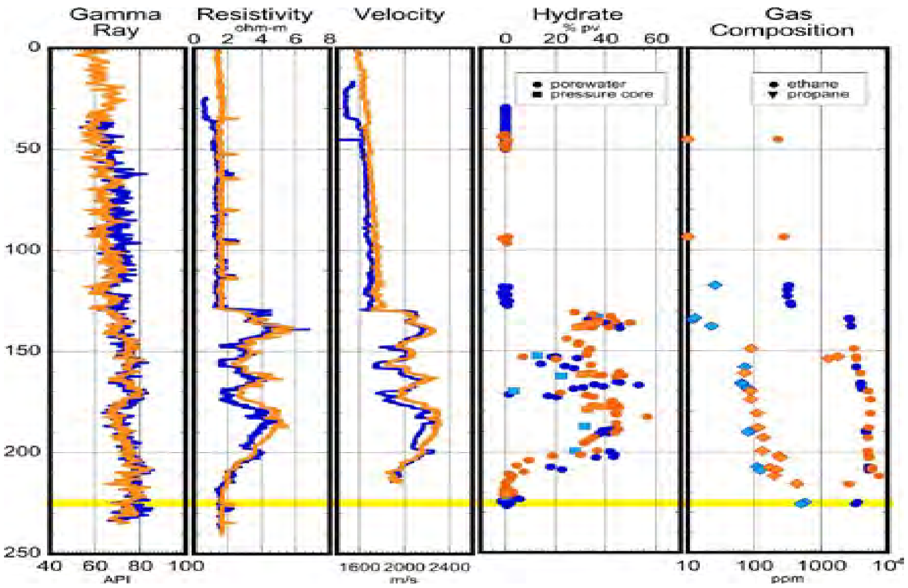
- Marine production testing 2017 & 2019
- Primary focus is Pearl River mouth basin (Shenhu area)
- GMGS-4 added new area to thesouth (Xisha area); 58 days/ 21 sites
- Reservoirs appear to be clay-rich silt with S_{gh} up to 40% (anomalous)
- Lateral heterogeneity over short distances
- 20-90 m thick at BGHS: Structure II GH with FG
- GMGS-5 included coring at 2017 test site



Onshore Testing

- Permafrost-associated: Thermogenic; Fractured-rock reservoirs
- Tibetan Plateau (Qilian) and Manchuria (Mohe)

Yang et al., FITI, 2017



China

2017 and 2019 Production Testing

Bluewhale 1 & 2
CPOE Operator
CNPC Client
Test site in South China Sea
Test zone ~250 mbsf
WD = 1,266 m

2017
Ministry of Land and Resources
60 days → 309,000 m^3

The highest output in one day is 35,000 m^3 (1.2 mmcf/day), and the average output a day is about 16,000 m^3 /day (0.6 mmcf/day)

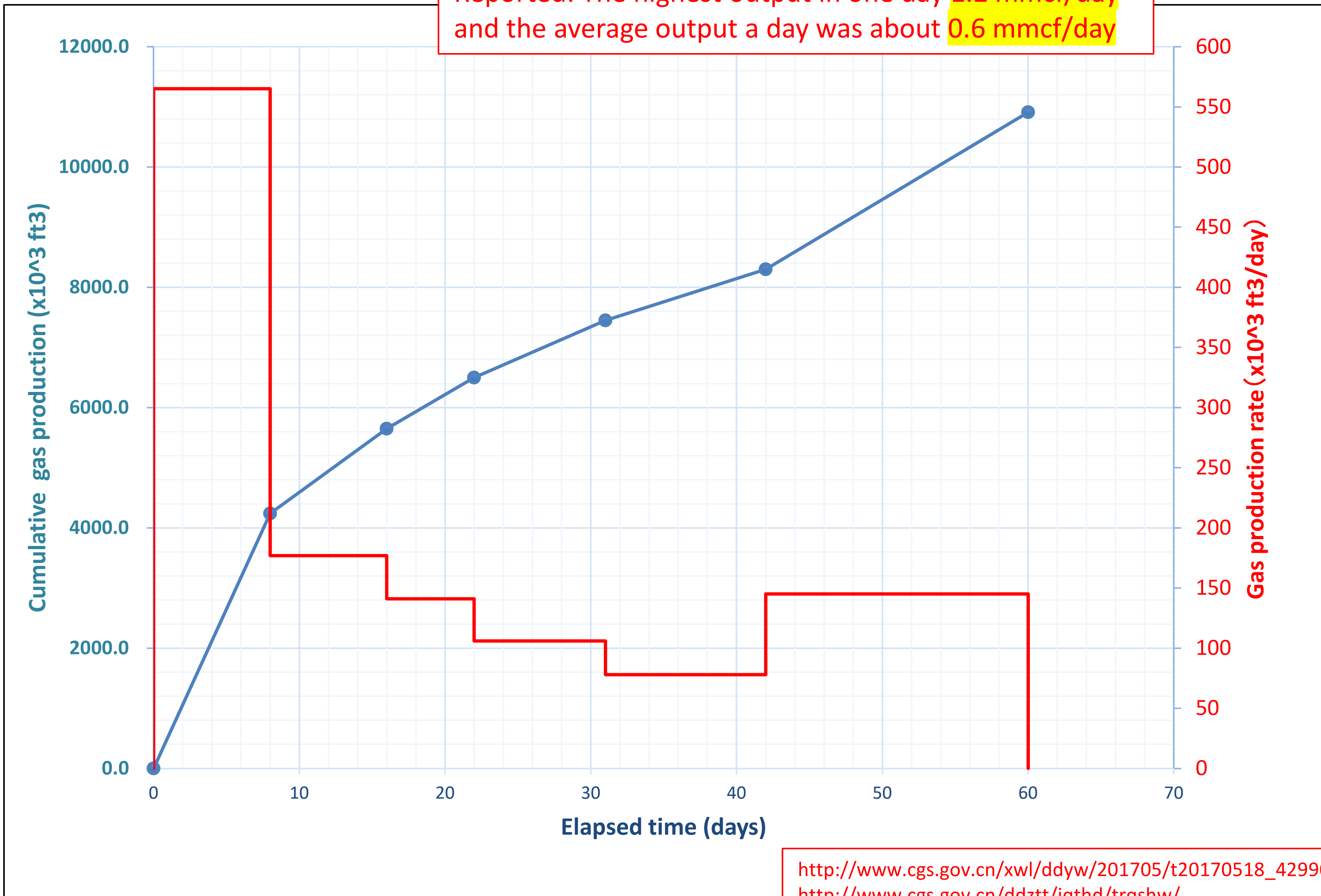
China Geological Survey
80 billion metric tons of reserves

2019
2019 Second GMGS marine gas hydrate production test; reported 861,400 m^3 of gas over a period of 31 days, with a reported average daily production rate of about 28,700 m^3 (1.0 mmcf/day)

China

2017 Production Test Results

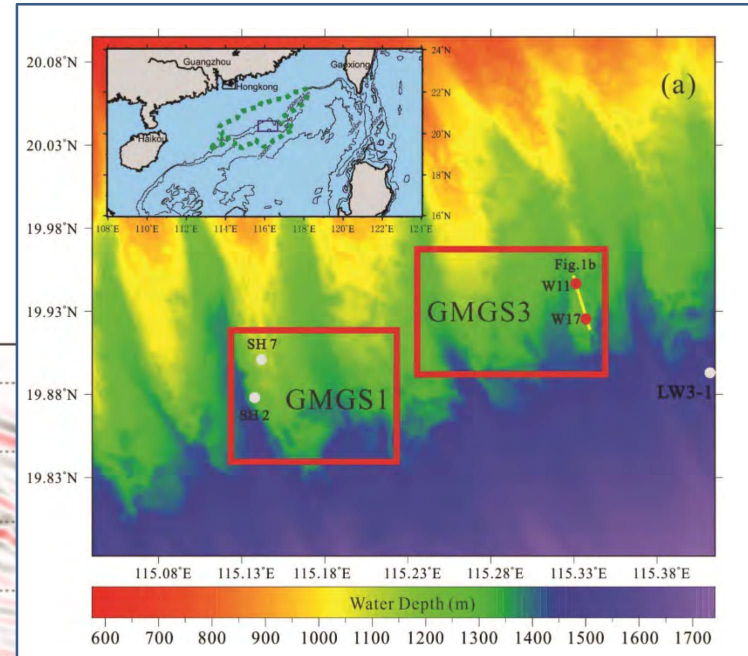
Reported: The highest output in one day 1.2 mmcf/day and the average output a day was about 0.6 mmcf/day

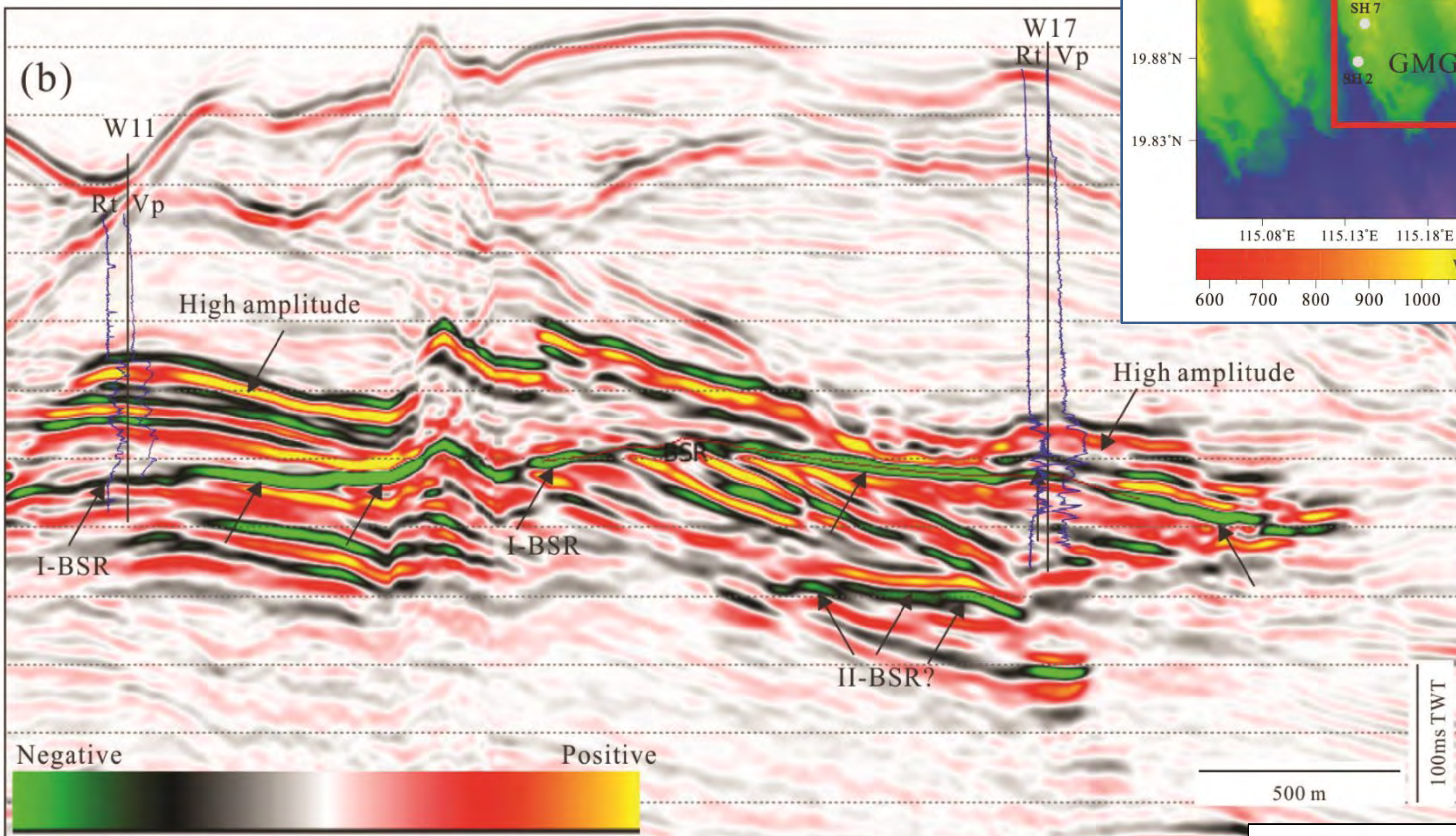


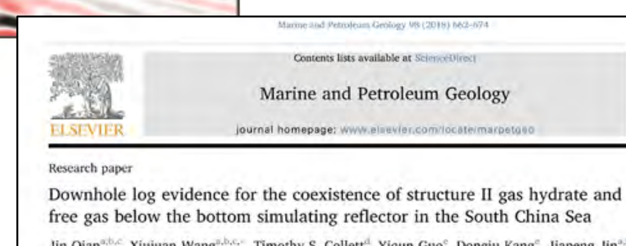
http://www.cgs.gov.cn/xwl/ddyw/201705/t20170518_429904.html
http://www.cgs.gov.cn/ddztt/jqthd/trqshw/
http://www.mlr.gov.cn/xwdt/jrxw/201707/t20170710_1524223.htm

GMGS-3 (2015) W11 & W17

- Seismic profile through Sites W11 to W17
- Resistivity (Rt) and P-wave velocity (Vp) logs







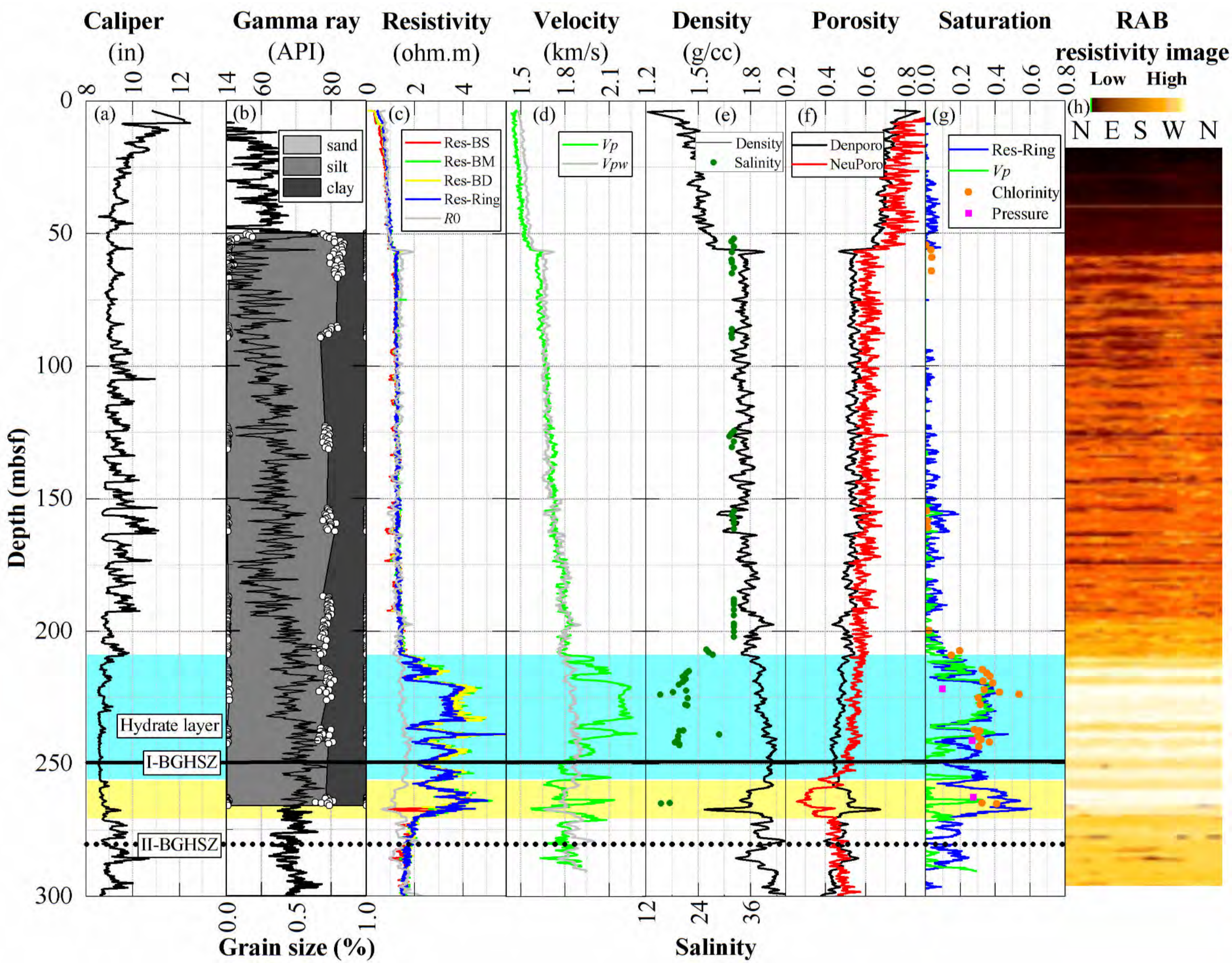
Marine and Petroleum Geology 98 (2018) 662-674
Contents lists available at ScienceDirect
Marine and Petroleum Geology
journal homepage: www.elsevier.com/locate/marpetgeo

Research paper

Downhole log evidence for the coexistence of structure II gas hydrate and free gas below the bottom simulating reflector in the South China Sea

Jin Qian[a,b,c], Xiujuan Wang[a,b,c,*], Timothy S. Collett[d], Yiqun Guo[e], Dongju Kang[e], Jiapeng Jin[a,f]

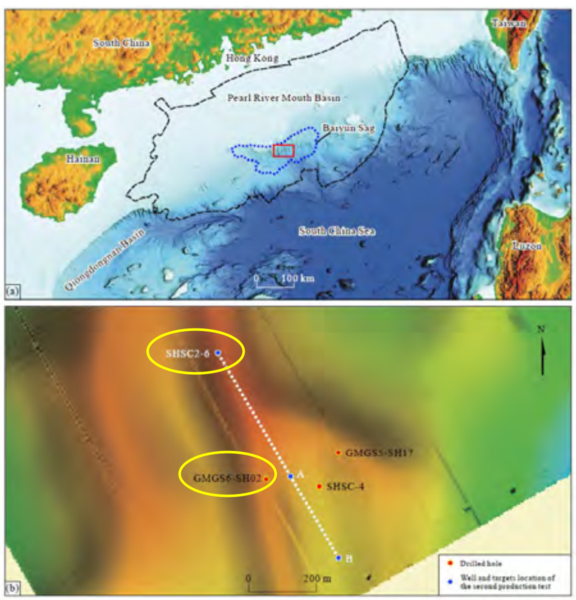
GMGS-3 (2015) W17

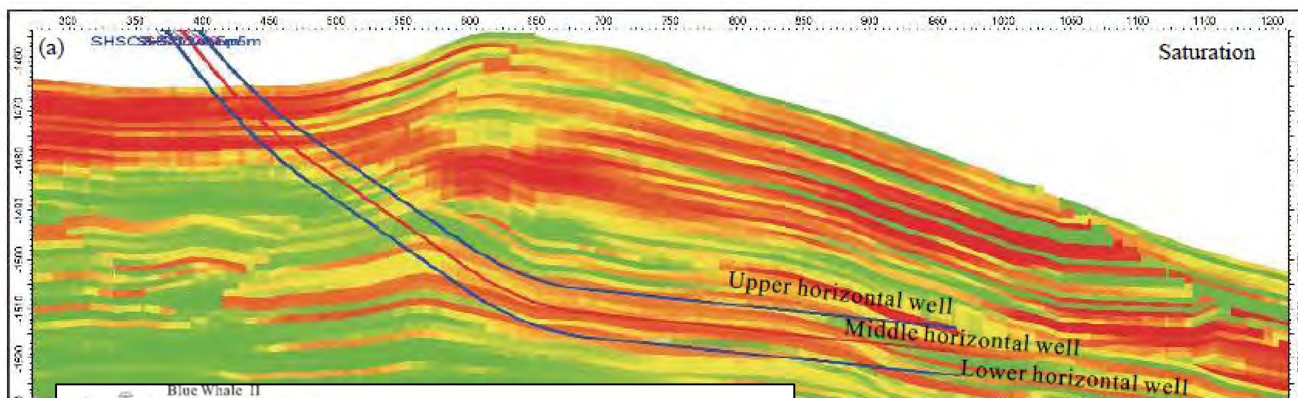


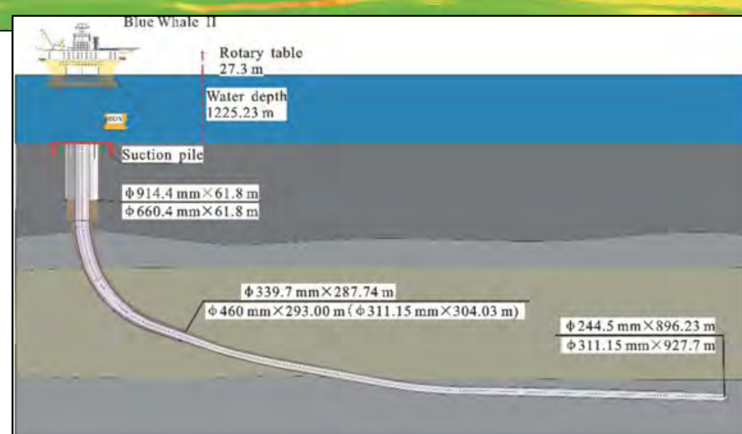
2019/2020 Gas Hydrate Production Test in the South China Sea

- Ye, J., Qin, X., Xie, W., Lu, H., Ma, B., & Qiu, H. (2020). The second natural gas hydrate production test in the South China Sea. China Geology, 2, 197–209. https://doi.org/10.31035/cg2020043
- Li, W., Gao, D., & Yang, J. (2020). Study of mud weight window of horizontal wells drilled into offshore natural gas hydrate sediments. Journal of Natural Gas Science and Engineering, 103575. https://doi.org/10.1016/j.jngse.2020.103575

Well GMGS6-SH02 is the pilot hole drilled for the optimal well trajectory of the second production test in 2019. It is about 70 m away from the target point A of the horizontal well for the production test. Converted GMG36-SH02 to a monitoring well.



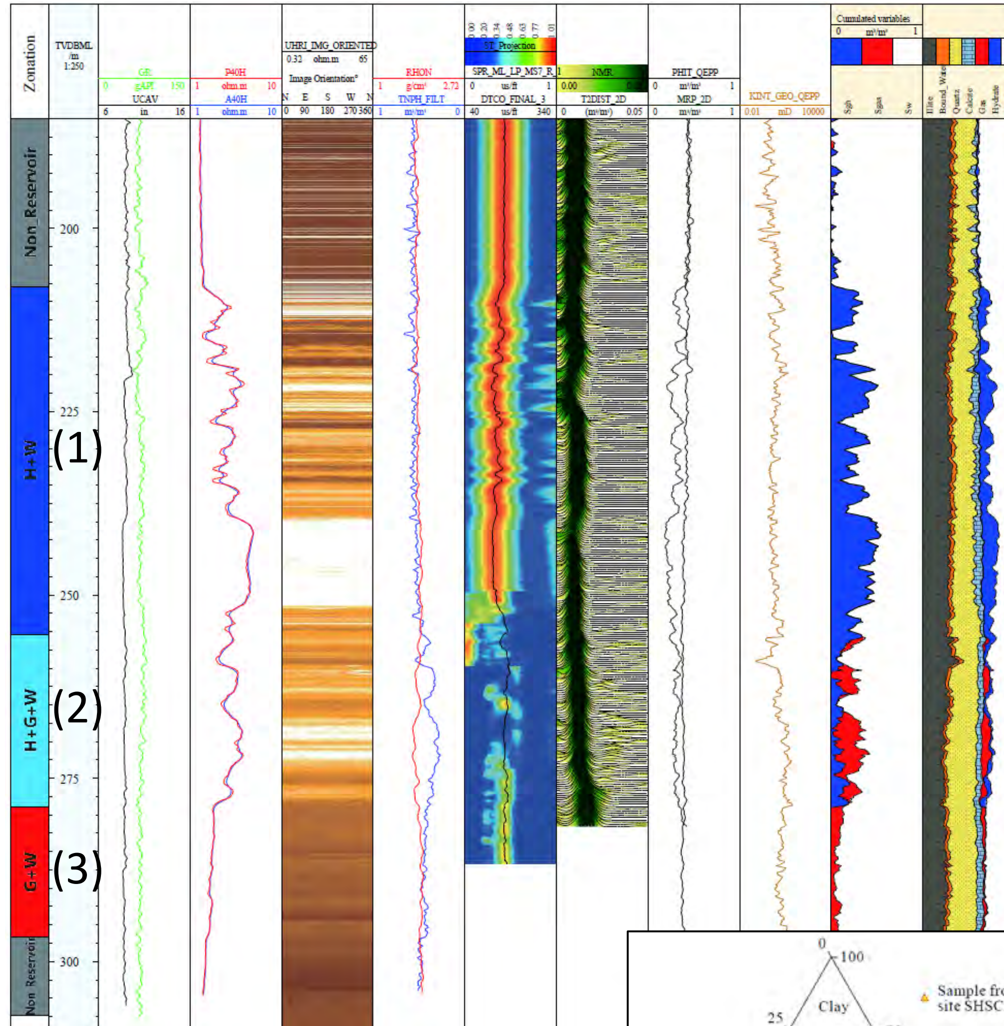


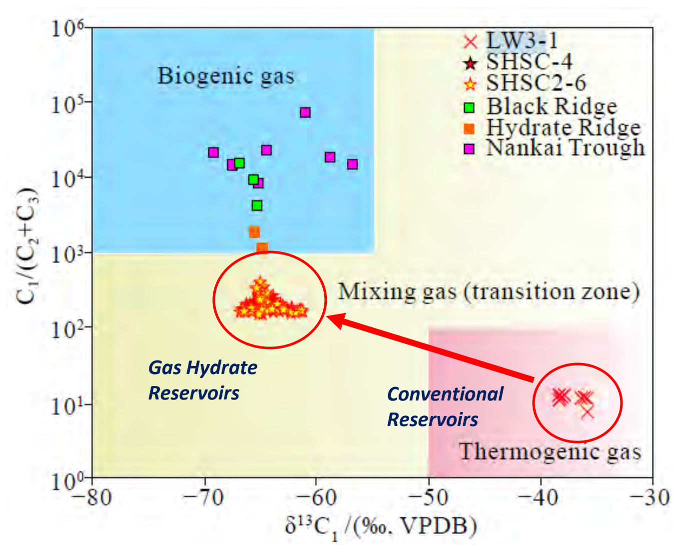


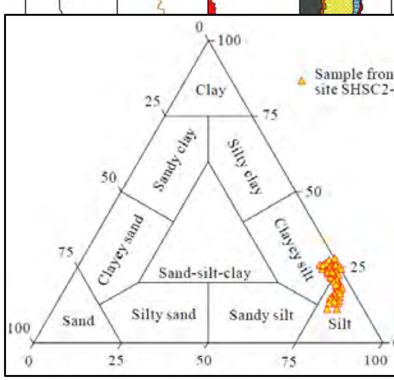
2019/2020 Gas Hydrate Production Test in the South China Sea

GMGS6-SH02: The lithology of reservoir characterized as clayey silt, and argillaceous sandy sediments with “calcareous” minerals.

(1) NGH 45.6 m thick, average effective porosity 37%, NGH saturation 31%, permeability 2.38 mD
(2) NGH 24.6 m thick, average effective porosity 35%, NGH saturation 12%, FG saturation 13 %, permeability 6.63 mD
(3) NGH 19 m thick, average effective porosity 35%, FG saturation 7 %, permeability 6.8 mD







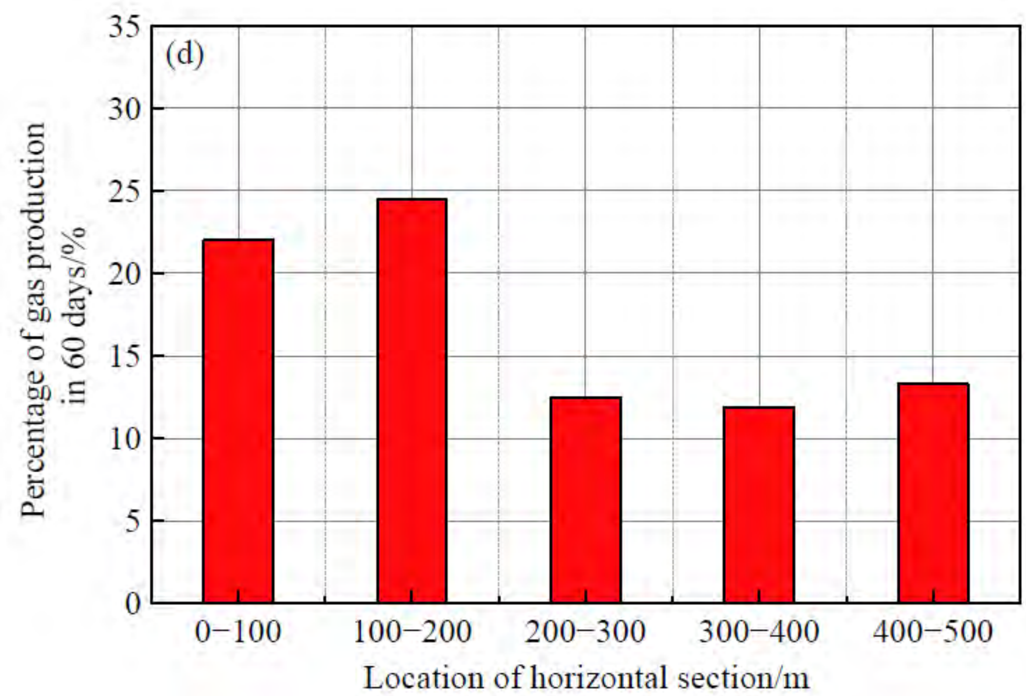
2019/2020 Gas Hydrate Production Test in the South China Sea

Test Results

(1) The horizontal well drilling and exploitation technology for shallow soft strata in deep sea was applied, greatly increasing the contact area between the wellbore and reservoirs.

(2) Thirty days of continuous gas production was achieved in 1225.23 m deep Shenhu Area, South China Sea, with cumulative gas production of 86.14×10^4 m^3. Thus, the average daily gas production is 2.87×10^4 m^3, which is 5.57 times as much as that obtained in the first production test.

(3) A distinctive environmental protection and monitoring system was established, i.e., the "four-in-one" environmental monitoring system of the bottom hole, seafloor,



Percentage of cumulative gas production along the horizonal length of the test well

- ***Nankai Trough, Japan***

  METI-JOGMEC MH21

Japan

Japan

2013 and 2017 Production Tests in Nankai Trough

2013 Field Experiment

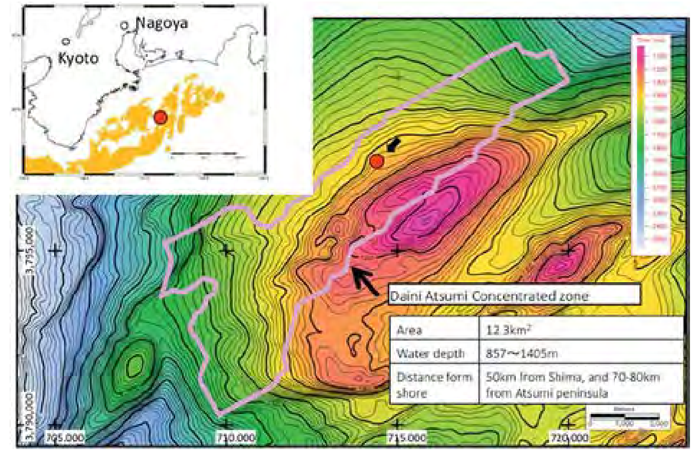
- Demonstration of technical recoverability
- 2 weeks planned: 1 week achieved
- Stable production obtained, but sand production issue
  - Rate of 700,000 ft^3 per day (for 6 days)

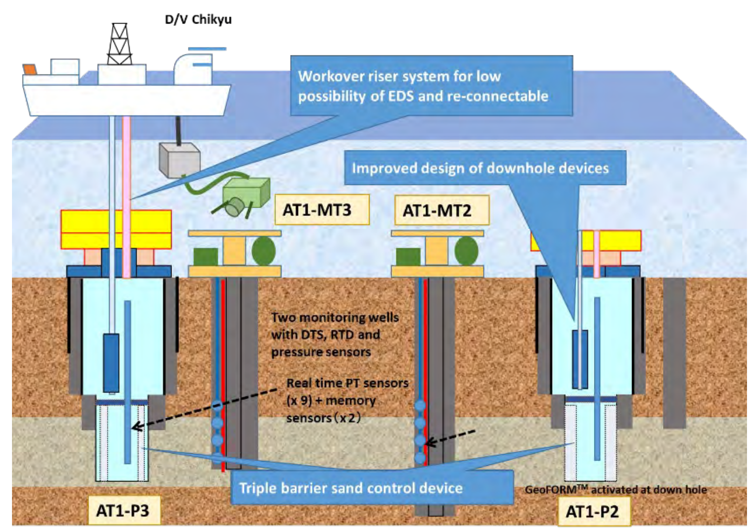
2017 Test

- Goal #1: Solve sand production issue
- Goal #2: Demonstrate increased rates over time

Outcome: per METI: "As a result of this test, while one of the two production wells suffered the sand-intrusion problem, ANRE achieved a certain level of success from the second well, in which no problems occurred. However, ANRE could not clearly confirm an increase in the production rates at either of the wells, leaving challenges in establishing gas production technologies unsolved." The 2017 test included two producer holes (AT1-P2/P3) and two monitoring holes (AT1-MT2/MT3).

- Well #1: Approximately 35,000 m^3 in total in 12 days
  - Rate of 102,083 ft^3 per day
- Well #2: Approximately 200,000 m^3 in total in 24 days
  - Rate of 291,667 ft^3 per day





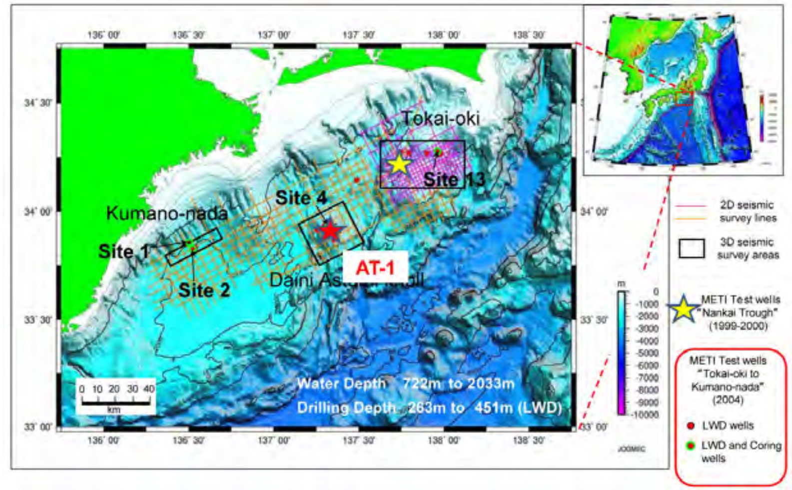
Fujii et al., 2015. Konno et al., 2017

Japan

Gas hydrate commercial production and accumulation reserve size – Koji Yamamoto 2020

Gas Hydrate Commercial Targets

- Production rate
  - Rate of about 1,750,000 ft^3 per day
- Accumulation reserve size
  - Volume 353 billion ft^3

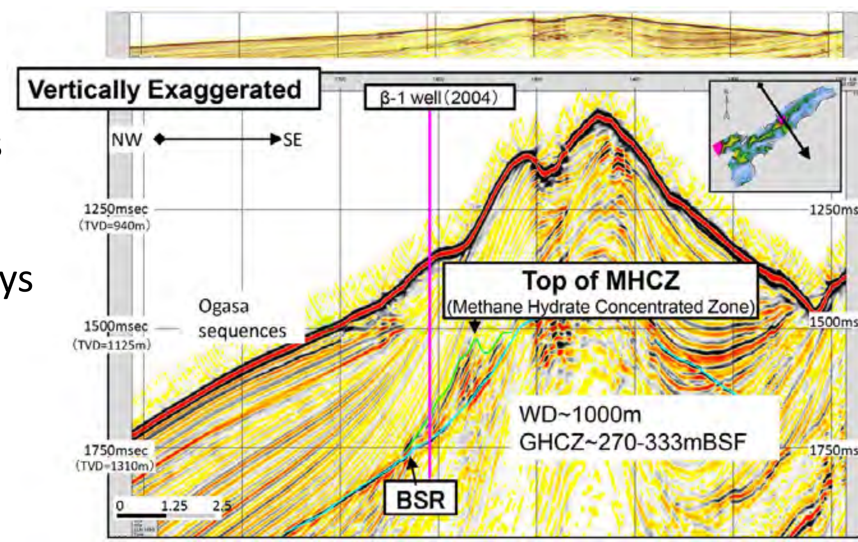


2013 Field Test Production Rate

- Stable production obtained, but sand production issue
  - Rate of 700,000 ft^3 per day (for 6 days)

2017 Field Test Production Rate

- Well #1: Approximately 35,000 m^3 in total in 12 days
  - Rate of 102,083 ft^3 per day
- Well #2: Approximately 200,000 m^3 in total in 24 days
  - Rate of 291,667 ft^3 per day

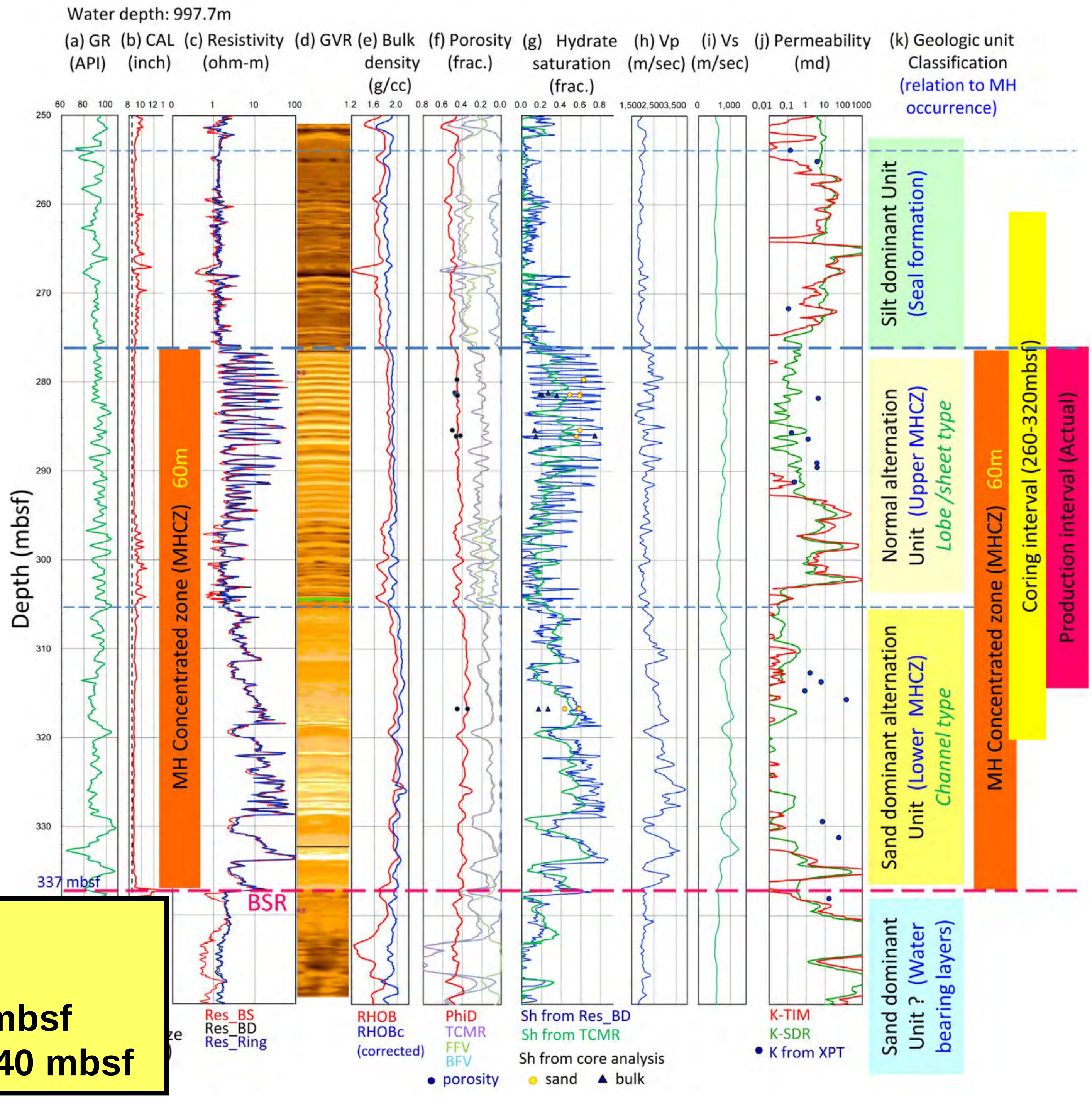


Accumulation Reserve Size

- ?????

JOGMEC
AT1-MC Log and
AT1-C Core Data

Fujii et al, 2015



Test Site:
Water depth 998 m
Reservoir top 277 mbsf
Core interval 250-340 mbsf

JOGMEC Gas Hydrate Production Test - 2013


Kawamoto (CSIS, 2014)

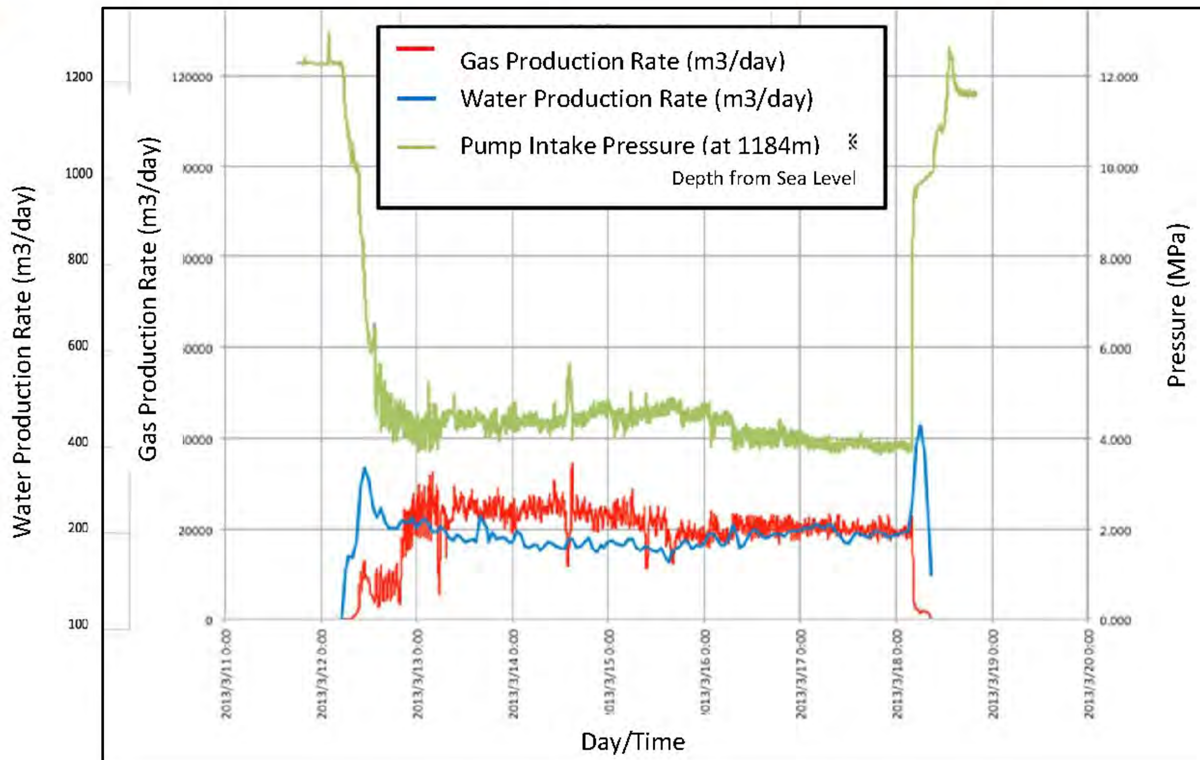
Progress of the Operation (Jan.28-Apr.1, 2013)

- March 12:
  - 5:40: Started flow test, decreasing pressure
  - 9:30: Confirmed gas production considered from methane hydrate formations
  - 10:00: Ignited flaring
- March 18:
  - 4:00: Confirmed sand production
  - 15:00: Completed kill well

Gas Production

- **Duration : approx. 6 days**
- **Cumulative gas production : approx. 120,000m^3**
- **Average gas production : approx. 20,000m^3/day**

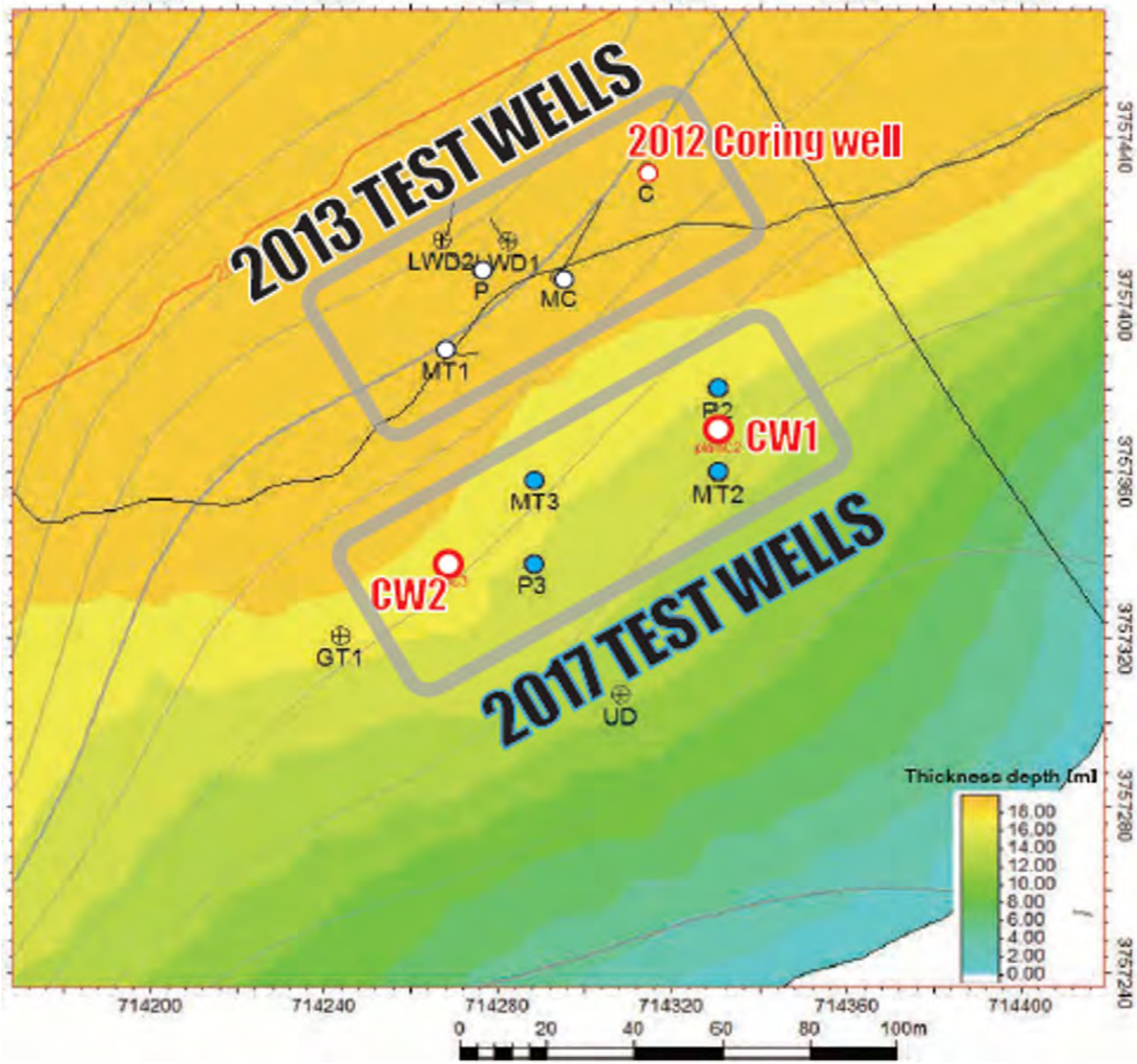
Rate of 700,000 ft^3 per day
Days 6



JOGMEC Gas Hydrate Production Test - 2017

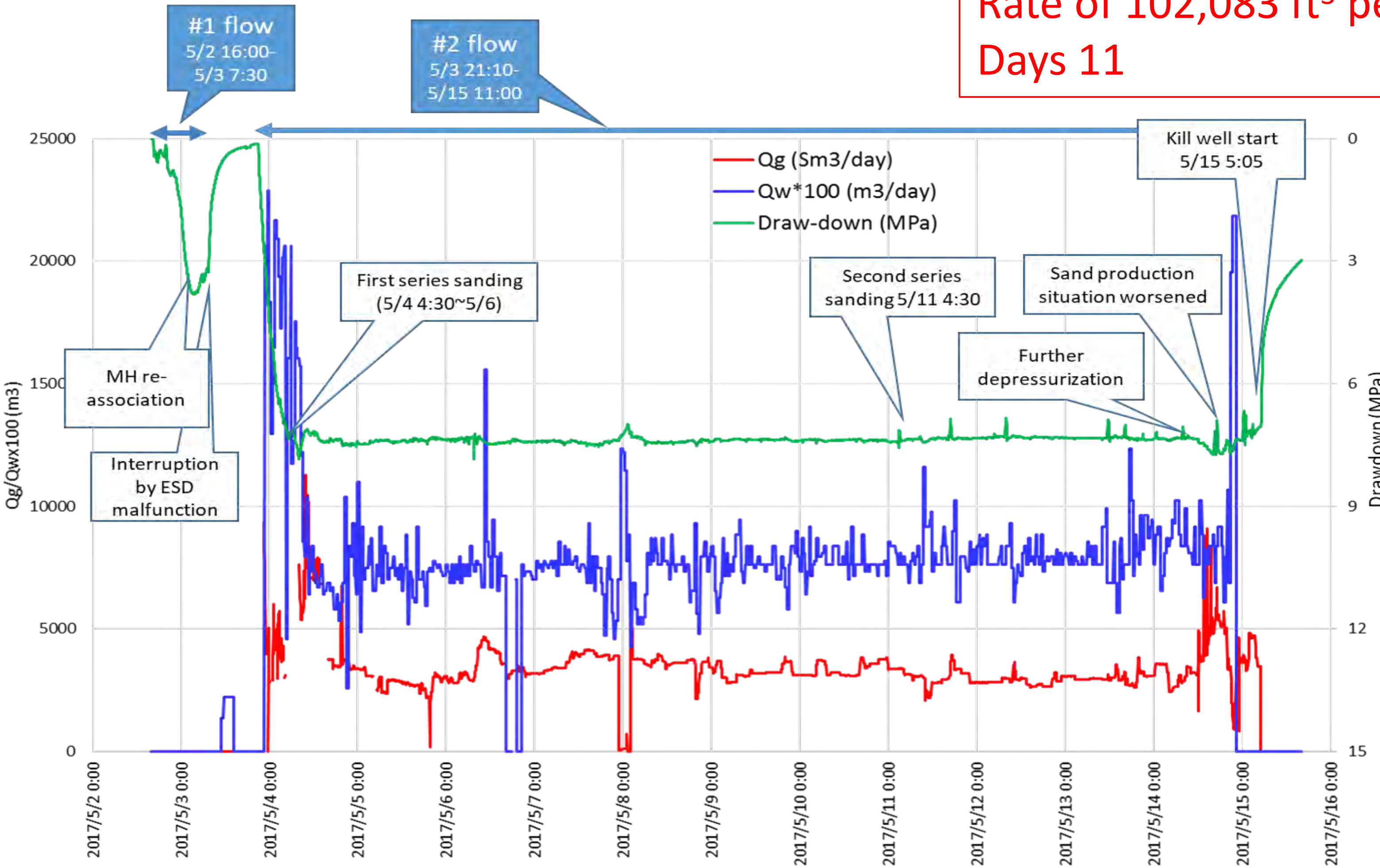
2017-2018 Test Holes:

- Two production holes
  - AT1 P2 and P3
- Two monitoring holes
  - AT1 MT2 and MT3
- Two core holes (2018)
  - CW1 and CW2



2017 Production Testing in Nankai Trough - AT1-P3 Well

Rate of 102,083 ft³ per day
Days 11



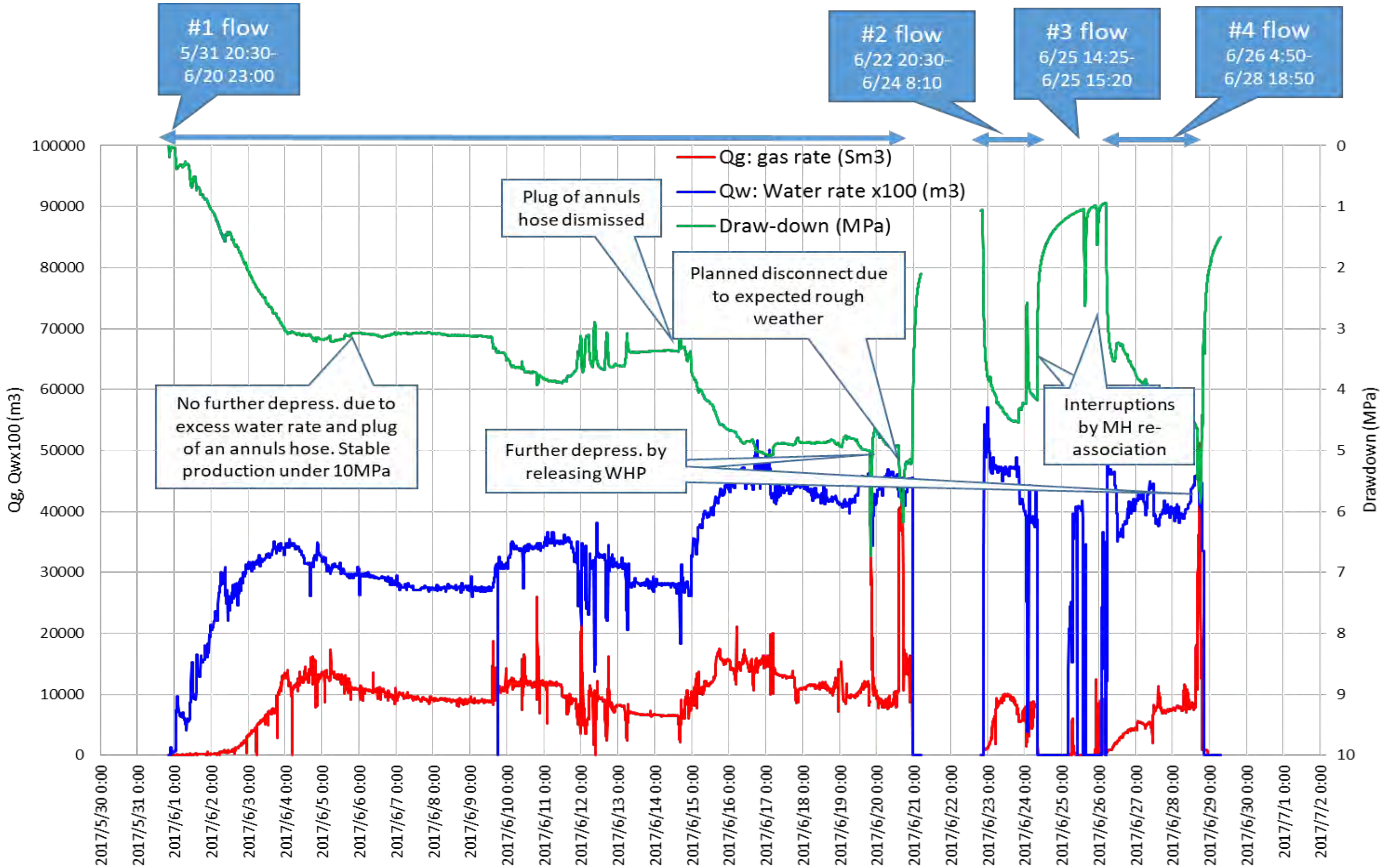
Test Duration
#1 flow 5/2 16:00 to 5/3 7:30 (0d15h30m)
- Interruption by ESD failure activation
#2 flow 5/3 21:10 to 5/15 11:00 (11d13h50m)
Total flow duration: 12d5h20m

Level of Drawdown
7.85 MPa (13.0 MPa – 5.15 MPa)

Cumulative Production
Gas: 40,849.9S m^3
Water: 922.5 m^3

Events
Sand detected during the following:
#1 5/4 4:30 through 5/6 6:00
#2 5/11 5:00 through 5/15 5:00

2017 Production Testing in Nankai Trough - AT1-P2 Well



Test Duration

#1 flow 5/31 20:30 to 6/20 23:00 (20d2h30m)

- Planned disconnect

#2 flow 6/22 20:30 to 6/24 8:10 (1d11h40m)

- Work on flow assurance issue

#3 flow 6/25 14:25 to 6/25 15:20 (0d0h55m)

(2d14h0m)

n

Level of Drawdown

Instantaneous:m6.73MPa (13.0MPa – 6.27MPa)

Stable: 5MPa (13.0MPa – 8MPa)

Cumulative Production

Gas: 222,587.1 Sm^3

Water: 8246.9m^3

Events

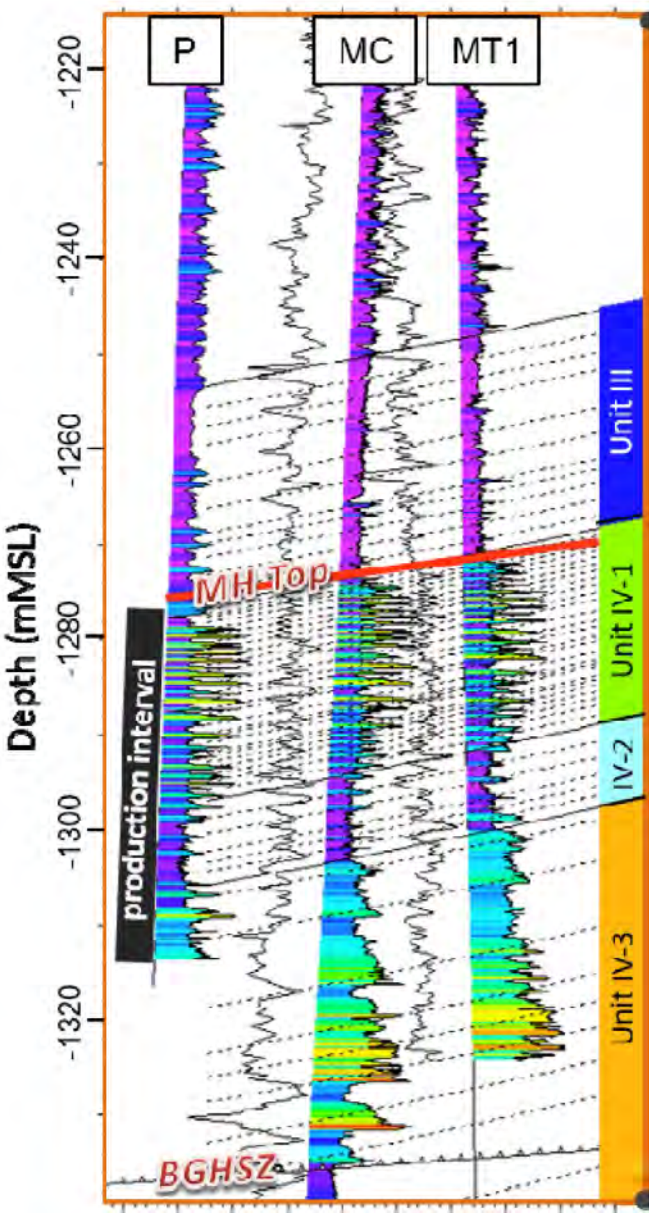
No sand production

Disconnect/Reconnect 6/21 6:15 to 6/22 11:30

Rate of 291,667 ft^3 per day

Days 24

2017 Production Testing in Nankai Trough



Tamaki et al. (2017)

Testing Considerations

- Discrepancy between model predicted and actually observed production behavior, increasing trend in gas rate under constant pressure was not observed.
- Heterogeneity of gas hydrate reservoir (saturation and permeability) properties.
- Hydraulic concerns associated with water-bearing reservoir (lack of a pressure containment).
- Possible impact of secondary gas hydrate formation.

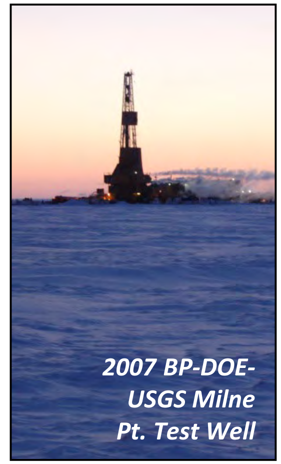
Briefing Outline

1. Gas hydrate scientific and industry drilling
2. International gas hydrate R&D projects
3. IODP gas hydrate related proposals and expeditions
4. European gas hydrate research and drilling programs
   - CAGE, GEOMAR/SUGAR, MARUM, MIGRATE
5. Gas hydrate production R&D projects - Update
   - India, China, Japan
6. **Summary**
7. **Outreach**

Summary - Technical

GH Prospecting - Characterization - Production Technology

- **Application of Petroleum System Concept**
  - Support of gas hydrate prospecting and assessments
- **Target Resource is Substantial**
  - 40,000 tcf globally
  - 10,000 tcf US offshore (BOEM)
  - 53 tcf technical recoverable Alaska (USGS)
- **Base Production Technology Demonstrated**
  - Four successful Arctic permafrost related scientific field tests, additional marine tests in China, Japan, and planned for India
  - Base technology (depressurization) identified
  - Modeled rates encouraging (up to 40 mmscf/d)
  - Recovery should be high (60-80%)
  - Long-term test required; Alaska opportunity in progressing
- **Wells Will be Challenging**
  - Cold reservoirs, low-pressure, etc.
  - Produced water & subsidence concerns
  - Environmental impact monitoring



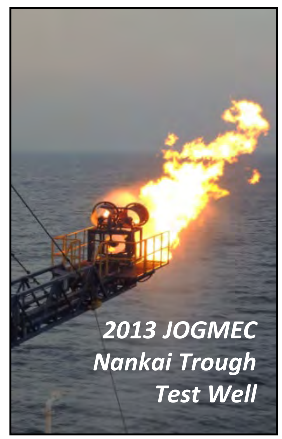
2007 BP-DOE-USGS Milne Pt. Test Well

2002 JNOC-GSC-USGS

2007/08 JOGMEC-NRCan

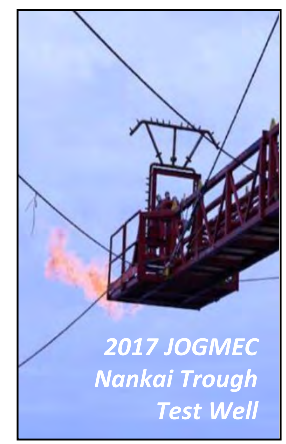
Mallik Test Wells

2011/2012 CP-DOE-JOGMEC Prudhoe Bay Test Well



2013 JOGMEC Nankai Trough Test Well

2017 2019 2020 CGS South China Sea Test Well



2017 JOGMEC Nankai Trough Test Well

Summary - Challenges

GH Prospecting - Characterization - Production Technology

Challenges

- In support of gas hydrate production modeling and testing efforts, continue to develop pressure coring equipment and pressure core analysis capabilities.
- “Scientific” production/mechanical testing designed to maximize scientific insight.
- Testing needs to include advance monitor programs to identify and assess mechanical/environmental response/impacts.
- Further development and calibration of gas hydrate production and mechanical models with results from field testing and pressure cores.
- “Demonstration” production/mechanical tests designed to maximize rates and establish deliverability.

Gas Hydrate Research Meetings/Conferences

- 2020 International Continental Scientific Drilling Program, ICDP Town Hall: Dec-2020
- 2021 Core-Log-Seismic Integration Center Workshop: April-2021
- 2020 AAPG Annual Convention & Exhibition Gas Hydrate Technical Session and EMD What's New in Energy Minerals Session (AAPG Explorer article); thanks to Peter Flemings & Dan McConnell: Sept-2020
- 2021 AAPG Annual Convention & Exhibition: Gas Hydrates and Hydrocarbons of the Future: May-2021
- 2021 10th International Conference on Gas Hydrates: July-2021
- 2020 Gordon Research Conference on Gas Hydrates: Feb-2020 (approved March-2022)

icdp **news:** winter **2020**

icdp | INTERNATIONAL CONTINENTAL SCIENTIFIC DRILLING PROGRAM

Virtual **ICDP & LacCore**

Town Hall Meeting on 7 Dec

ICDP kindly invites you to attend online the ICDP Town Hall Meeting on December 7th, 2020. This Town Hall Meeting will be a great opportunity to meet ICDP representatives and scientists for program updates, future developments and to discuss continental Scientific Drilling. The meeting will be jointly held with colleagues of the US CSDCO and is accessible through:

https://us02web.zoom.us/j/83270434770
Meeting-ID: 832 7043 4770
Code: ICDP

Date and Time: 7th December 2020, 4pm Central European Time, 7am Pacific Standard Time, 10am Eastern Standard Time, 11pm China Standard Time.

CLS-I CORE LOG SEISMIC INTEGRATION CENTER

Inaugural Workshop, April 15-16, 2021, GEOMAR Helmholtz Centre for Ocean Research Kiel

The Helmholtz research centres GEOMAR, AWI and GFZ are planning an inaugural workshop (April 15-16, 2021, at GEOMAR in Kiel) to open a new virtual research centre for core-log-seismic integration. ***Our vision is to establish a collaborative network of experts in the various fields of core-log-seismic integration, with the central aim of developing new research projects across academia and industry.***

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Dr. Ulrich Harms	Head of Scientific Drilling Working Group Helmholtz Research Centre for Geosciences (GFZ) Potsdam E: ulrich.harms@gfz-potsdam.de T: +49 331 288-1085
Dr. Karsten Gohl	Head of Geophysics Section Alfred Wegener Institute Helmholtz-Centre for Polar and Marine Research (AWI), Bremerhaven E: karsten.gohl@awi.de T: +49 471 4831-1361
Dr. Simona Pierdominici	Research Scientist Helmholtz Research Centre for Geosciences (GFZ) Potsdam E: simona.pierdominici@gfz-potsdam.de T: +49 331 288-1083

ACE 2021 23-26 MAY DENVER
INCORPORATING — THE SEPM — ANNUAL MEETING
AAPG ANNUAL CONVENTION & EXHIBITION

AAPG-ACE 2021 Abstract Solicitation
American Association of Petroleum Geologists Annual Convention & Exhibition
EMD Theme of "New Energy Frontiers, Critical Minerals, and Planetary Geology"

Gas Hydrates and Hydrocarbons of the Future

Theme 9: New Energy Frontiers, Critical Minerals, and Planetary Geology
Theme 9 represents the domain of greatest uncertainty in the energy mix and (perhaps) the coming great waves of opportunity, where to invest long-term, what disruptions may await, what resources and new technologies may be transformational, how may the futures of energy and minerals be intertwined?

AAPG-ACE 2021 Abstract Solicitation Directions: The AAPG 2021 Annual Convention and Exhibition (ACE) is scheduled to be convened in **Denver, Colorado, 23–26 May 2021**; which may also be convened as a virtual meeting. You can upload your abstracts at the following website by the **14-January-2021** *https://ace.aapg.org/2021*

COVID-19 Notices

In view of the COVID-19 related travel restrictions and difficulties to obtain travel approval by the end of this year, the ICGH10 has been postponed to *18 July to 23 July 2021*. The deadlines for early bird registration is extended until *16 April 2021*. Further updates will be shared shortly in the website and via email. Sorry for the inconvenience and we thank you for your support.

Conference Timeline and Important Dates

April 16, 2021	**Early Bird Registration closes; Regular Registration opens (extended)**
TBA	Conference program available
June 30, 2021	**Regular Registration closes; Late Registration opens (extended)**
July 16, 2021	Closure of Online Registration
July 18, 2021	**ICGH10 begins**
July 23, 2021	**ICGH10 ends**

Natural Gas Hydrate Systems

Gordon Research Conference

March 13 - 18, 2022

Apply Now

Chair
Zachary M. Aman

Vice Chair
Judith M. Schicks

Contact Chairs

Hotel Galvez
2024 Seawall Boulevard
Galveston, TX, US

Venue and Travel Information

Application Information

Applications for this meeting must be submitted by **February 13, 2022**. Please apply early, as some meetings become oversubscribed (full) before this deadline. If the meeting is oversubscribed, it will be stated here. *Note*: Applications for oversubscribed meetings will only be considered by the conference chair if more seats become available due to cancellations.

Conference Description

The chair is currently developing a description for this conference. This information will be available by **May 13, 2021**. Please check back for updates.

Related Meeting

This GRC will be held in conjunction with the "Natural Gas Hydrate Systems (GRS)" Gordon Research Seminar (GRS). Those interested in attending both meetings must submit an application for the GRS in addition to an application for the GRC. Refer to the associated GRS program page for more information.

Conference Links

- Conference History
- Natural Gas Hydrate Systems (GRS)
- Contribute Financially to This Conference
- Conference Fees
- Similar Conferences

Poster Information

The 2020 Business Model – Looking Forward
Domestic and International Gas Hydrate Cooperative Projects and Working Groups

<u>Special Working Groups</u>

- International Code Comparison Study (2018-2020; JMPG, September 2020)
- Pressure Core Working Group - Yi Fang, University of Texas Austin

<u>Gulf of Mexico</u>

- University of Texas-Austin: (1) Operational and Science Planning Team, (2) GOM Drill Site Review and Selection Team, and (3) Pressure Core Development Team

<u>Alaska (Japan)</u>

- Extended Duration Scientific Reservoir Response Test at Site 7-11-12, Prudhoe Bay Unit - Operational Plan (US-DOE, USGS, JOGMEC/TOYO/AIST, long list of research partners and contractors

<u>Colorado School of Mines</u>

- Geophysics: Alaska North Slope 4D seismic data model, processing, analysis cooperative
- Petroleum Engineering / Chemical Biologic Engineering: Gas hydrate production "stimulation" research cooperative

RED TEXT = Working/Commination Groups with USGS participation

The 2020 Business Model – Looking Forward
Domestic and International Gas Hydrate Cooperative Projects and Working Groups

<u>US – International Gas Hydrate Formal Agreements</u>

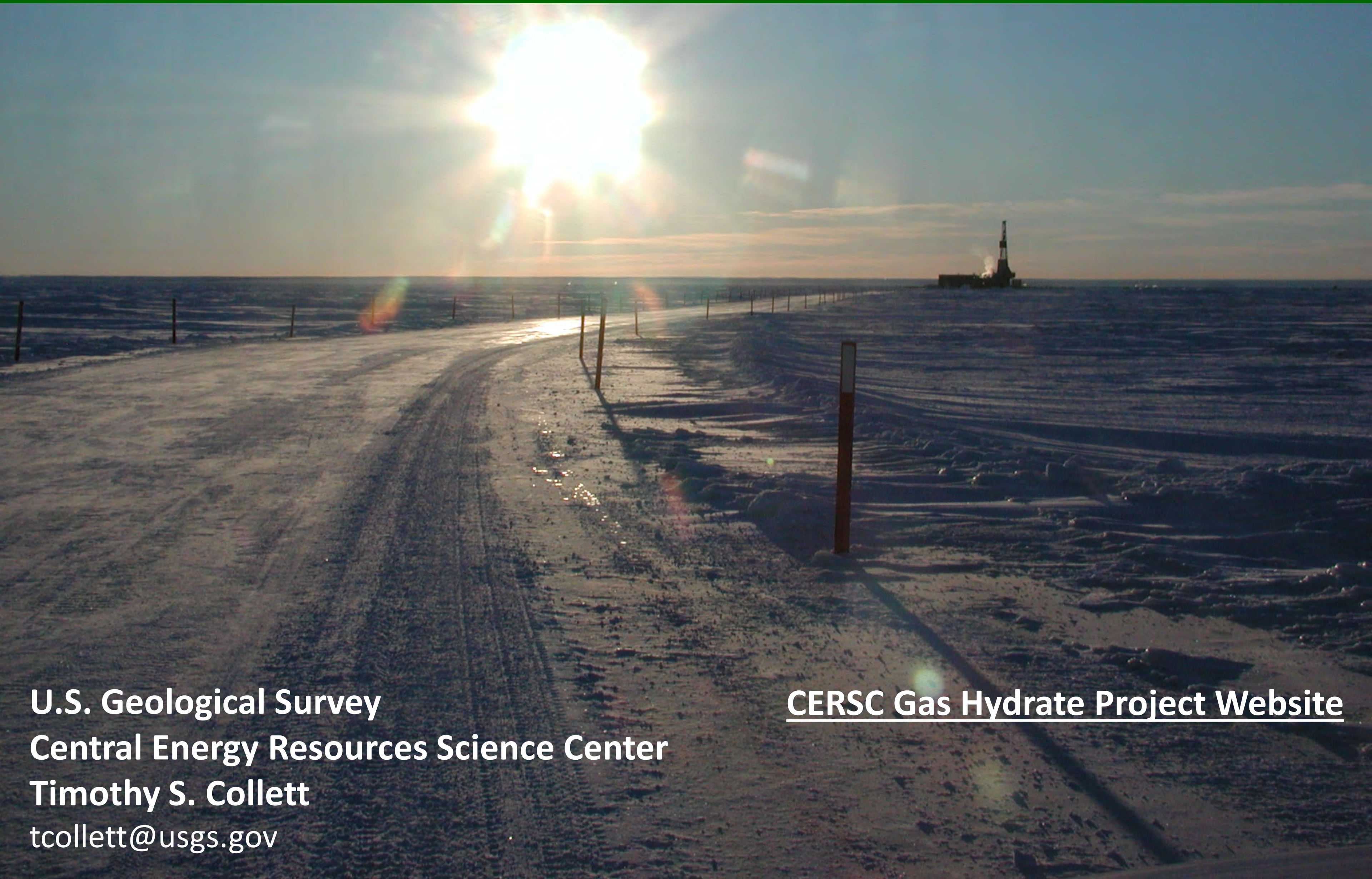
US/Japan: DOE – METI	Statement of Intent
US/Japan: NETL – JOGMEC	MoU
US/Japan: NETL – JOGMEC	CRADA
US/Japan: USGS – AIST	Letter of Intent
US/India: DOE – MoPNG	MoU
US/India: USGS – DGH/MoPNG	MoU
US/Korea: DOE – MKE	Statement of Intent
US/Korea: USGS – KIGAM	Letter of Agreement

<u>Consideration</u>

Based on the success of the FITI Newsletter would there be value in considering a virtual FITI Lecture Series?

USGS Gas Hydrate Project

USGS Energy Resources Program



U.S. Geological Survey
Central Energy Resources Science Center
Timothy S. Collett
tcollett@usgs.gov

CERSC Gas Hydrate Project Website