CELEBRATING
50 YEARS
1969–2019

OTC 2019 to Host Gas Hydrate Events on Wednesday May 8th

This year's Offshore Technology Conference (OTC 2019) is quickly approaching and is scheduled to host two oral sessions on gas hydrate research, as well as a luncheon on gas hydrate R&D history. All three events will take place on Wednesday, May 8th:

9:30 am – noon Technical Session: New Developments in Gas Hydrate Production

International drilling and coring programs are making significant contributions to our understanding of the energy resource potential of gas hydrates. Results of some of the major international efforts will be presented during this session. Chaired by George Moridis, Lawrence Berkeley National Laboratory and Greg Easson, University of Mississippi.

12:15 pm -1:45 pm Luncheon: Gas Hydrate R&D History as a Guide to the Future

The luncheon session will include a brief history of hydrate science and engineering, followed by a discussion of landmark achievements from major hydrate flow assurance laboratories. The potential for hydrates as an energy resource will be discussed from a historic perspective, and lessons of the past will be summarized as a guide to future innovation. Chaired by Timothy Collett, US Geological Survey; Moderated by Norman Carnahan, Carnahan Corporation; Speaker E. Dendy Sloan, Professor Emeritus, Colorado School of Mines.

2:00 pm - 4:30 pm Technical Session on Advances in Gas Hydrate Production Technology

Because conventional production technologies favor sand-dominated reservoirs, these are considered the most viable economic target for gas hydrate production. Talks in this session will focus on past and future gas hydrate production studies and production technologies. Chaired by Norman Carnahan and Timothy Collett.

For more information on these events and the OTC meeting, please visit the OTC 2019 Technical Program at http://2019.otcnet.org/seminar.

Gordon Research Conference on Gas Hydrate Systems, February 23-28, 2020

Gordon Research Conferences
Frontiers of Science

The 2020 Gordon Research Conference (GRC) will be held in February, 2020 on "Nonequilibrium Controls on the Formation and Dissociation of Gas Hydrates in Natural and Engineered Systems." The conference is intended to bring together academic, government, and industry researchers to discuss gas hydrate formation, evolution, and destruction in natural and engineered systems. The conference program this year will consist of nine sessions:

- Keynote Session: Dynamic Controls on the Formation and Dissociation of Gas Hydrates
- Thermodynamic and Kinetic Properties of Multicomponent Gas Hydrate Systems
- Processes Controlling Multiphase Gas Hydrate Systems in Nature
- Gas Hydrate Related Physical, Chemical and Biological Processes
- Detection and Characterization of Gas Hydrate Systems
- Impact of Gas Hydrate Occurrence and Dissociation on Their Host Environment
- Planetary Ices and Gas Hydrates
- Characterization of Various Types of Gas Hydrate Occurrences and Systems
- Integrated Modeling of Gas Hydrate Systems from Formation to Dissociation

The GRC 2020 will be held at the Hotel Galvez in Galveston, TX. The GRC 2020 chair is Timothy Collett, and the vice chair is Zachary Aman. The preliminary program for the GRC will be available July 1, 2019.

Applications for the meeting must be submitted by January 26, 2020, but early applications are strongly encouraged!

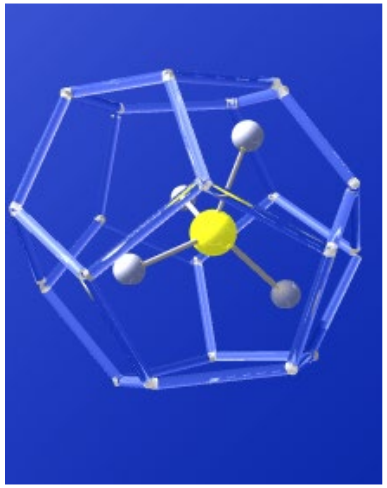
For more information, please visit https://www.grc.org/natural-gas-hydrate-systems-conference/2020/

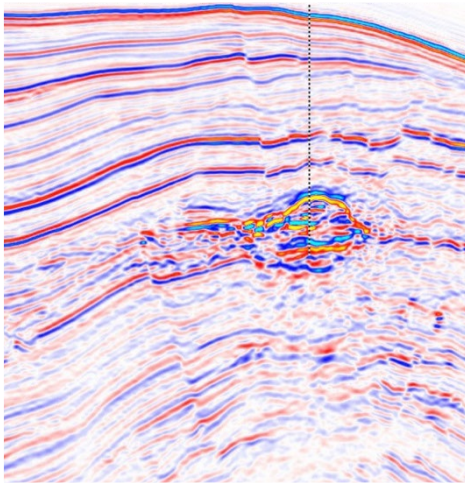
10Th International Conference on Gas Hydrates in Singapore, June 21-26, 2020

The Tenth International Conference on Gas Hydrates (ICGH10) will be held in Singapore on June 21-26, 2020 at the Suntec Singapore International Convention and Exhibition Centre. The event is jointly organized by the National University of Singapore, InPrEP Pte Ltd., and AIChE Singapore Local Section.

ICGH10 is intended as an active platform for the international gas hydrates community to review research developments that have occurred over the previous three years, to foster synergistic collaboration and professional networking, and to plan near-term and long-term research objectives. The organizers anticipate topics related to all facets of gas hydrate research, including gas hydrate fundamentals, gas hydrate technologies, gas hydrate exploration and recovery, flow assurance, and environmental impacts.

Additional information and periodic updates are available at www.icgh10.com




Current Activities of the International Hydrate Drilling Programs

Timothy S. Collett

U.S. Geological Survey

Colorado School of Mines

Methane Hydrate Advisory Committee Meeting

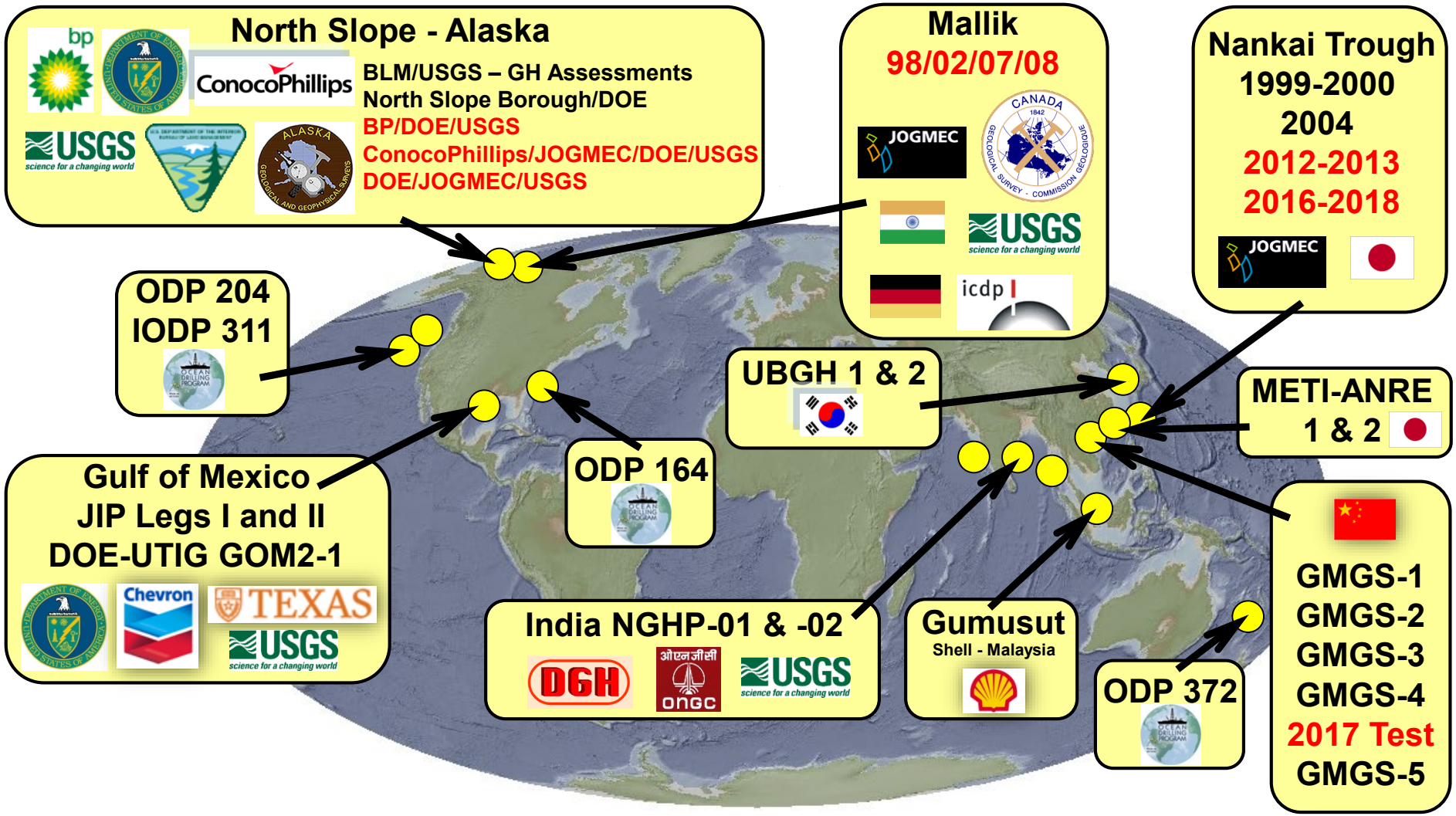
April 23-24, 2019

USGS
science for a changing world

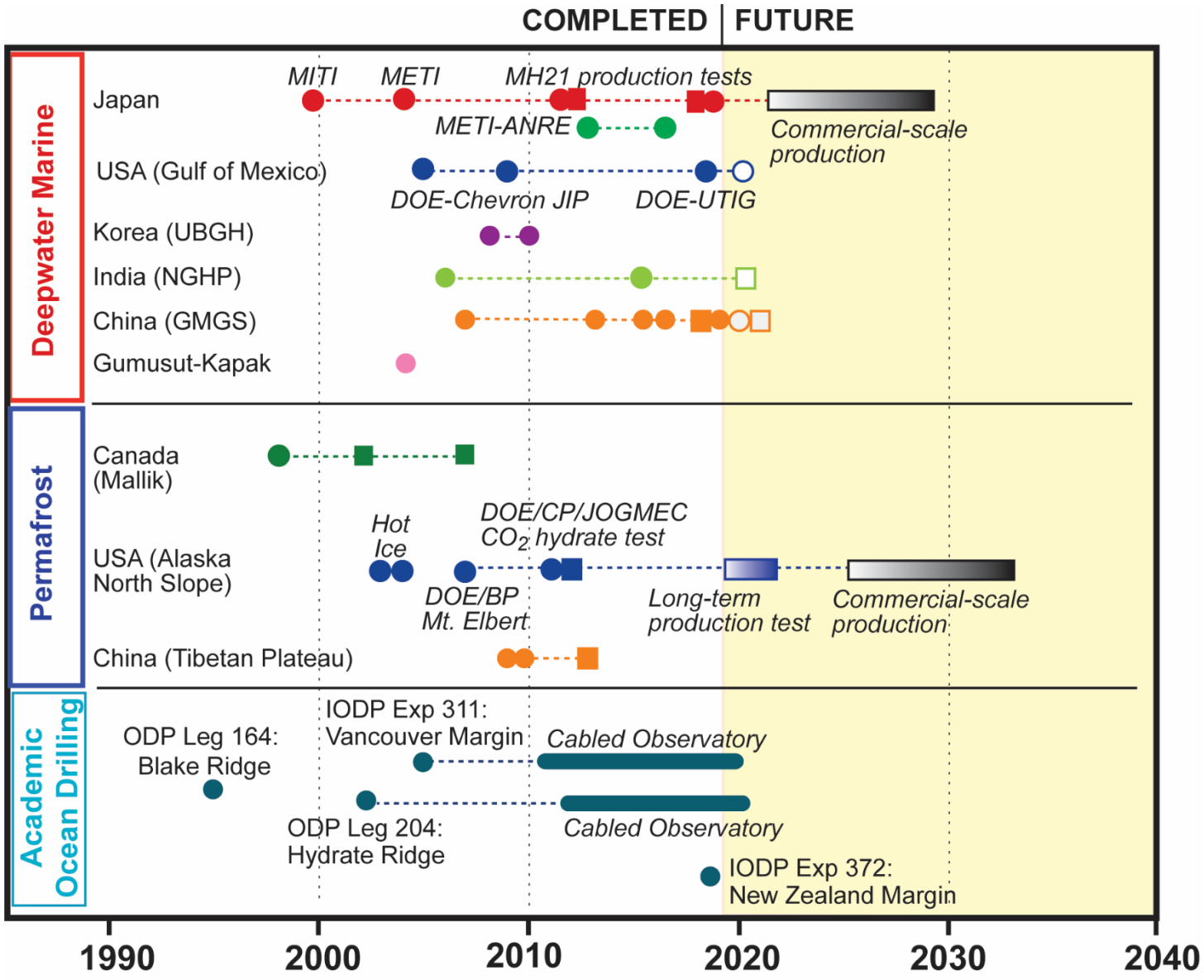
Briefing Outline

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
   -MIGRATE, CAGE, GEOMAR/SUGAR, MARUM
   - New Zealand, Svalbard, Black Sea, Taiwan
5. Gas hydrate production R&D projects - Update
   - Korea, India, China
6. 2017 METI/JOGMEC Nankai Trough Gas Hydrate Test - Results
7. Summary

Gas Hydrate Scientific and Industry Drilling

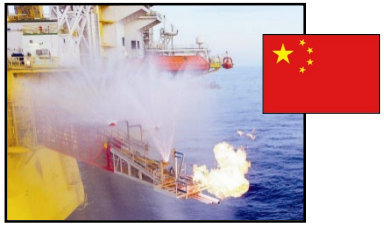


Gas Hydrate Scientific and Industry Drilling



International R&D

- **Japan**
  - *1998-2013: Collaboration on Arctic and marine international projects*
  - *2013: One-week marine production test*
  - *2014/2019: METI-ARNE Japan Sea project*
  - *2016/17: Extended (12 and 14 day) marine production test*
  - *2014/2016-19: Collaboration USA: Ignik Sikumi and Extended Prod. Test*
  - *April 2019: Three year extension to MH21*



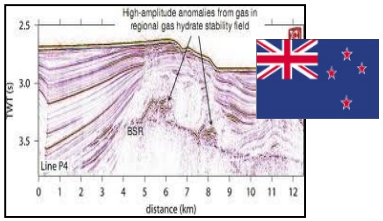
- **China:**
  - *2007 & 2013 & 2015: GMGS-1 & GMGS-2 & GMGS-3 expeditions*
  - *2007 through 2014: Onshore "tests"*
  - *2016 GMGS-4 expedition*
  - *2017 Geological Survey of China SCS production test*
  - *2017 GMGS-5*
  - *Possible: Multi-well production test*

- **India**
  - *2006: NGHP-01 expedition*
  - *2009-2014: Site review collaboration*
  - *2015: NGHP-02 expedition*
  - *2019: JMPG Special Issue SRV NGHP-02*
  - *Proposed: NGHP-03 gas hydrate production testing (2-3 months)*

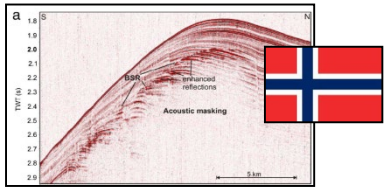
International R&D

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

- **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)*



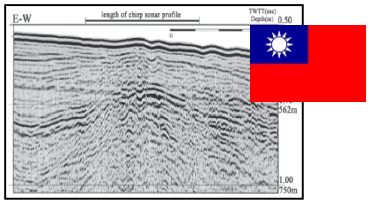
- **New Zealand**
  - *Gas Hydrate on the Hikurangi Margin, GNS, Univ. of Auckland*
  - *NETL support NRL/GNS Co-Op and Stanford Univ (PetroMod)*
  - *IODP Expedition 372 (11/17-01/18) Geomechanical/Deformation*



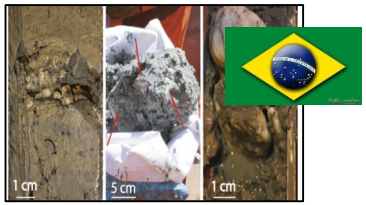
- **Norway**
  - *Gas hydrate global screening & production studies, Statoil/Equinor*
  - *CAGE, Centre for Arctic Gas Hydrate Environment and Climate (Tromsø)*

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

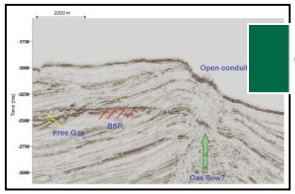
International R&D



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

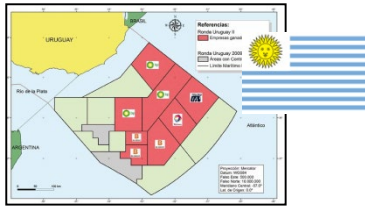


- **Brazil**
  - *Petrobras – Energy and Geohazard focus studies ?*
  - *Academic and related IODP proposals*



- **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) Alberto 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**

- **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

- **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

- **885-Pre (2015) J. Bahk: Ulleung Basin gas hydrates and submarine landslides: climate-driven hazards; Ulleung Basin, Korea**

- **910-Full (2018) Alberto Malinverno: Carbon cycling in methane-charged continental margin sediments: Rio Grande Cone; Brazil Atlantic margin**

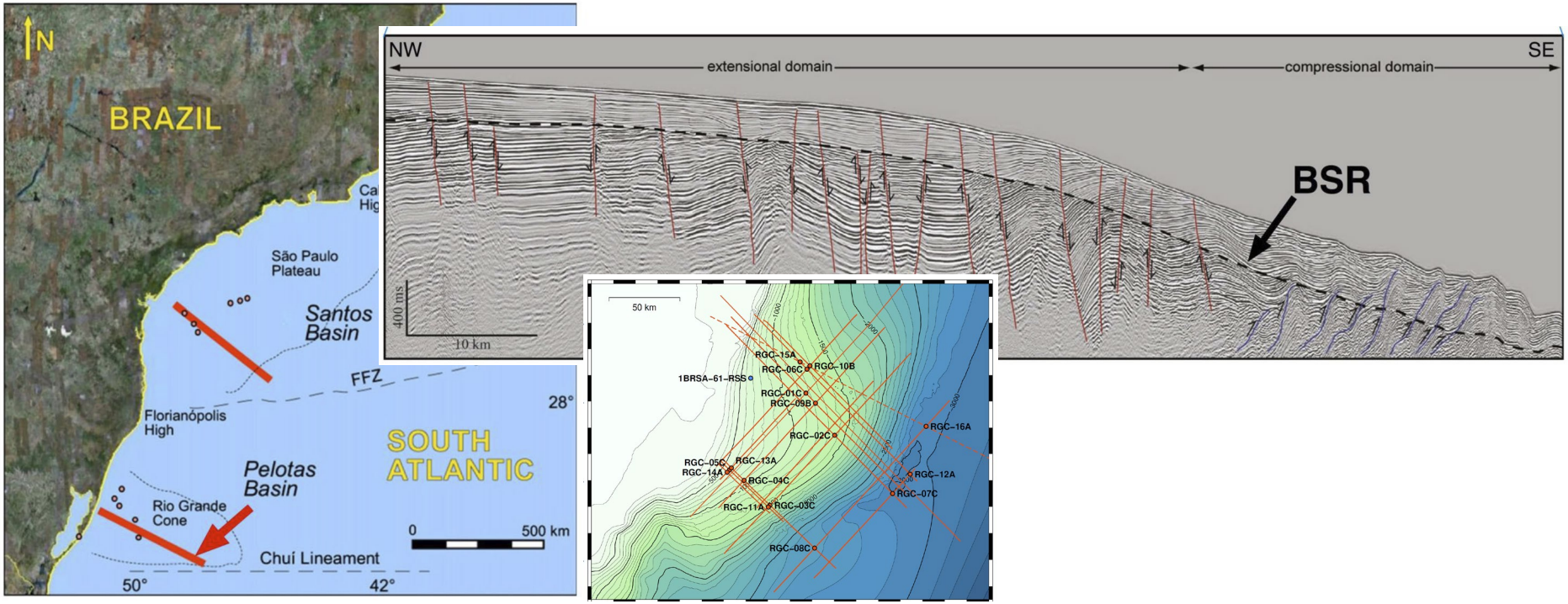
- **935-Full (2019) Stefan Bünz: Pleistocene evolution of Arctic gas hydrates and fluid flow Systems – POLARIS; Fram Strait**

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.



European Union and Other Major European Gas Hydrate Research Programs

MIGRATE -
Marine gas hydrate - an indigenous resource of natural gas for Europe
EU research coordination effort: Study areas span the European continental margins, including the Black Sea, the Nordic Seas, the Mediterranean Sea and the Atlantic Ocean.

MIGRATE Working Groups (WG)
WG 1: Resource assessment
WG 2: Exploration, production, and monitoring technologies
WG 3: Environmental challenges
WG 4: Integration, public perception, and dissemination

MIGRATE Members (for complete list see https://www.migrate-cost.eu/members)
GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany (Wallmann/Ulbrich)
CAGE-Center for Arctic Gas Hydrate, Environment and Climate, Norway (Bunz)
Helmholtz Centre Potsdam German Research Centre for Geosciences GFZ, Germany (Schicks)
Aristotle University of Thessaloniki, Greece (Sismani)

European Union and Other Major European Gas Hydrate Research Programs

MIGRATE Members (for complete list see https://www.migrate-cost.eu/members)

University of Southampton, UK
National Oceanography Centre, Southampton, UK
Heriot-Watt University, UK
British Geological Survey, UK
The University Centre in Svalbard, Norway
University of Vigo, Spain
Dokuz Eylul University, Turkey
National Institute of Oceanography and Applied Geophysics, Italy
Geological Survey of Denmark and Greenland, Denmark
Geological Survey of Spain, Spain
Portuguese Institute for Sea and Atmosphere, Portugal
University of Haifa, Israel
Israel Oceanographic and Limnological Research, Israel
Irish Shelf Petroleum Studies Group, Ireland
University of Aveiro, Portugal
University College Dublin, Ireland
Institute of Oceanology, Bulgaria
Spanish Institute of Oceanography, Spain
University of Gent, Belgium
Ifremer, France
University of Bergen, Norway

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

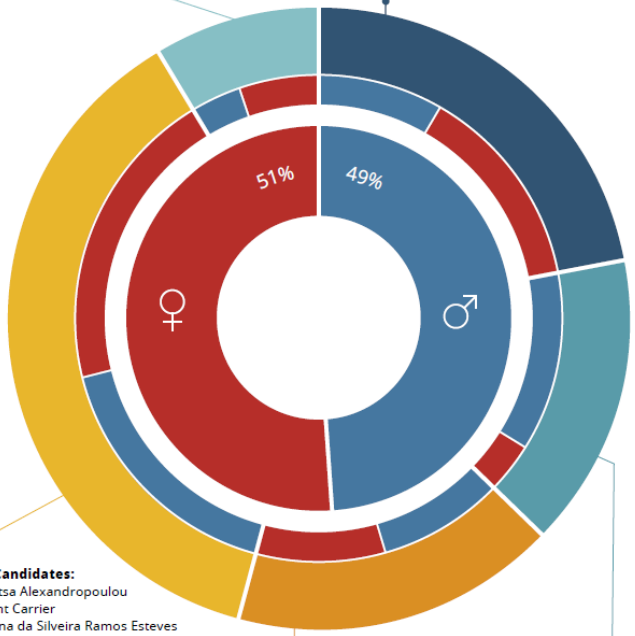
GEOMAR: GEOMAR Helmholtz Centre for Ocean Research Kiel
SUGAR: Submarine Gas Hydrate Reservoirs (SUGAR I-III 2008-2018)

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 University of Tromsø, Norway

Adminstrative and technical staff:
Jessica Green, Communications advisor (temporary)
Matteus Lindgren, Manager, Mass Spectrometer Laboratory
Fabio Sarti, Data manager
Lone Smelror, Administrative coordinator
Maja Sojtaric, Communications advisor

Senior scientific staff:
Karin Andreassen, Director, Temp Leader WP2, Professor
Stefan Bünz, Temp Assist. Director, Leader WP1/Professor
Bénédicte Ferré, Leader WP4, Researcher
Alun Hubbard, Professor
Jochen Knies, Assist. Director, Leader WP5, Researcher
Renata Lucchi, Adjunct Professor
Jürgen Mienert, Professor
Helge Niemann, Adjunct Professor
Giuliana Panieri, Research School Leader, Adjunct Professor
Tine L. Rasmussen, Leader WP6, Professor
Mette Marianne Svenning, Leader WP3, Professor
Monica Winsborrow, Assist. Director, Leader WP2, Researcher
Katarzyna Zamelczyk, Co-leader WP6, Researcher



PhD Candidates:
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Mariana da Silveira Ramos Esteves
Knut Ola Dølven
Naima El Bani Altuna
Pär Gunnar Jansson
Deniz Koseoglu
Katarzyna Melaniuk
Manuel Moser
Siri Ofstad
Kärt Paiste
Emilia Piasecka
Andrea Schneider
Pavel Serov
Muhammed Fatih Sert
Calvin Shackleton
Sunny Singhroha
Espen Valberg
Malin Waage
Kate Waghorn
Haoyi Yao
Emmelie Åström

Postdoctoral Researchers:
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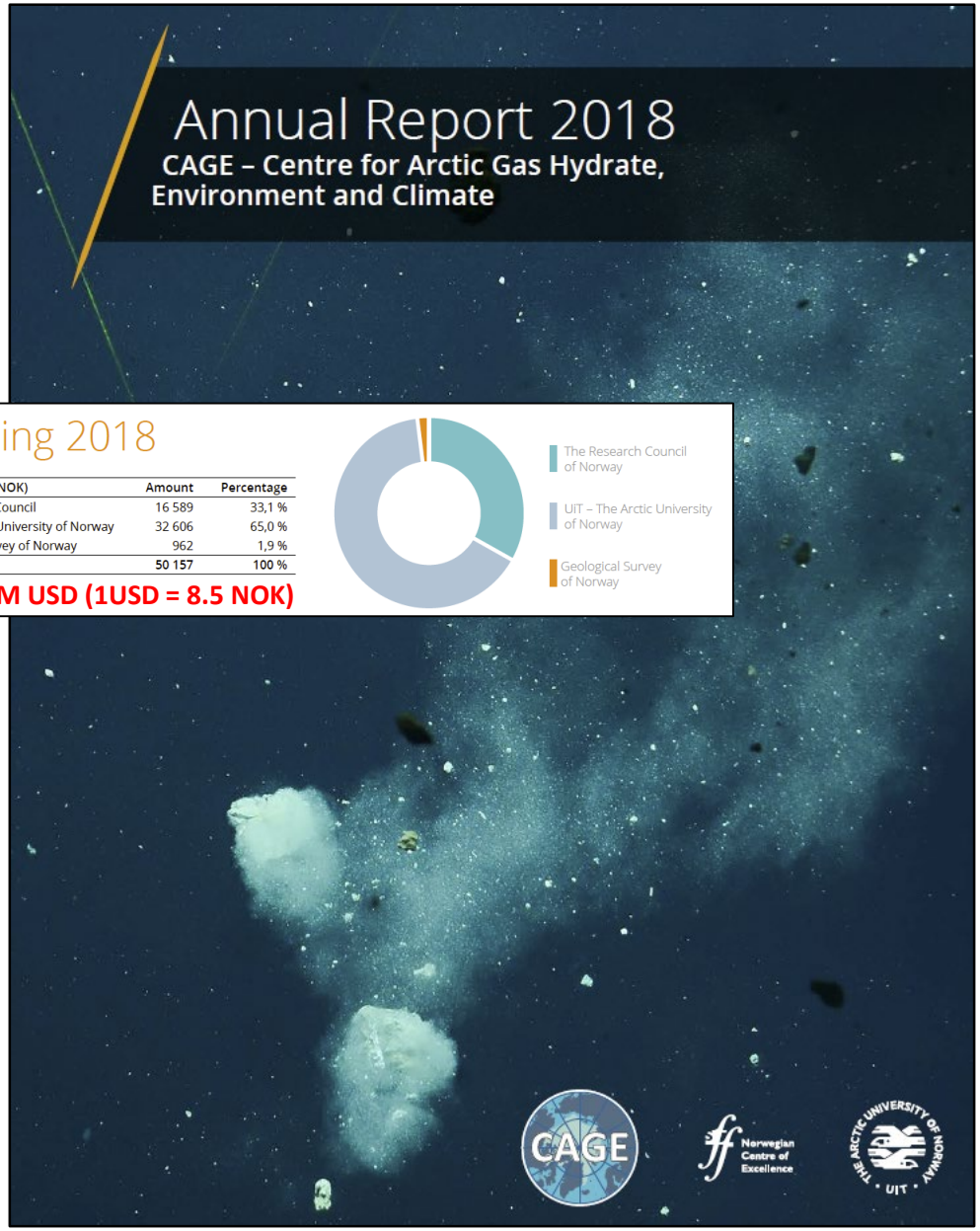
Pierre-Antoine Dessandier
Mohamed Ezat
Friederike Gründger
Tobias Himmler
Wei Li Hong
Dimitri Kalenitchenko
Simone Sauer
Christiane Schmidt
Arunima Sen

Researchers:
Michael Carroll
Shyam Chand
Karl Fabian
Andreia Plaza Faverola
Aivo Lepland
Henry Patton
Anna Silyakova
Terje Thorsnes
Sunil Vadakkepuliyambatta



Funding 2018

Funding (1000NOK)	Amount	Percentage
The Research Council	16 589	33,1 %
UiT The Arctic University of Norway	32 606	65,0 %
Geological Survey of Norway	962	1,9 %
Total	50 157	100 %

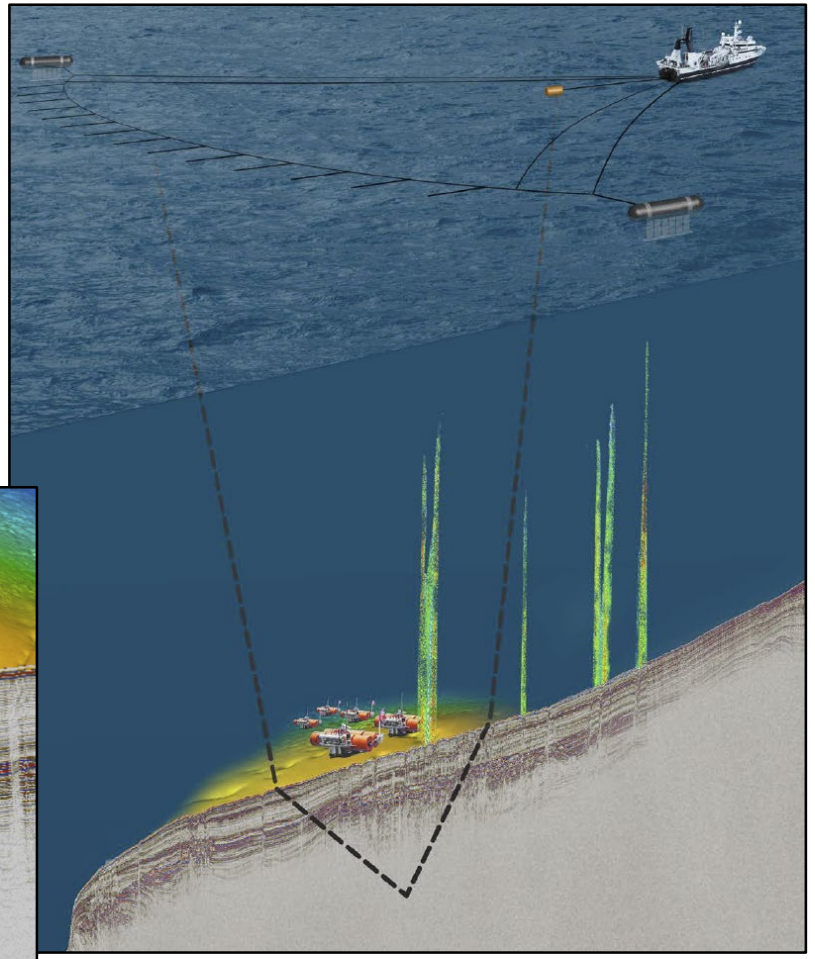
$ 5.9 M USD (1USD = 8.5 NOK)

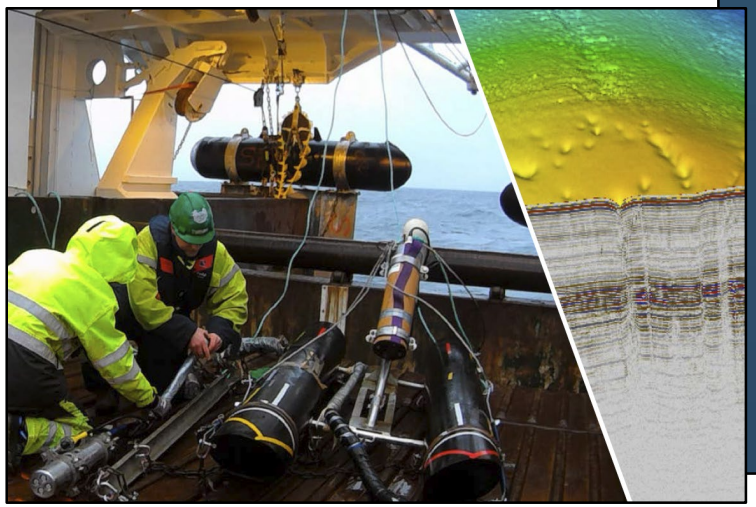
CAGE: Centre for Arctic Gas Hydrate Environment and Climate

CAGE investigates methane release, a greenhouse gas far stronger than CO2, 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.

CAGE Research Groups

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, CO2 and ocean acidification
Methane emissions to the atmosphere

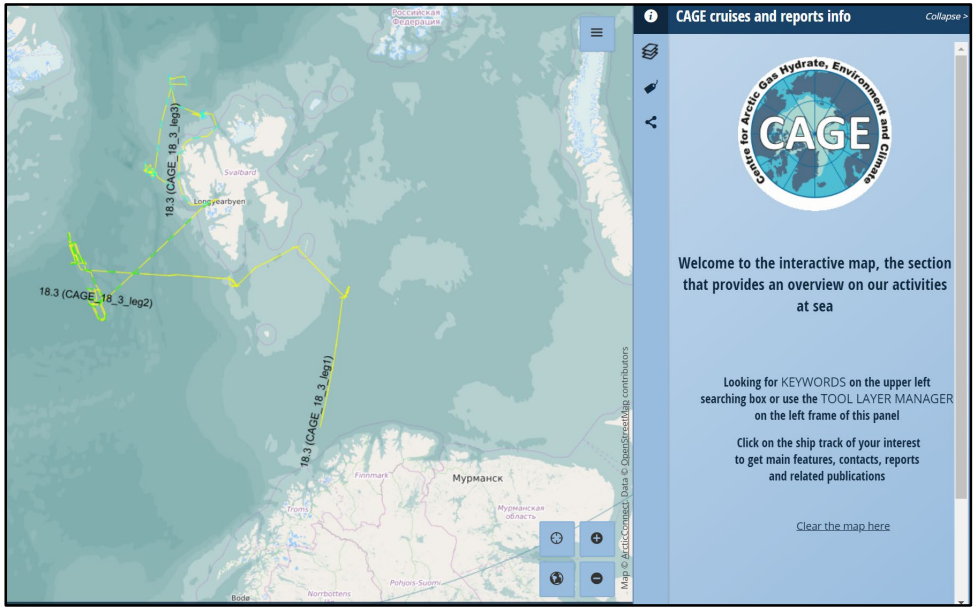




CAGE: Centre for Arctic Gas Hydrate Environment and Climate

CAGE Gas Hydrate Expeditions

Acoustic Imaging of Gas Hydrate and Methane Venting Systems (17.3)
AMGG Research School Cruise 2017 (17.2)
LoVe Observatory Cruise (18.2)
AMGG Research School Cruise 2018 (18.6)
Geological Controls on NW-Barents Sea Seepage (18.1)
Methane Seep Site Investigation (18.3)
Investigation of Sediment Cores, Porewater, and Water Masses (17.1.2)
CTD Measurements and Water Sampling (17.1.1)
Investigation of Water Masses and Planktonic Faunas (16.1)
Acoustic Survey of Methane Seepage Systems (13.4)
Ocean Acidification Fram Straight Project Cruise (13.1)
OAFS Project and Paleo-CIRCUS Project Cruise (13.2)
Exploration of Sub-seabed CO2 Storage Site (13.3)
AMGG Research School Cruise 2013 (13.5)
GlaciBar Project Cruise (13.6)
Gas Release Activity & Underwater Landslide Research Cruise (13.7)
AMGG Research School Cruise 2014 (14.1)
Exploration of Seafloor Gas Venting Systems (14.3)
Methane Seep Site Investigation Cruise (14.4)
Examining Gas Hydrated Sub-seabed & Water Column(14.5)
CO2 Winter Cruise (15.1)
Methane Emission Investigation Cruise (15.2)
OS1 & OS2 – First Observatory Deployment Cruise (15.3)
Time-lapse 4D Seismic Studies of Methane Seeps (15.4)
Exploration of Gas Venting & Subglacial Meltwater Systems (15.5)
AMGG Research School Cruise 2015 (15.7)
Sub-seabed Examination for Arctic Gas Hydrates (15.6)
Cruise to New Investigation Areas (16.2)
Multidisciplinary Data Collection Cruise (16.3)
OS1 & OS2 Observatory Recovery Cruise (16.4)
ROV Inspection of Active Methane Seep Sites (16.5)
P-Cable seismic survey of gas hydrate systems (16.6)
K-Lander 1 & 2 Observatory Deployment Cruise (16.7)
K-Lander 2 Observatory Recovery Cruise (17.4)
Geomorphic Mapping & Seismic Stratigraphy Cruise (17.5)



Submarine Gas Hydrate Reservoirs
SUGAR

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

The German gas hydrate initiative "SUGAR – Submarine Gas Hydrate Reservoirs" is a collaborative R&D project with 16 partners from SMEs, industry and research institutions. The project is coordinated by the Helmholtz Centre for Ocean Research Kiel (GEOMAR). SUGAR-I was launched in 2008 and successfully continuing in its 2nd phase, running from 2011 to 2014 and the current 3rd phase running until March 2018.

SUGAR: The Main Aims

- Develop and test cost-efficient and environmentally sound technologies for gas hydrate exploration and exploitation
- Enable German industries to provide key technologies for the future global gas hydrate market
- Foster knowledge transfer between industry and academia
- Prepare a large-scale European gas hydrate initiative and a field test in European waters where gas is produced from hydrates using novel production technologies

Submarine Gas Hydrate Reservoirs
SUGAR

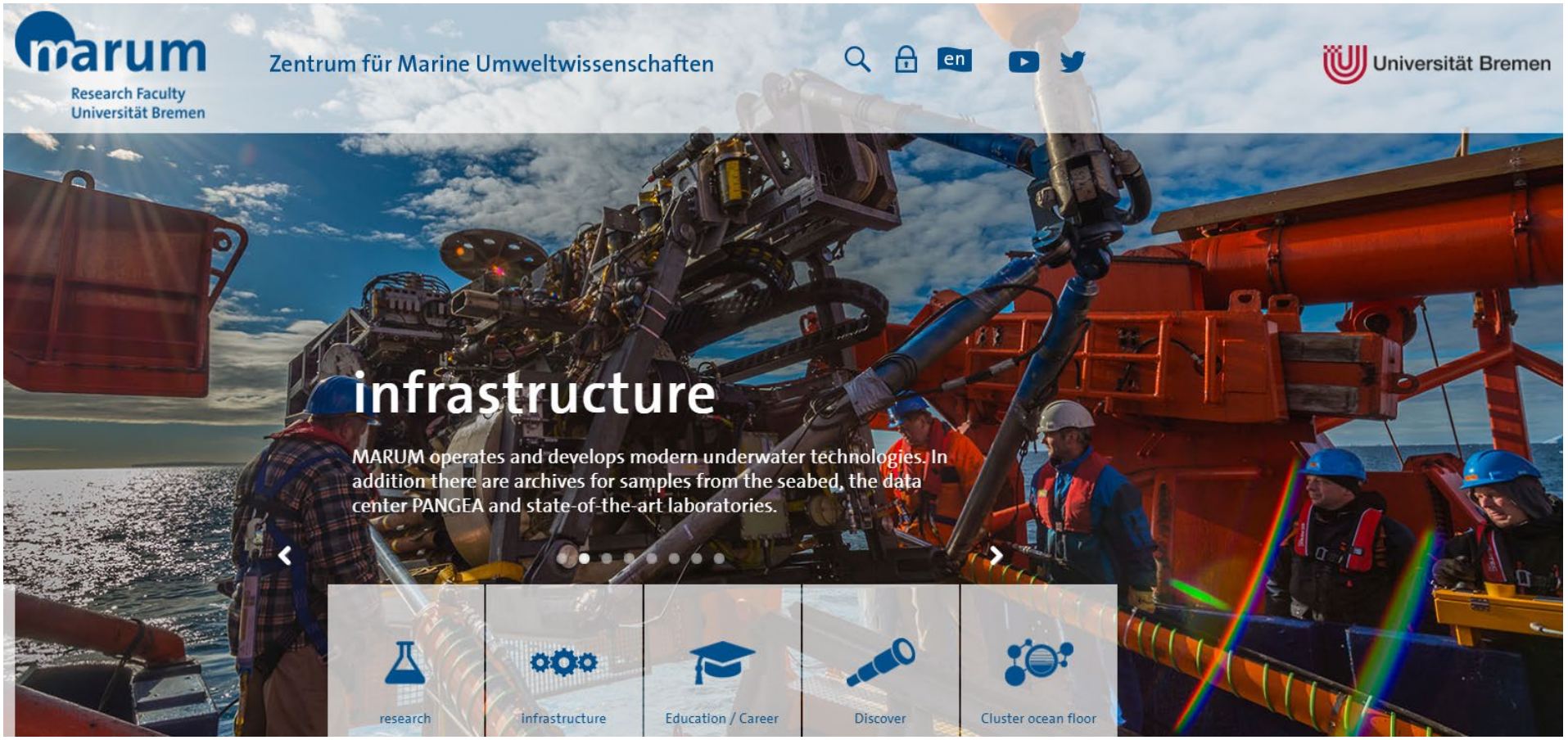
SUGAR I: August 2008 – July 2011
SUGAR II: August 2011 – July 2014
SUGAR III: October 2014 – March 2018

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.

University of Bremen
Center for Marine Environnemental Sciences (MARUM)

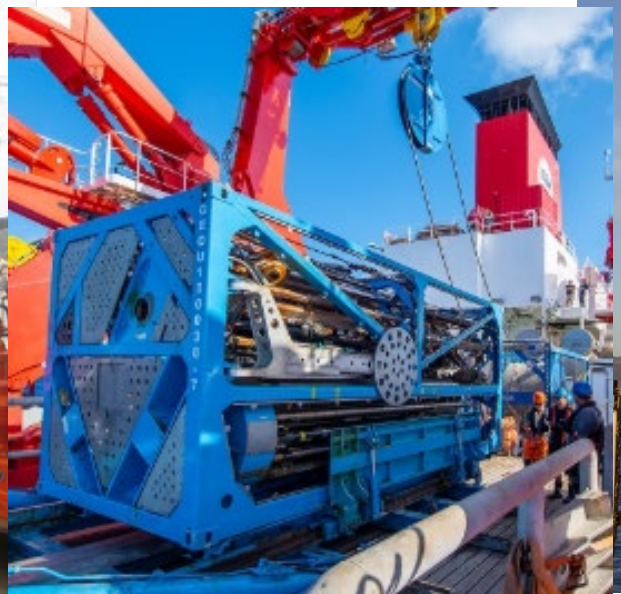


<u>MeBo Drilling/Coring Systems</u>

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)

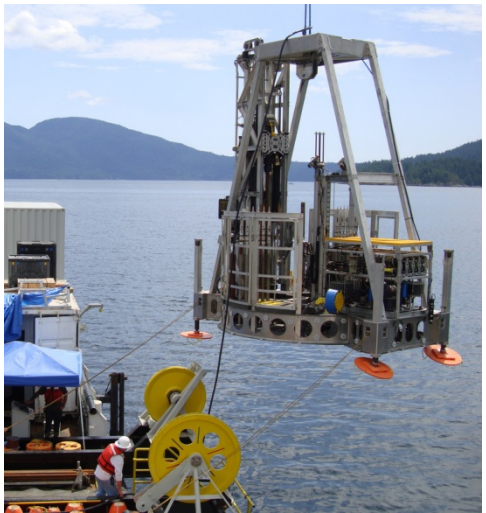
Remotely Operated Scientific Seabed Drills

	Marum Mebo	Marum MeBo200	BGS RD2
Water depth	2000m	2700m	4000m
Weight in Sea	7.5T	30T	5T
Penetration depth	70m	200m	15/50m
Core diameter	63mm	63mm	63mm
Core run	2.35m	2.35m	1.7m
Wireline coring	Yes	Yes	Yes Build Phase
Wireline logging	Spectral gamma, etc	Spectral gamma, etc	Gamma, Density, Acoustic, etc
Other Developments	PCB hydrates	PCB hydrates	



Remotely Operated Commercial Seabed Drills

	BMT PROD1, 2, 3	Seafloor Geoservices RovDrill1, M50, 3	Gregg Drilling SDS	Williamson ACS, A-BMS
Water depth	2000m	4000m	3000m	3000m
Weight in water	10T	9T	10T	?
Penetration depth	85-125m	90-200m	150m	150m
Core diameter	44-73mm	73mm	50-73mm	63mm
Core run	2.75m	?m	2m	2m
Wireline coring	No	Yes	Yes	Yes
Wireline logging	No	No	?	?
Other	CPT	CPT	CPT	PCB – Hydrate Indian Navy JOGMEC x 2



MARUM (Bremen) – MeBo New Zealand (2016)

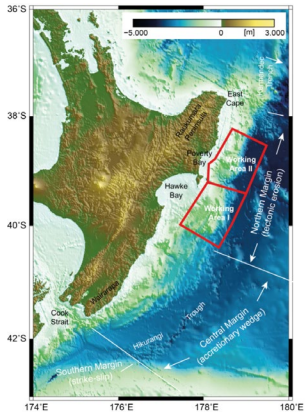
Center for Marine Environnemental Sciences (MARUM)

SO247: FS SONNE; March 27, 2016 - April 28, 2016; Wellington - Auckland (New Zealand)

SLAMZ - Investigation of triggers of submarine landslides in the Hikurangi Subduction Zone, New Zealand

Objective

As part of the SO247 expedition, the active Hikurangi continental margin will be divided into two sediment-tectonically distinct areas: (I) Rock Garden and (II) the Tuaheni slide investigated the interplay of tectonic steepening, gas hydrate conversion and slope destabilization. Core material up to 200m in length from potentially unstable overhanging slope segments with documented gas hydrates is expected to provide a systematic drilling campaign with the MeBo seabed drill. In addition to sedimentological, Sediment physical and geochemical surveys of these sediments are designed to provide high resolution heat flux measurements information on the local thermal structure of the continental slope. Corresponding heat flow data are indispensable for quantitatively testing the complex gas hydrate systems and their postulated importance as slides in models.

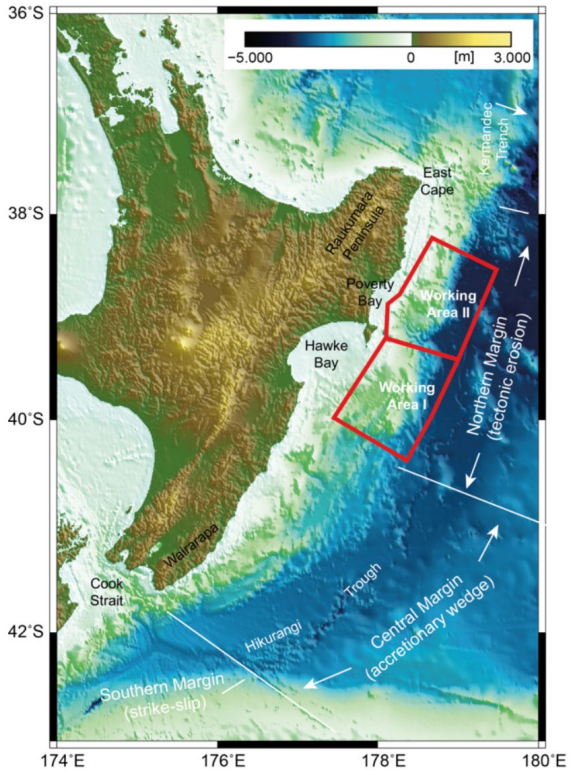


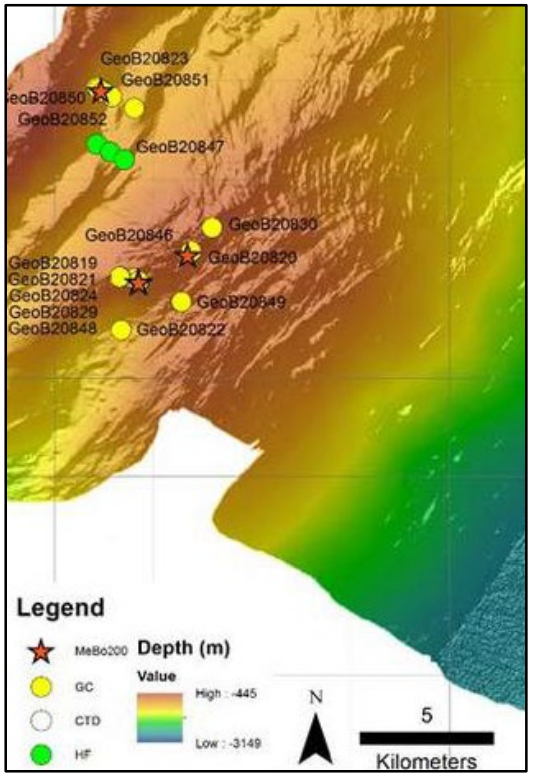
https://www.marum.de/wir-ueber-uns/SedMod/SO247.html

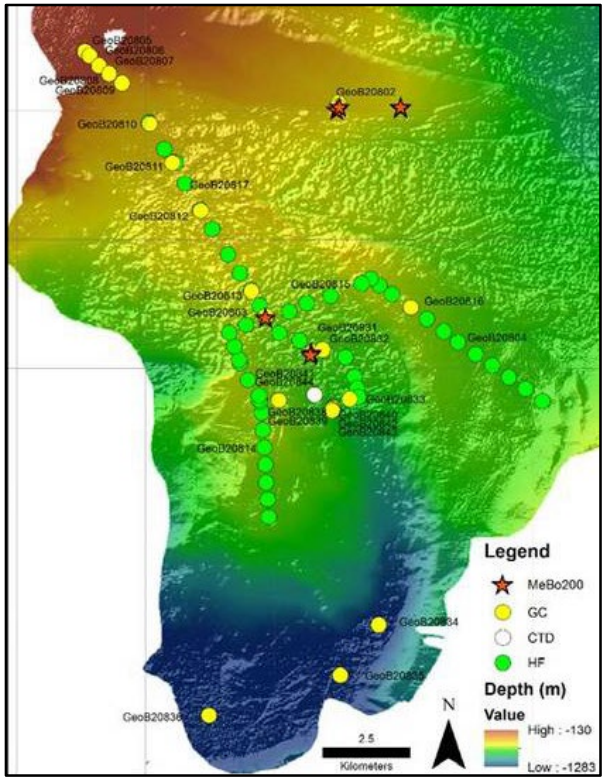
SO247: FS SONNE; March 27, 2016 - April 28, 2016; Wellington - Auckland (New Zealand)

Result

The first scientific expedition with the new drilling rig of the MARUM, the MeBo200, was extremely successful with ~500 meters of drilling at 12 sites, a maximum drilling depth of 105 m and the first use of the MeBo pressure core collector (MDP). The goal of the expedition was the investigation of landslide processes on the eastern continental slope of New Zealand. The resulting sediment cores will provide information about the potential trigger mechanisms of slope slides. For this purpose, first geochemical, sedimentological, mineralogical and geotechnical tests were carried out on board.







MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Taiwan (2018)

Center for Marine Environnemental Sciences (MARUM)

FS SUN - Expedition SO266: 15.10.2018-18.11.2018; Kaohsiung - Kaohsiung (Taiwan)

Taiwanese-German expedition to study methane hydrates, their distribution and dynamics on the southwestern continental margin of Taiwan

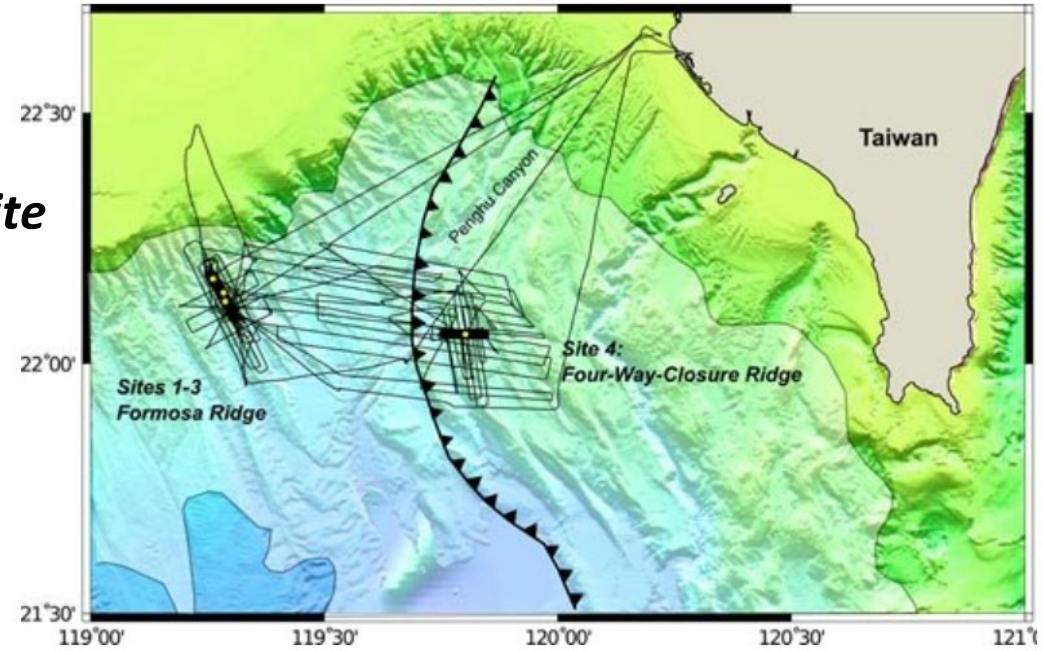
Objective

After previous seismic exploration during SO227, four targeted MeBo drill holes will be drilled during SO266 to provide quantitative information on gas hydrate formation and dissolution processes and to better estimate the resource potential of the gas hydrate province.

Drill Sites:

-Formosa Ridge

-Four Way Closure Site



https://www.marum.de/Forschung/SO266.html

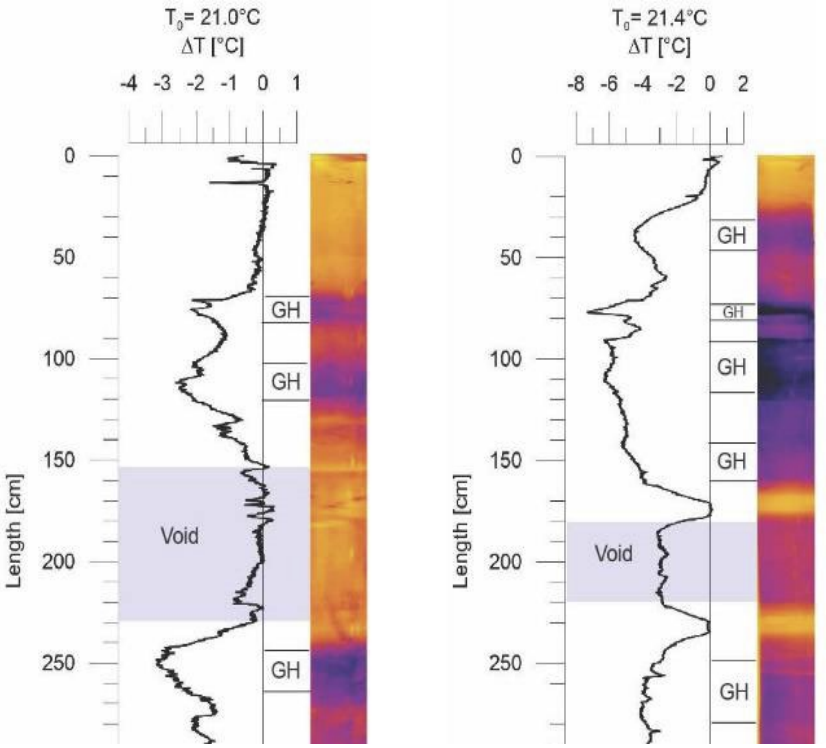
FS SUN - Expedition SO266: 15.10.2018-18.11.2018; Kaohsiung - Kaohsiung (Taiwan)

Results

At the first site on Formosa Ridge a total of 33 cores were recovered to a depth of 109.91 m below the seafloor. The recovered sediments consisted mainly of fine-grained hemipelagic muds with low hydrate saturations to about 20-30 mbsf and higher hydrate concentrations at 98 mbsf. At the “Four Way Closure Site” Mebo acquired core at one site to a total depth 126.35 mbsf (90.6% core recovery), based on chloride pore water chemistry and core scan IR anomalies numerous thin but “significant hydrate occurrences” were identified.

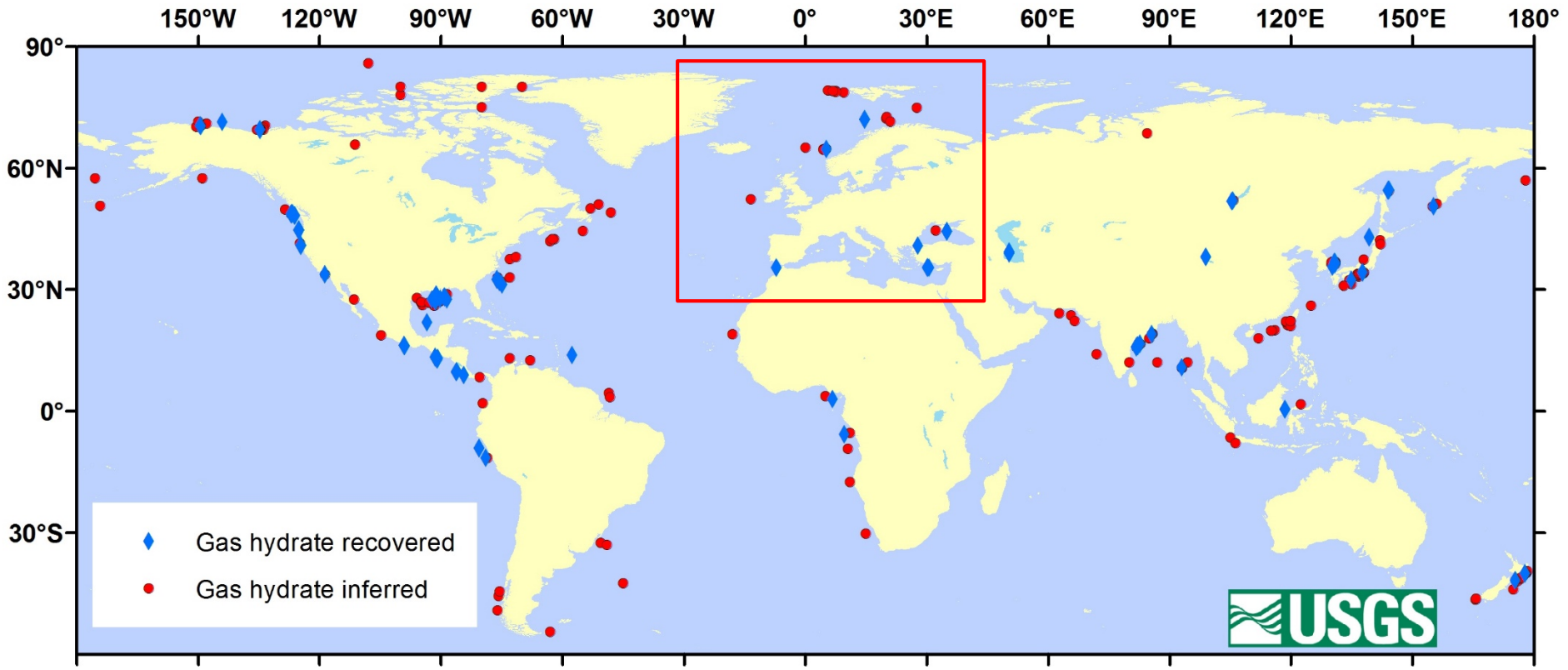
MeBo200 – Total 11 Stations and 17 Holes

2018/17/10 04-1 MeBo 22°02.916 119°48.091 1322m
2018/21/10 12-1 MeBo 22°06.888 119°17.130 1142m
2018/22/10 13-1 MeBo 22°06.886 119°17.136 1142m
2018/24/10 13-1 MeBo 22°06.886 119°17.136 1142m
2018/25/10 16-1 MeBo 22°02.919 119°48.089 1322m
2018/27/10 16-1 MeBo 22°02.919 119°48.089 1322m
2018/03/11 25-1 MeBo 22°03.487 119°47.979 1352m
2018/05/11 27-1 MeBo 22°06.886 119°17.137 1142m
2018/06/11 27-1 MeBo 22°06.886 119°17.137 1142m
2018/07/11 30-1 MeBo 22°06.887 119°17.147 1141m
2018/08/11 31-1 MeBo 22°02.919 119°48.083 1324m
2018/09/11 31-1 MeBo 22°02.919 119°48.083 1324m
2018/10/11 34-1 MeBo 22°03.461 119°48.049 1355m
2018/11/11 34-1 MeBo 22°03.461 119°48.049 1355m
2018/12/11 37-1 MeBo 22°09.139 119°52.493 1231m
2018/13/11 37-1 MeBo 22°09.139 119°52.493 1231m
2018/14/11 40-1 MeBo 22°02.926 119°48.075 1324m

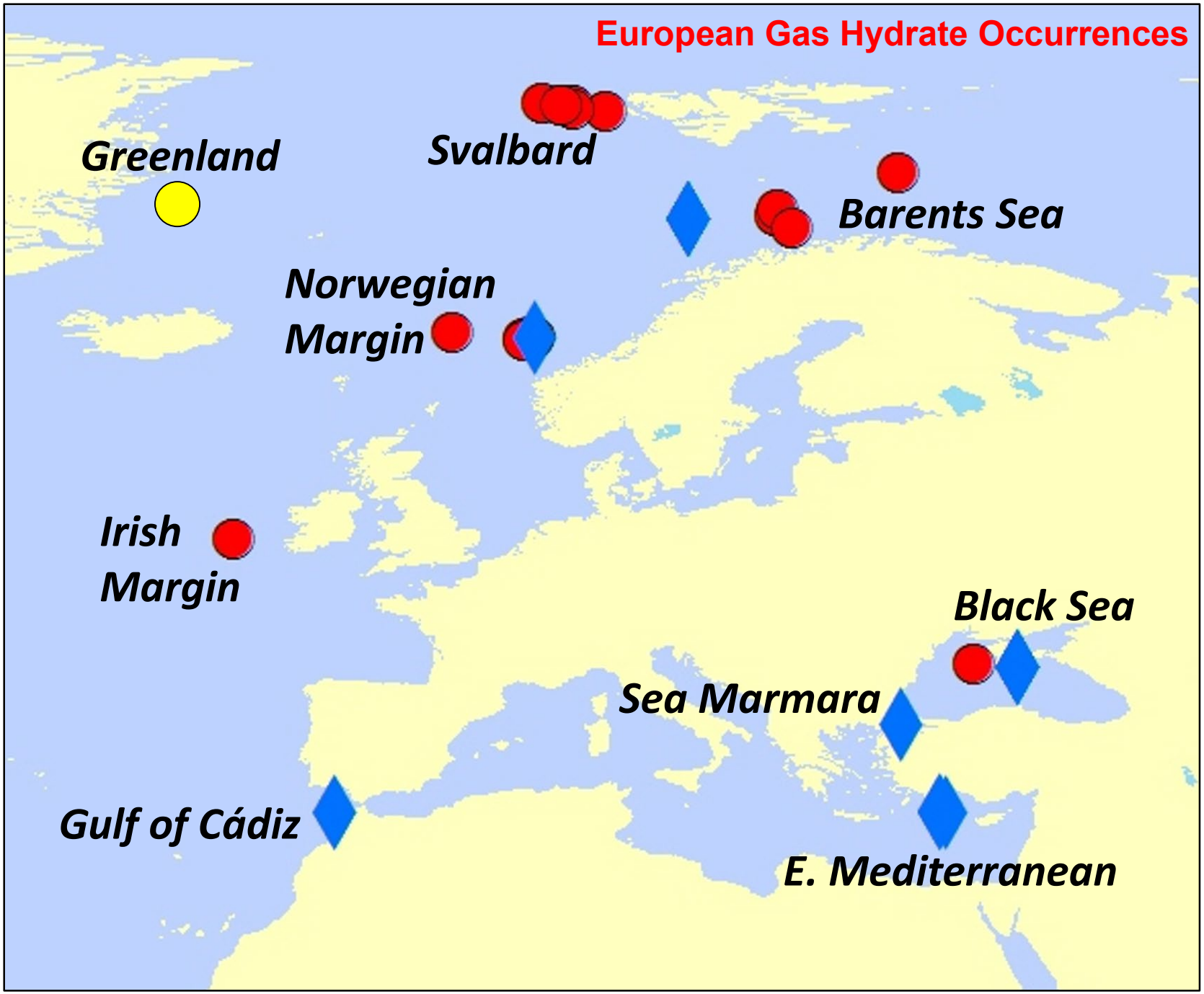


Two Mebo sediment cores with the thermal images indicating the presence of gas hydrate

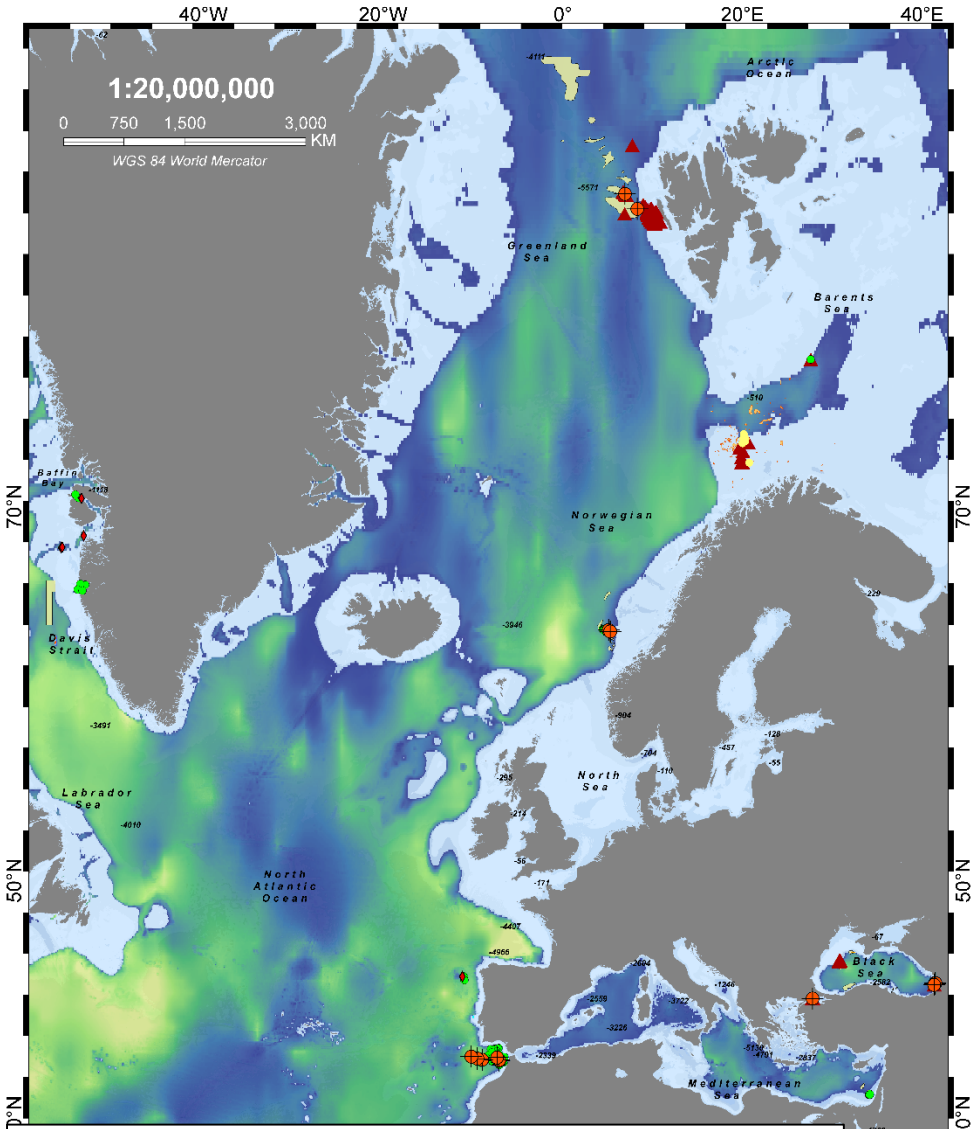
European Gas Hydrate Occurrences and Research Programs



https://woodshole.er.usgs.gov/project-pages/hydrates/database.html


European Gas Hydrate Occurrences
Greenland
Svalbard
Barents Sea
Norwegian
Margin
Irish
Margin
Black Sea
Sea Marmara
Gulf of Cádiz
E. Mediterranean

GAS HYDRATE DISTRIBUTION EUROPE



© 2016 MIGRATE

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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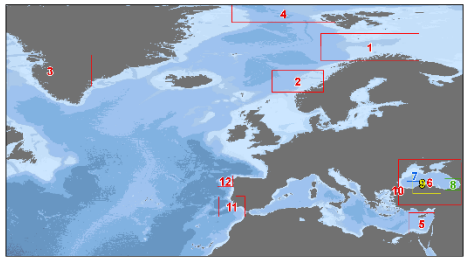
Addtional Maps for Gas Hydrate



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

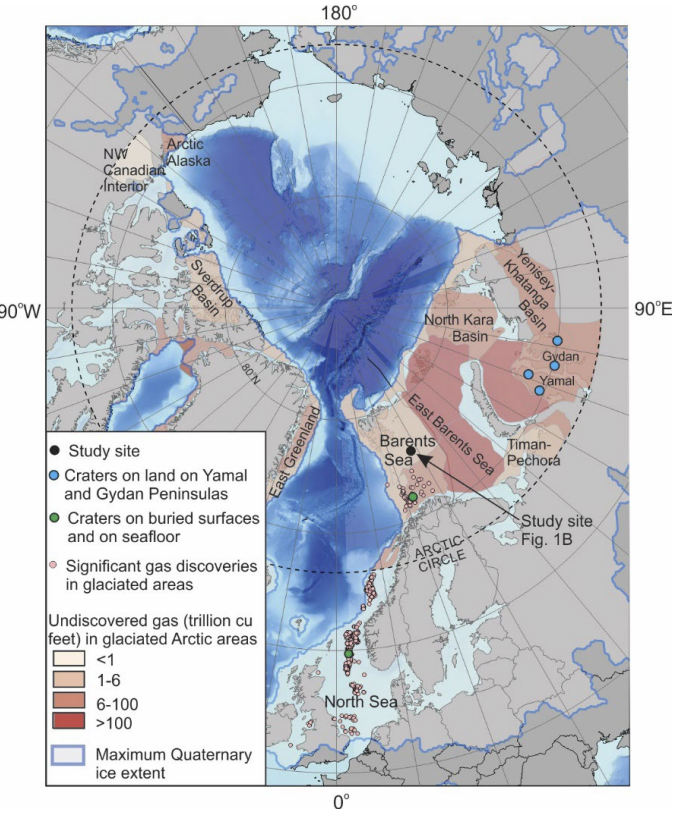
cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

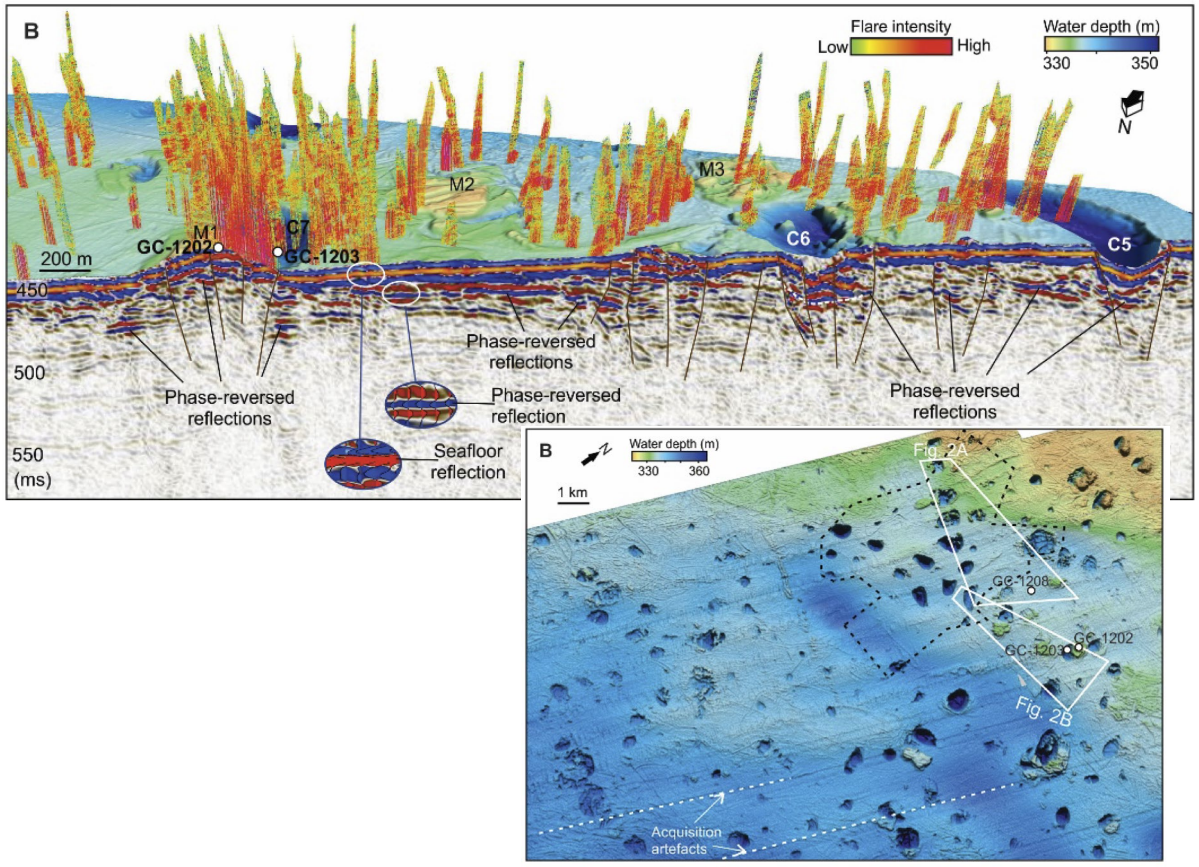
European Gas Hydrate Occurrences

Andreassen et al., (2017)
CAGE

Barents Sea

Arctic continental shelves and land areas host vast amounts of methane trapped as hydrates. Geophysical data document clusters of kilometer-wide craters and mounds from the Barents Sea floor associated with large-scale methane expulsion. Ice sheet/gas hydrate modeling indicate that during glaciation, natural gas migrated from underlying hydrocarbon reservoirs and was sequestered extensively as subglacial gas hydrates. Upon ice sheet retreat, methane from this hydrate reservoir concentrated in massive mounds before being abruptly released to form craters.

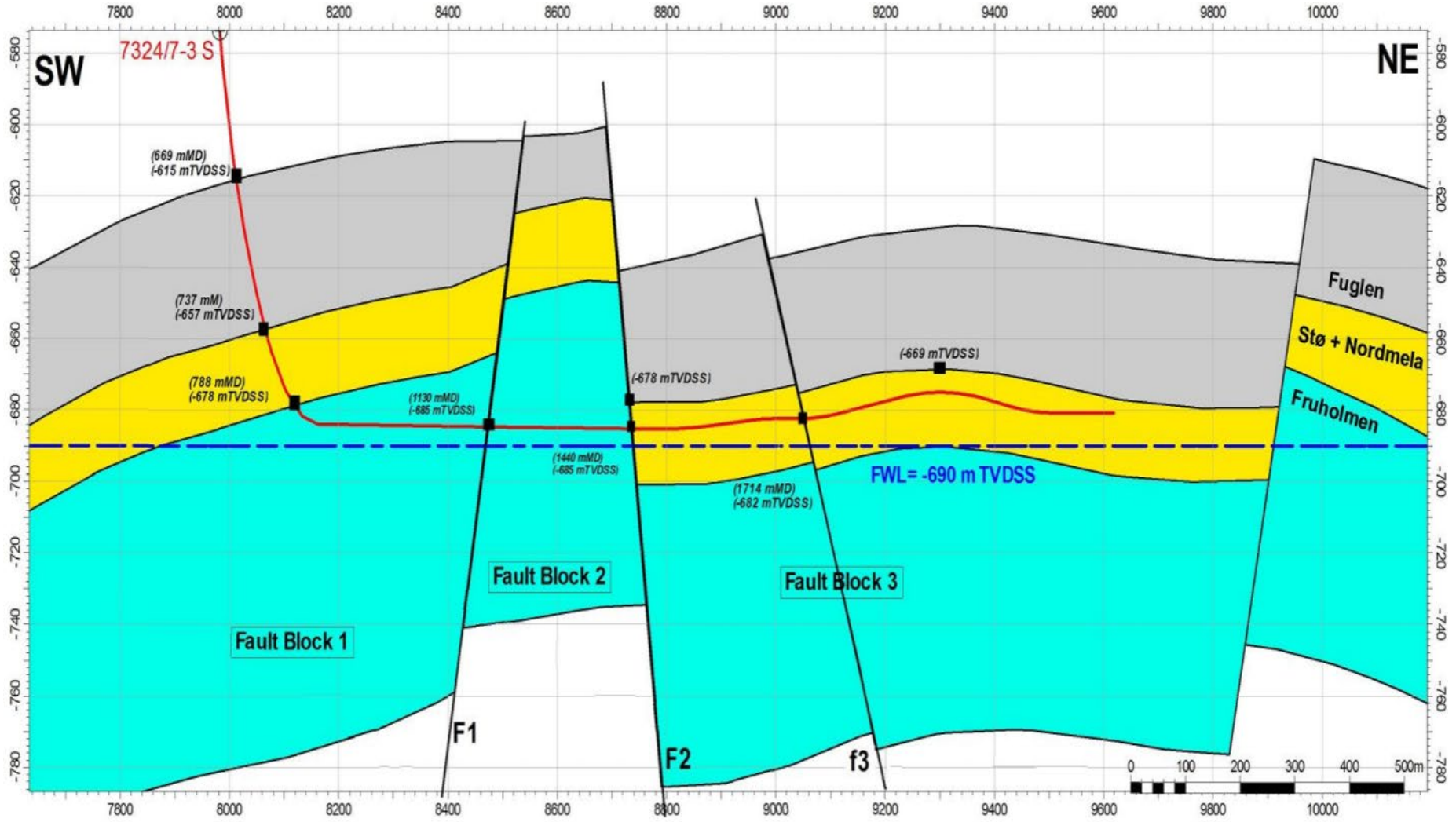




European Gas Hydrate Occurrences

Barents Sea

Actual Well Trajectory on Pre-Drill X- Section

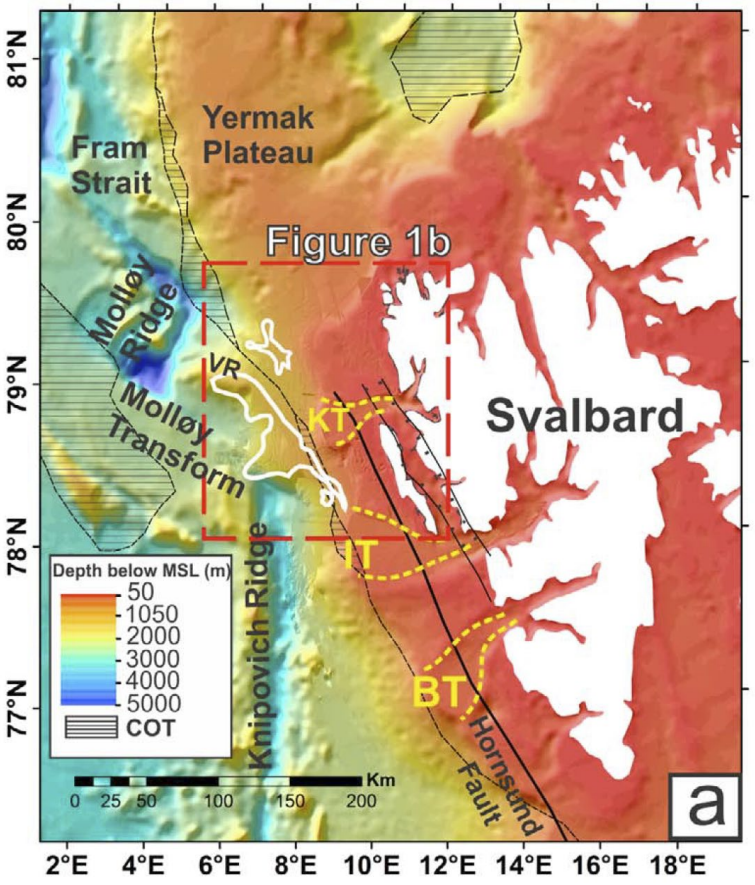


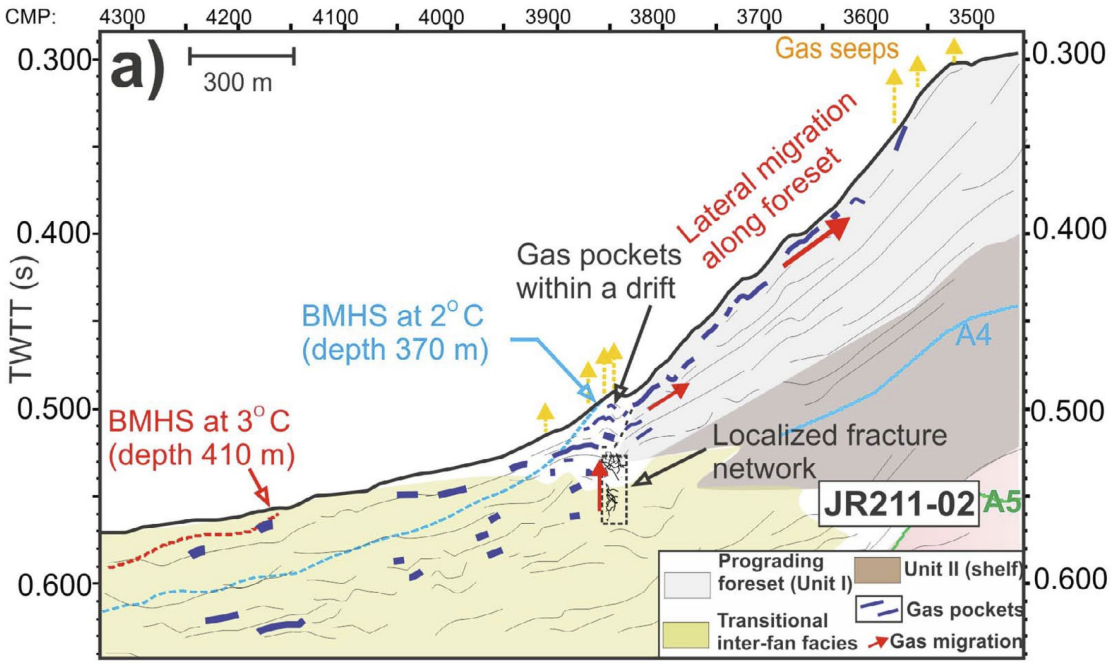
European Gas Hydrate Occurrences

Sarker et al., (2012)
University of Southampton

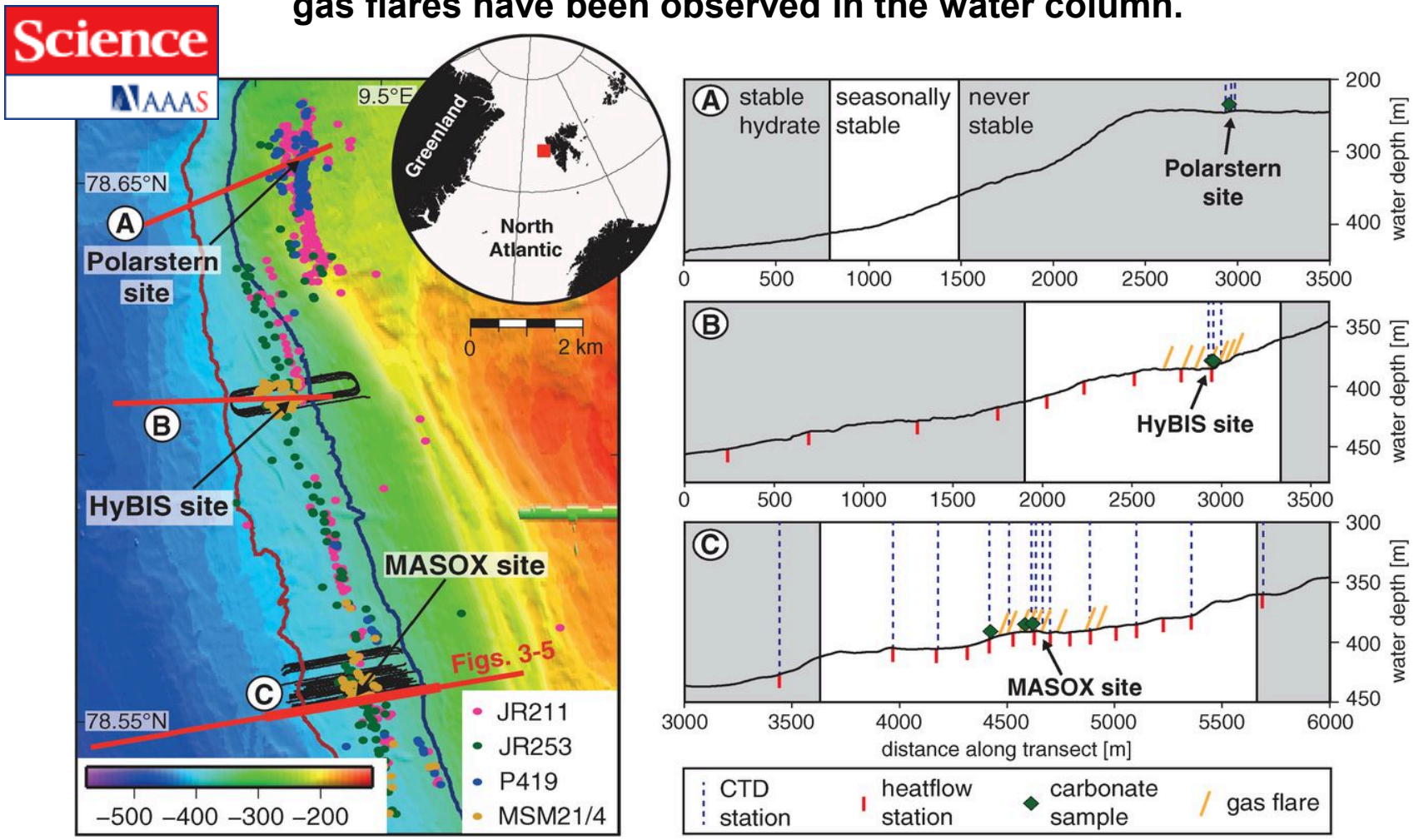
Svalbard Marine

Active gas venting occurs off west Svalbard near the upslope from the present-day intersection of the base of methane hydrate stability between the Kongsfjorden and Isfjorden cross-shelf troughs. Integrated analysis of seismic reflection profiles have been used to map BSRs and analyze the subsurface gas migration and accumulation. Gas seeps mostly occur areas where the gas hydrate stability zone to retreat over the recent past (1975–2008) as a consequence of a bottom water temperature rise of 1 deg C.





At water depths shallower than 400 m off the western margin of Svalbard, numerous gas flares have been observed in the water column.



C. Berndt et al. Science 2014;343:284-287

Brendt et al., (2014) present a record of methane seepage from marine sediments off the coast of Svalbard showing that such emissions have been present for at least 3000 years, the result of normal seasonal fluctuations of bottom waters. Thus, contemporary observations of strong methane venting do not necessarily mean that the clathrates that are the source of the methane are decomposing at a faster rate than in the past.

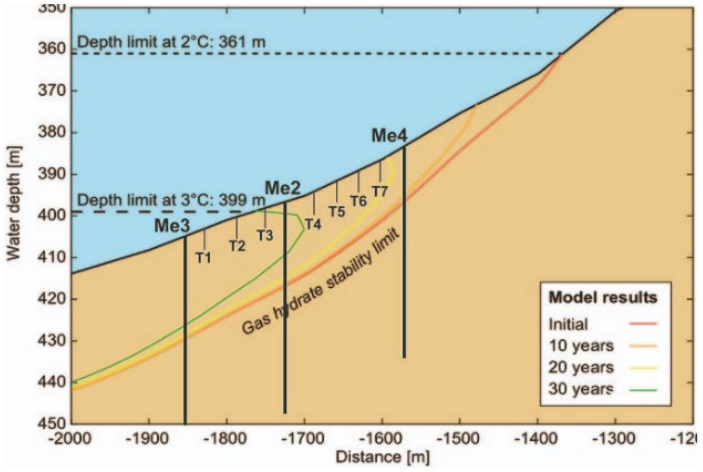
MARUM/CAGE (U. Tromsø/Bremen) – MeBo Svalbard (2016)

Center for Marine Environnemental Sciences (MARUM)
Centre for Arctic Gas Hydrate Environment and Climate (CAGE)
MSM 57-2: RV Maria S. Merian; 13.08.2016-07.09.2016; Longyearbyen-Reykjavik

Gas hydrates and seafloor dynamic West of Svalbard

Objective

Characterization upper continental margin of Svalbard, where the lower edge of the gas hydrate stability zone subcrops at the seafloor, emissions of free methane gas in the form of acoustic gas plumes and increased methane concentrations in the water column are more frequently detected. As part of this expedition, we plan to sample gas hydrates in the area of methane seepage for the first time with 5 double bores of the MeBo mobile drill rig and to specify the stability limit based on their chemical composition and physical parameters.



https://www.marum.de/Forschung/RV-Maria-S.-Merian-MSM-57-2-13.08.-07.09.2016-longyearbyen-reykjavik.html

MSM 57-2: RV Maria S. Merian; 13.08.2016-07.09.2016; Longyearbyen-Reykjavik

Results

During expeditions MSM57-1/2 in 2016, initially 9+ MeBo holes were drilled to +25m on the continental margin of Svalbard near the upper limit of methane hydrate stability. Pressure and temperature, as well as the composition of the hydrate gases were acquired to determine the exact limit of hydrate stability conditions. MeBo coring on the Prins Karls Foreland and Vestnesa Ridge (Lunde pockmark) sampled to a depth of 62.5 mbsf.

Cores from Prins Karls Foreland contained no evidence of gas hydrate occurrence at this location. Fluid freshening observed in sediment cores reflect hydrate dissociation around 8 ka BP, when isostatic uplift outpaced eustatic sea-level rise, and the resulting decrease in hydrostatic pressure led to gas hydrate dissociation. Gas hydrate dissociation in this high-latitude setting is not the result of anthropogenic warming, but was likely triggered by tectonic and glacio-eustatic forcing.

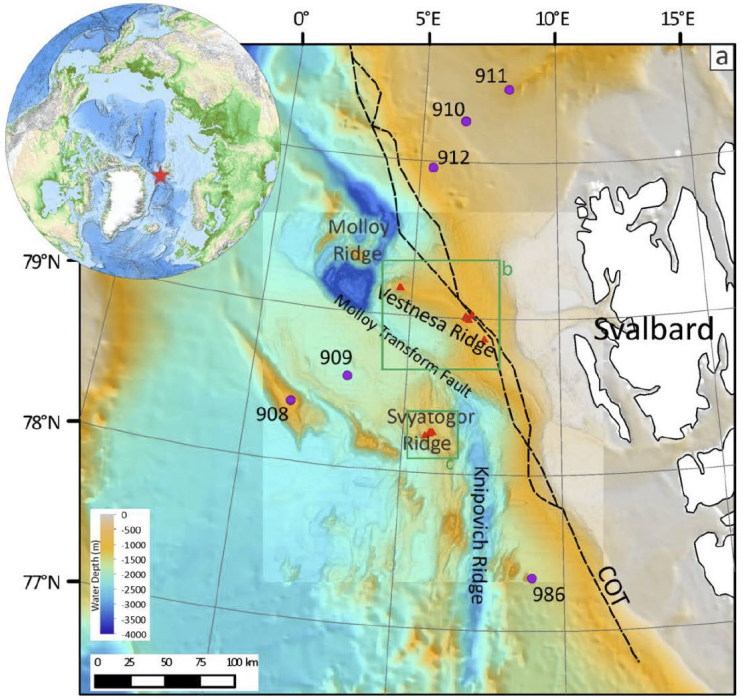
Samples from pressure cores (MeBo-Druckkern-Probennehmer) recoverd from the Vestnesa Ridge, were used to characterize different fluid regimes. At the reference site, the deepest gas sample (62 mbsf) had a major component of migrated thermogenic hydrocarbons. Sediments shallower than 50 mbsf show a prevalence of microbially-generated methane.

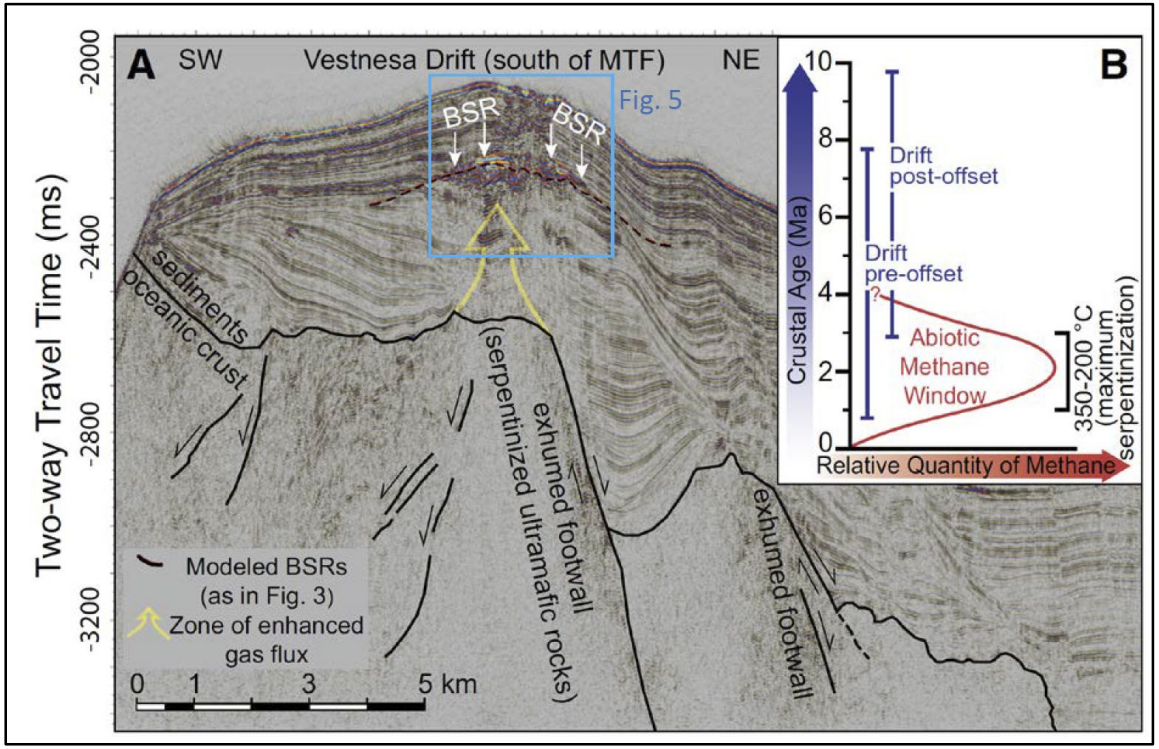
IODP Proposal 935-Full: Pleistocene evolution of Arctic gas hydrates and fluid flow Systems POLARIS

Proponents: Stefan Bünz, Andreia Plaza-Faverola, Sunil Vadakkepuliyambatta, Jochen Knies, Joel Johnson, Fumio Inagaki, Michael Riedel, Marta Torres, Giuliana Panieri, Timothy Collett, Helge Niemann, Javier Escartin, Gerhard Bohrmann, Dan Condon, Aivo Lepland, Carolyn Ruppel

Scientific Objectives

The overall goal is to quantify the links between large scale geological and climate change events that drive fluid expulsion in a tectonically active, formerly glaciated Arctic margin; the microbial response to these changes; and the consequential impact on global carbon cycling (particularly quantifying the role of methane formed by microbial and thermogenic methanogenesis and serpentinization of ultramafic rocks as a source of abiotic methane)



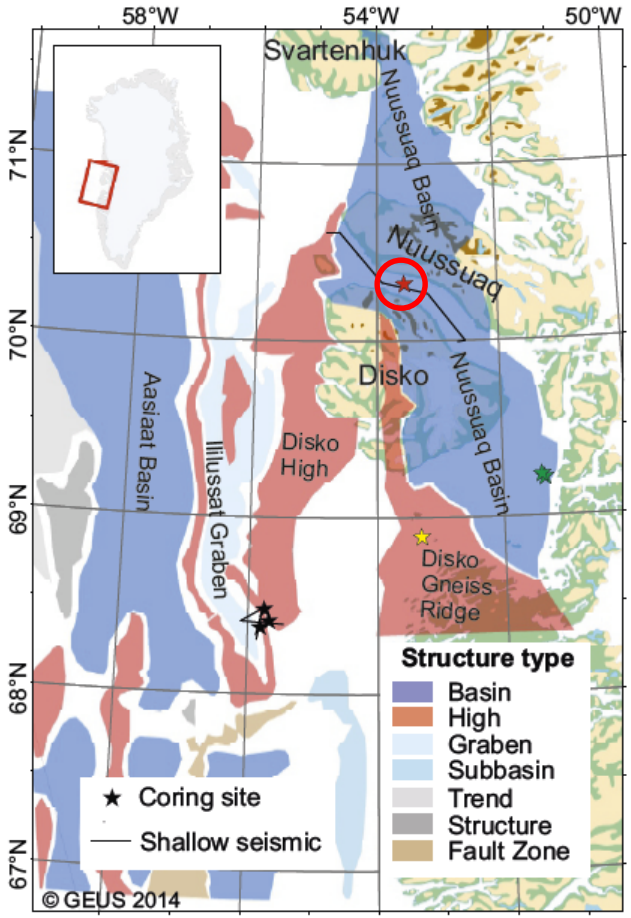


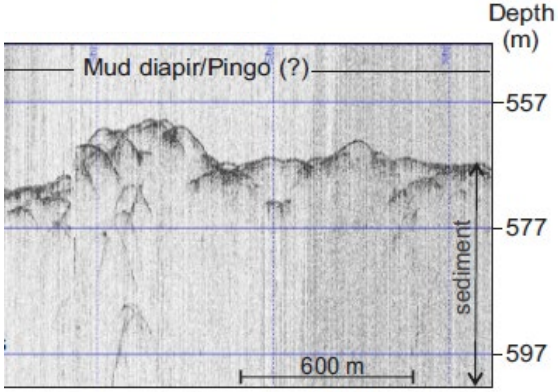
European Gas Hydrate Occurrences

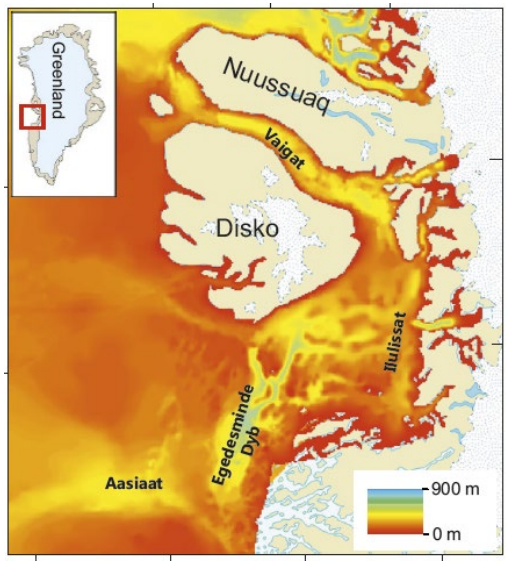
Nielsen et al., (2003)
CAGE

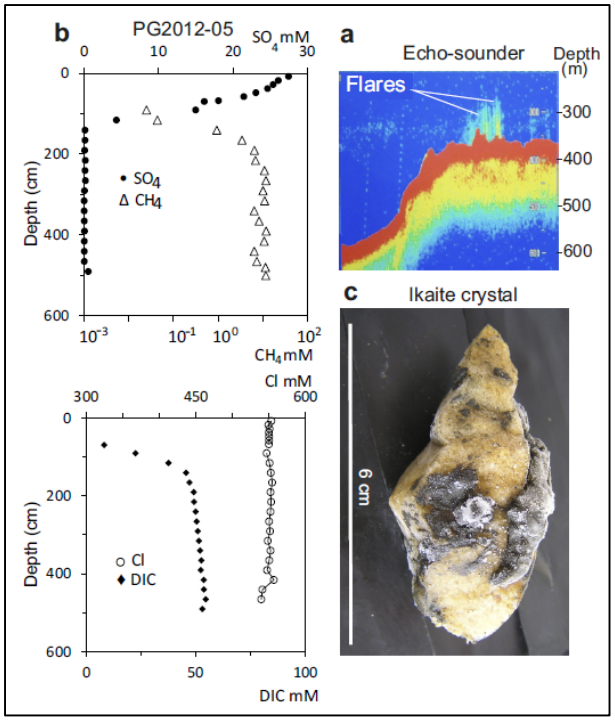
Greenland Marine

Gas hydrates offshore West Greenland appear to be associate with numerous occurrences of shallow hydrocarbons in the vicinity of Disko Bugt (Bay). Seismic records crossing the elongated depression (20×35 km large, 575 m deep) on the inner shelf west of Disko Bugt show BSRs within faulted Mesozoic strata. Seabed coring of several pockmark sites observed around the mouth of Ilulissat Isfjord (Icefjord) have reveled the presence of gas hydrate.







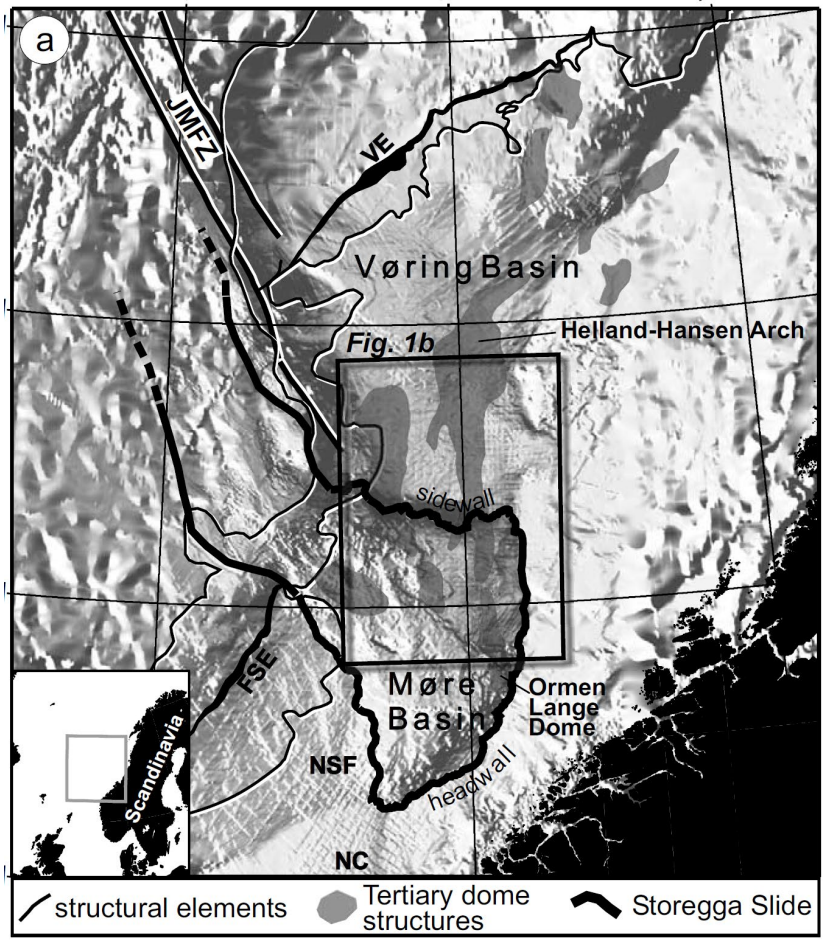


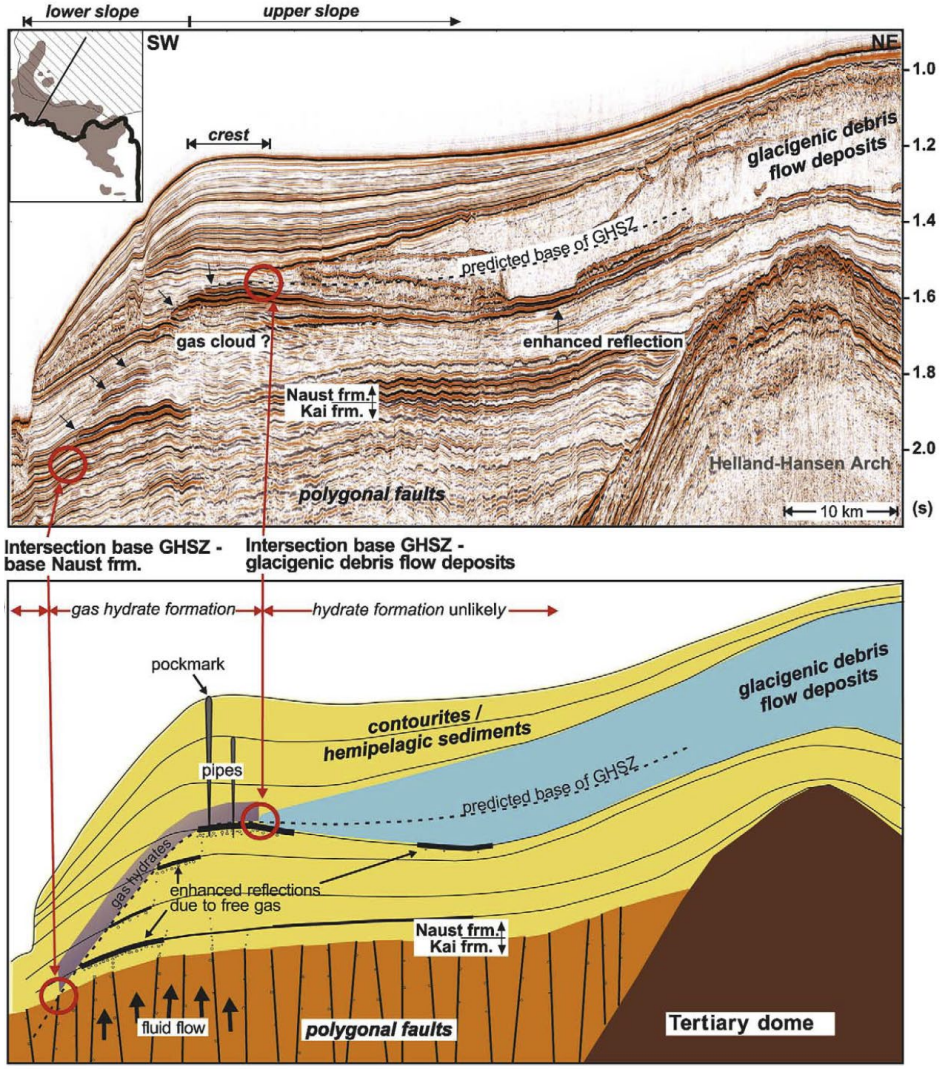
European Gas Hydrate Occurrences

Bünz et al., (2003)
University of Tromso

Norwegian Margin

The geologic setting of the formerly glaciated mid-Norwegian continental margin exerts specific controls on the formation of a bottom-simulating reflector (BSR) and the inferred distribution of gas hydrates in the Møre and the Vøring Basins.



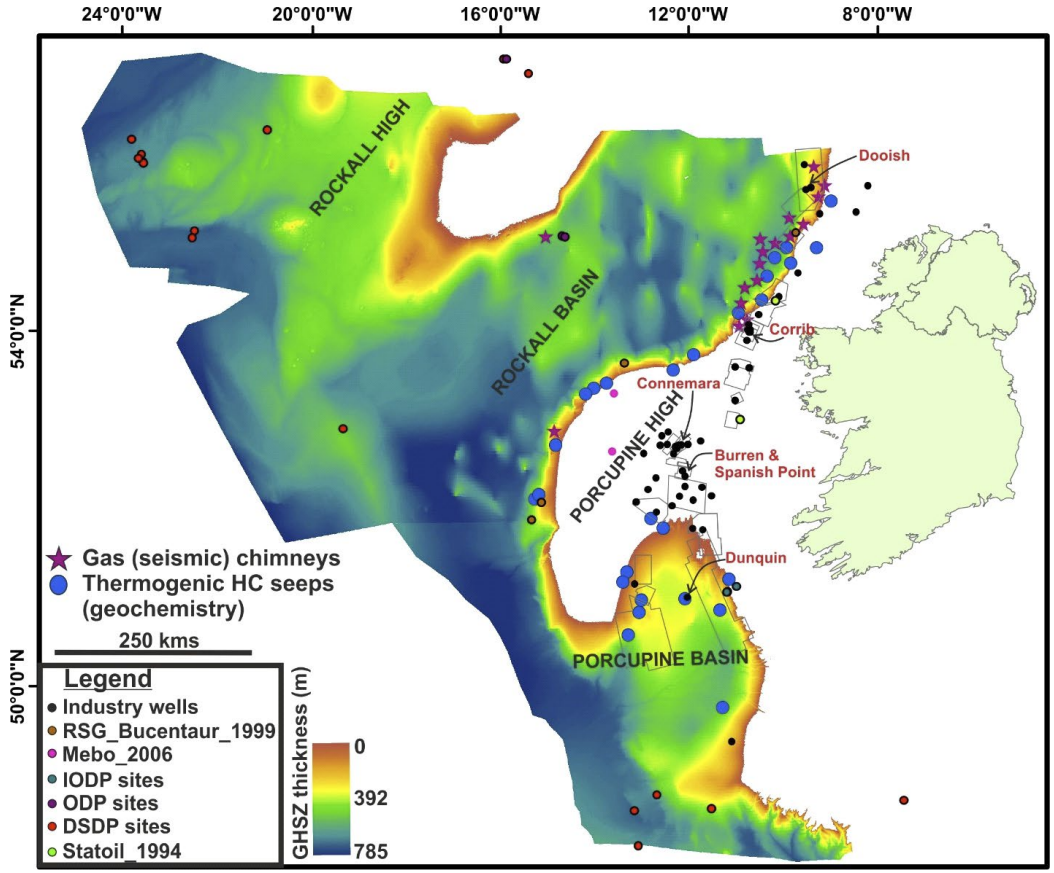


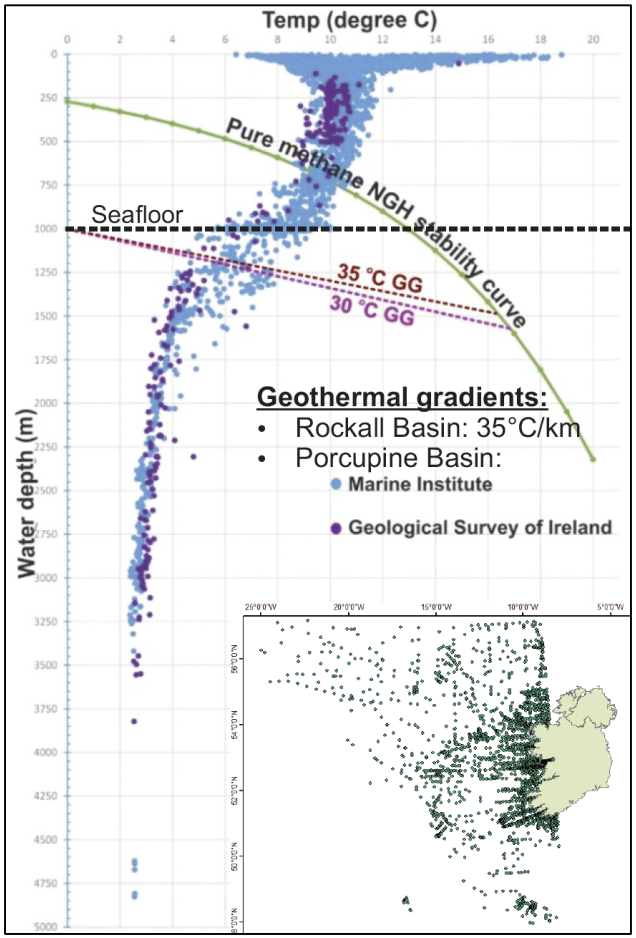
European Gas Hydrate Occurrences

Srikumar Roy, Michael Max and John Walsh
University College Dublin

Irish Margin

Map of gas hydrate stability zone (GHSZ) thickness calculated from bathymetric data, geothermal gradients, and seafloor temperature data. Gas chimneys and thermogenic hydrocarbon seeps are aligned along the continental slope. Hydrocarbon field discoveries lie below the GHSZ in NE Seafloor Rockall and Porcupine Basin. Various types of seismic amplitude anomalies (some of which are BSR-like) have been observed in close proximity to the calculated BGHSZ.



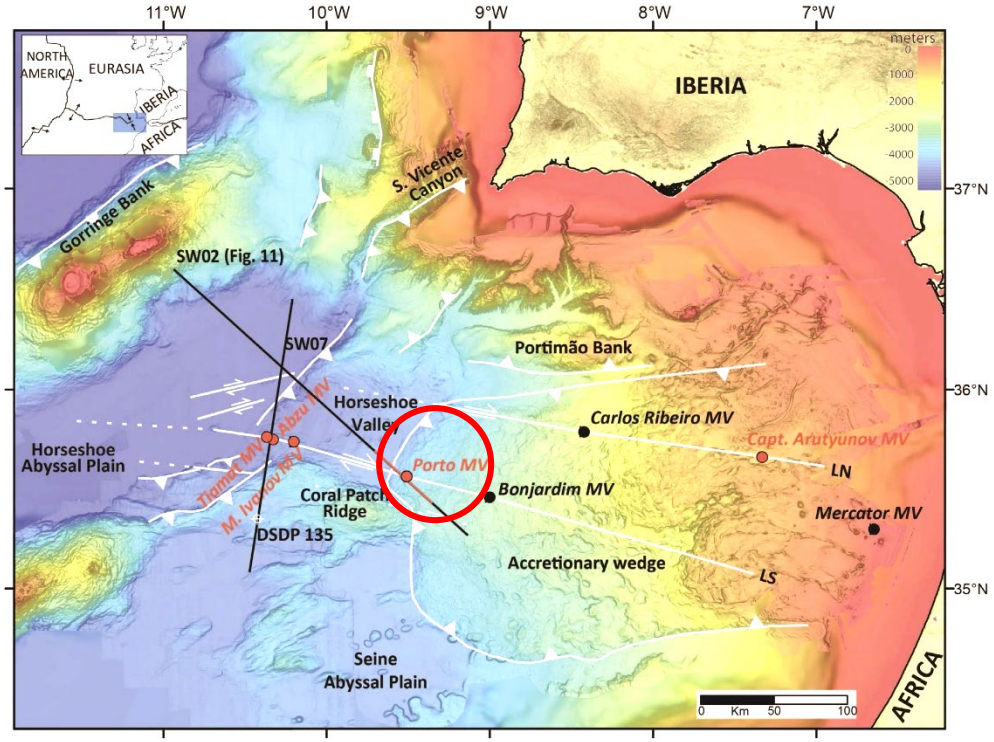


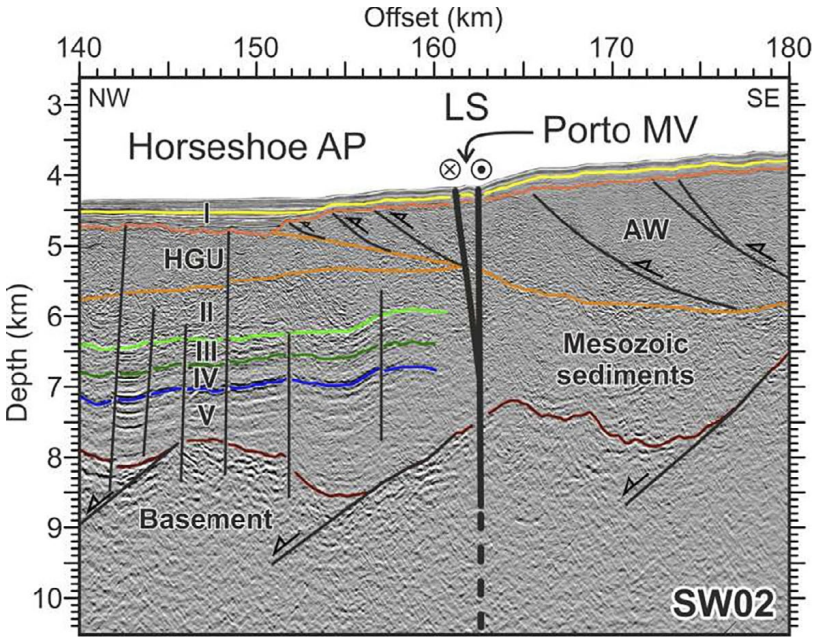
European Gas Hydrate Occurrences

Schmidt et al., 2017
GEOMAR

Gulf of Cádiz

Mud Volcanism and fluid seepage are widespread phenomena in the Gulf of Cadiz (SW Iberian Margin). In this seismically active region located at the boundary between the African and Eurasian plates, fluid flow is typically focused on deeply rooted active strike-slip faults. The geochemical signature of emanating fluids from various mud volcanoes (MVs) and recovered gas hydrate samples indicate the presence of thermogenic gas.





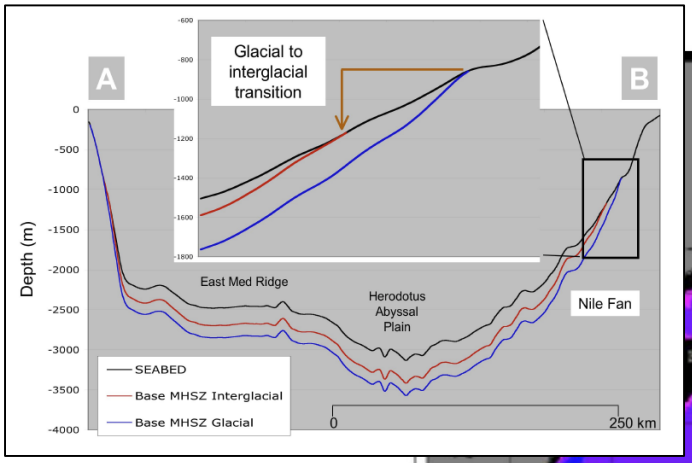
European Gas Hydrate Occurrences

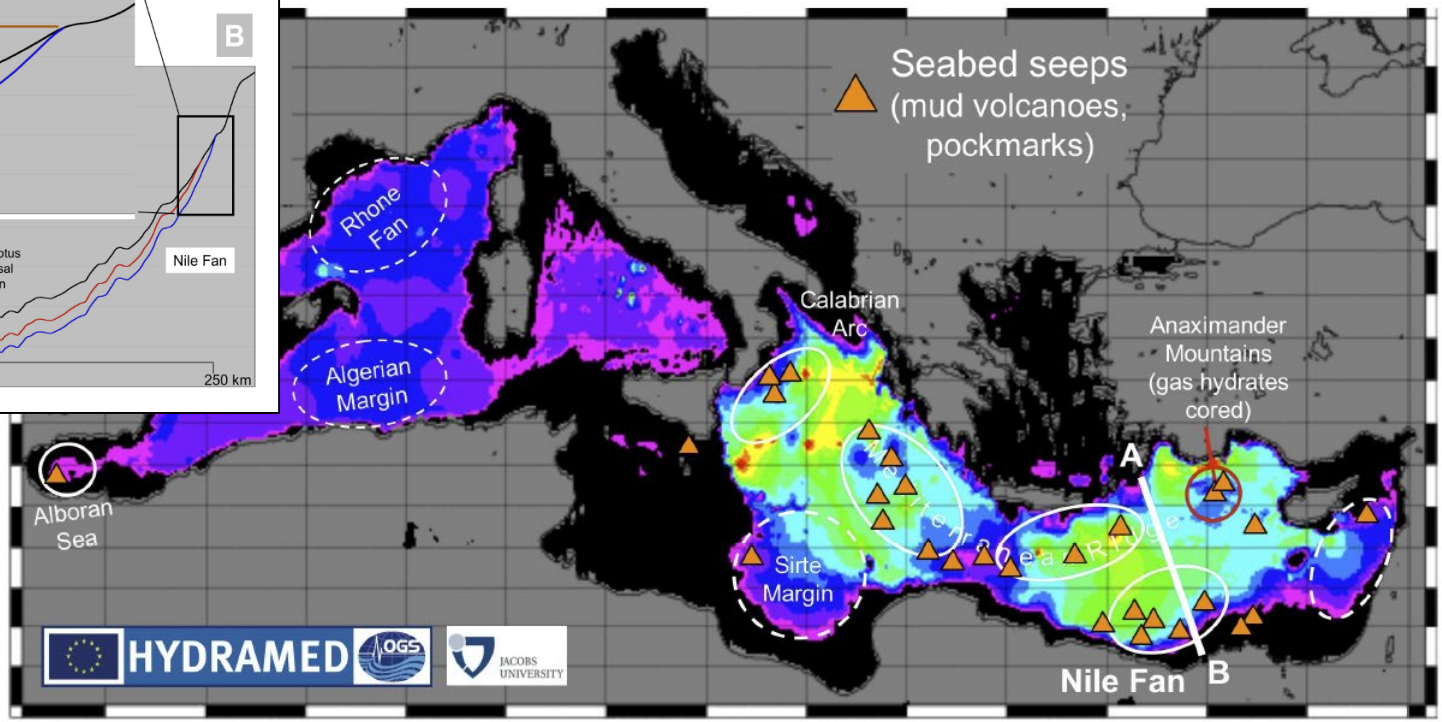
Praeg et al., 2011

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Mediterranean Sea

Modeling of the methane hydrate stability zone (MHSZ) shows it to be present in most of the Mediterranean Sea, albeit in deep waters (>1000 m) due to warm bottom waters (12.5-14°C) and in greater thicknesses (200-500 m) in the geothermally cooler eastern basin. Comparison of the MHSZ with known or possible zones of gas flux to seabed suggests prospective areas for hydrate occurrence, mainly in the eastern basin.





Present-day MHSZ thickness below seabed

(m)

1 50 100 150 200 250 300 350 400 450 500 1100

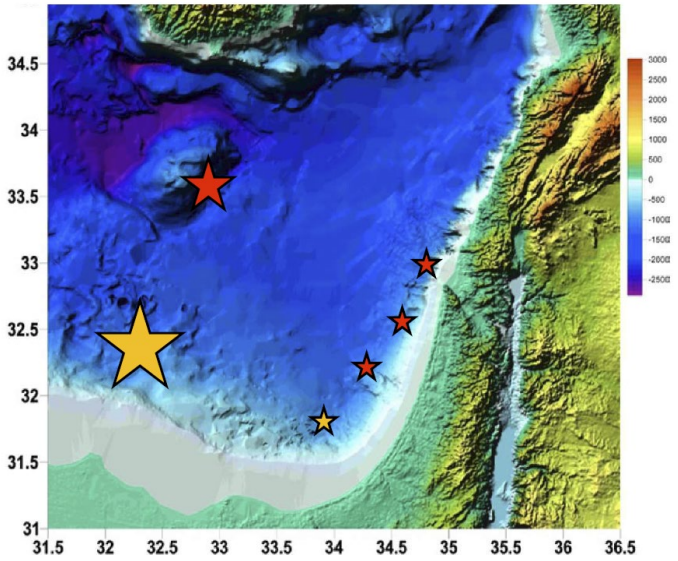
European Gas Hydrate Occurrences

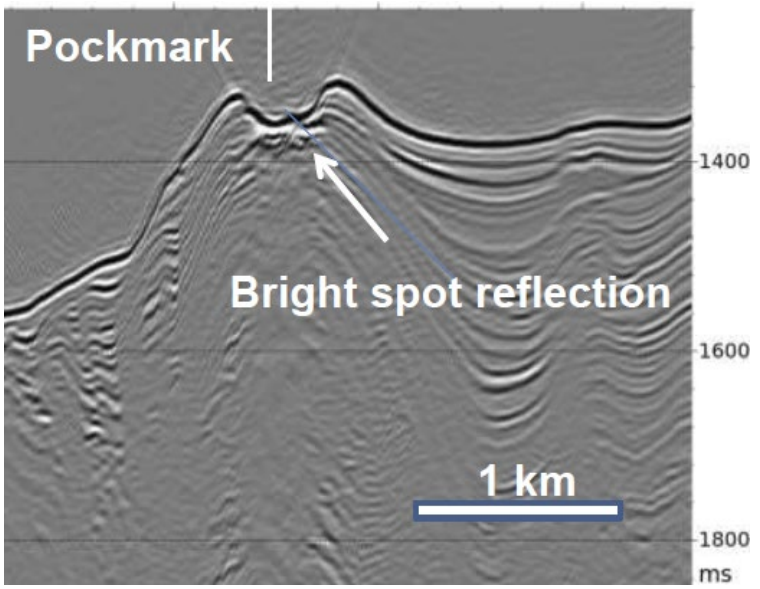
Makovsky et al., 2017
University of Haifa, Israel

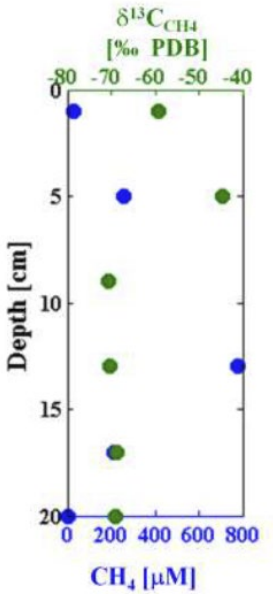
Mediterranean Sea

Presentation: *Active seafloor processes in the Levant: observations and potential implications*

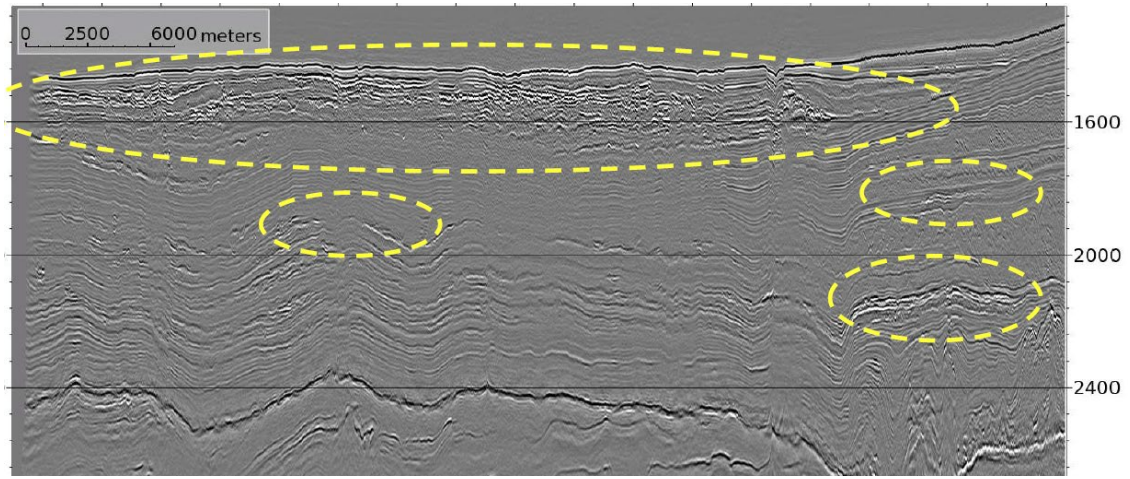
Methane seepage is now found in a rim around much of the Levant basin







Several apparent gas shows within the post Messinian section



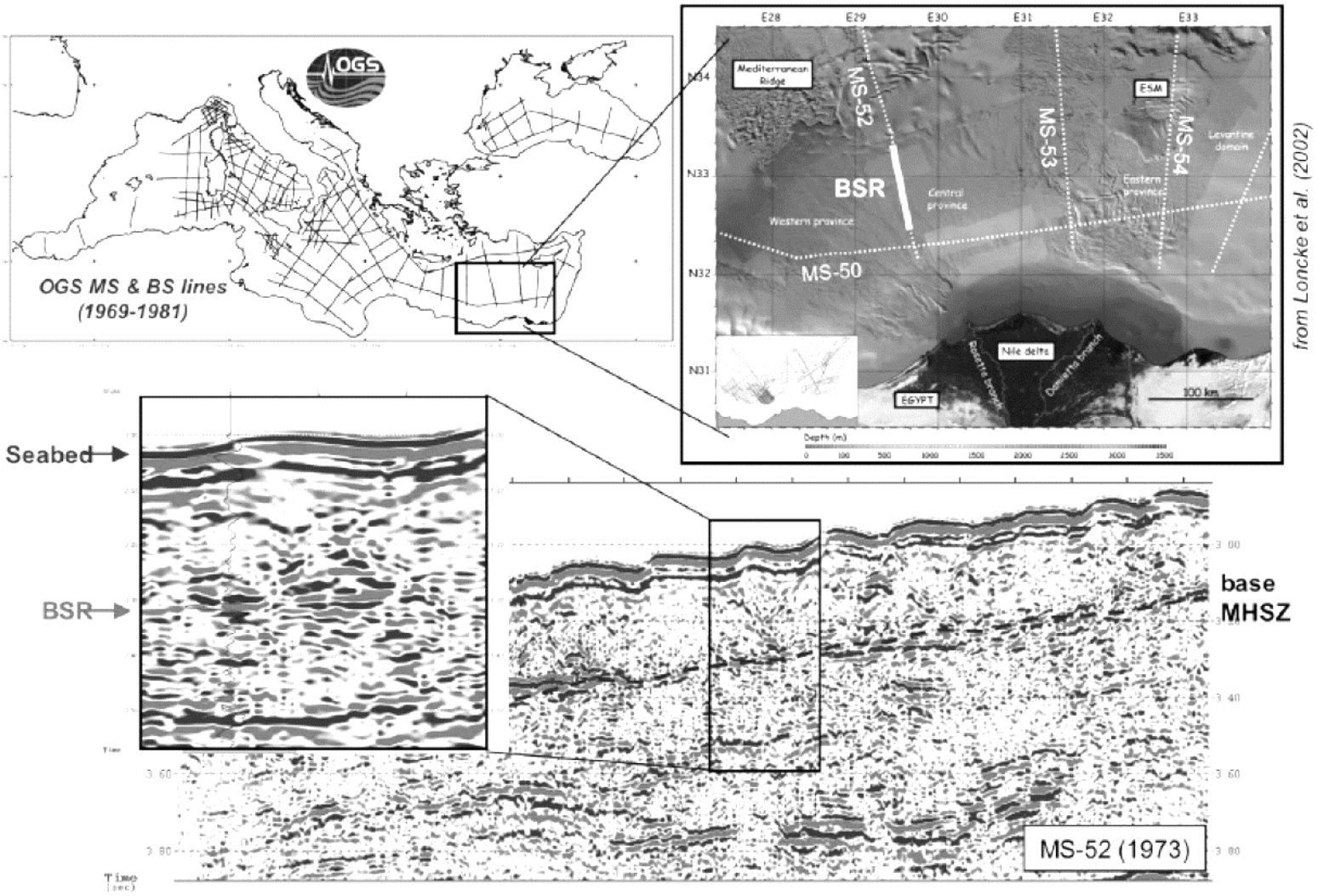
European Gas Hydrate Occurrences

Praeg et al., 2014

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Mediterranean Sea

Bottom simulating reflections in the Nile fan (offshore Egypt) are reported at depths of 200-300 mbsf and water depths around 2500 m. These depths match the theoretical calculations for the base of a structure II gas hydrate stability zone.

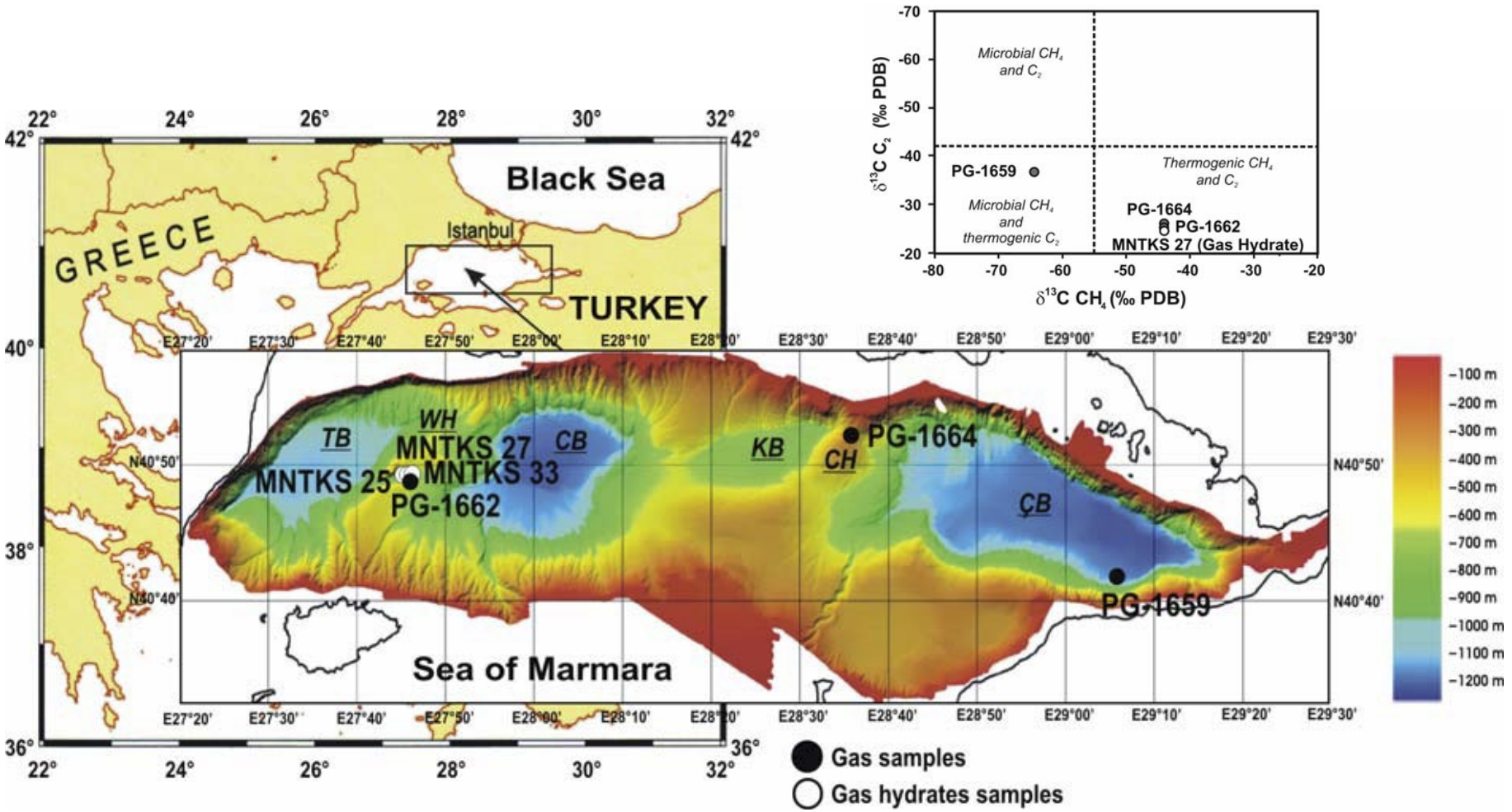


European Gas Hydrate Occurrences

Bourry et al., 2009
IFREMER

Sea of Marmara

Gas hydrates were sampled in the western part of the Sea of Marmara in the Çinarcik Basin. Methane is the major component of hydrates (66.1%), but heavier gases such as C2, C3, and *i*-C4 are also present in high concentration. The methane contained within gas hydrate is thermogenic as evidenced by a low C1/C2 + C3 ratio and isotopic data (δ13CCH4 of − 44.1‰).

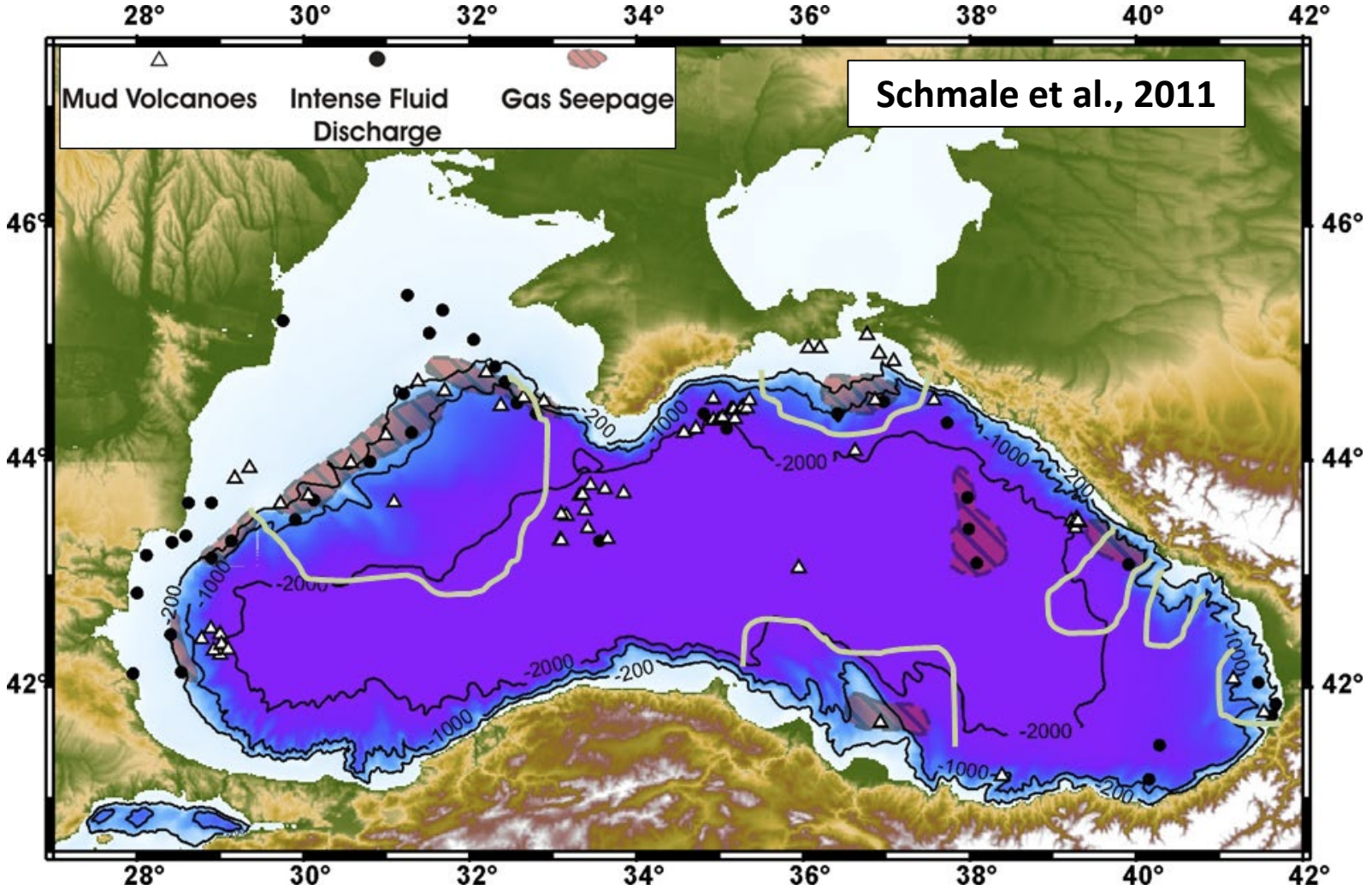


European Gas Hydrate Occurrences

MIGRATE - 2016

Black Sea

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

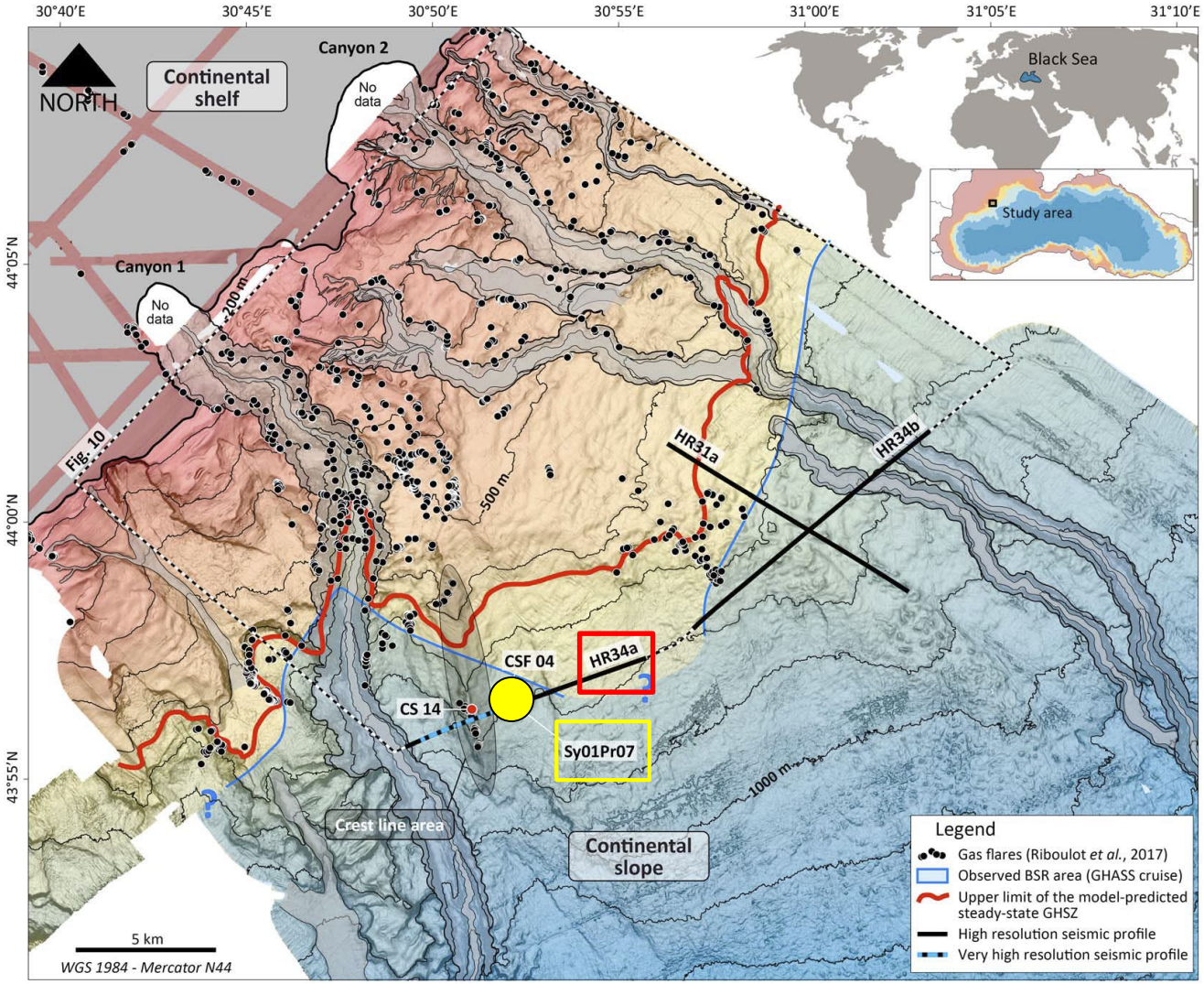


European Gas Hydrate Occurrences

Ker et al., 2019
Ifremer

Black Sea

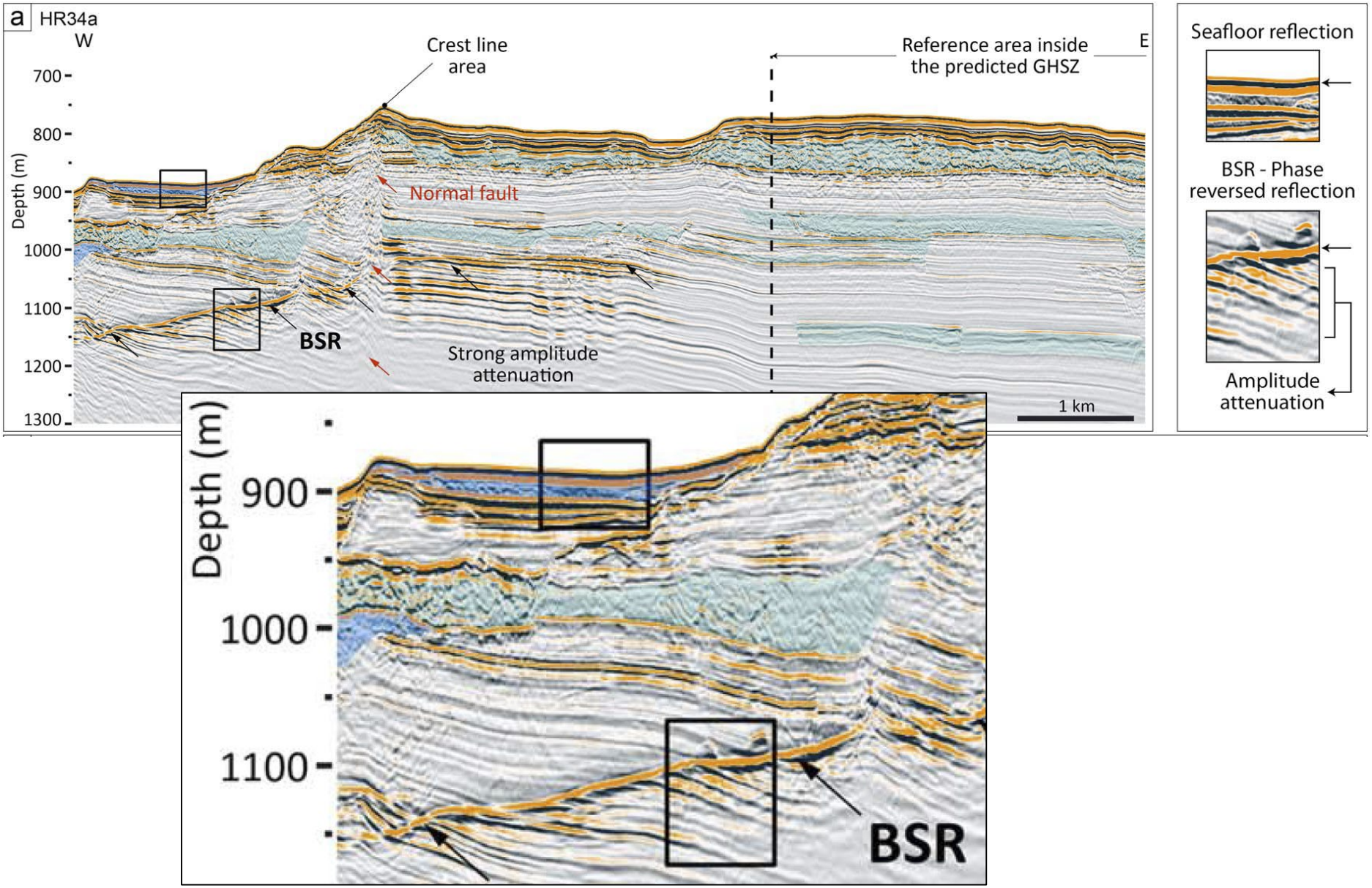
The presence of gas hydrates in the Danube Fan, located in the western part of the Black Sea, is inferred from the identification of a hydrate related BSRs. Gas seeps and gas-related seismic evidences have been also reported in the Danube Fan.



European Gas Hydrate Occurrences

Black Sea

Ker et al., 2019
Ifremer

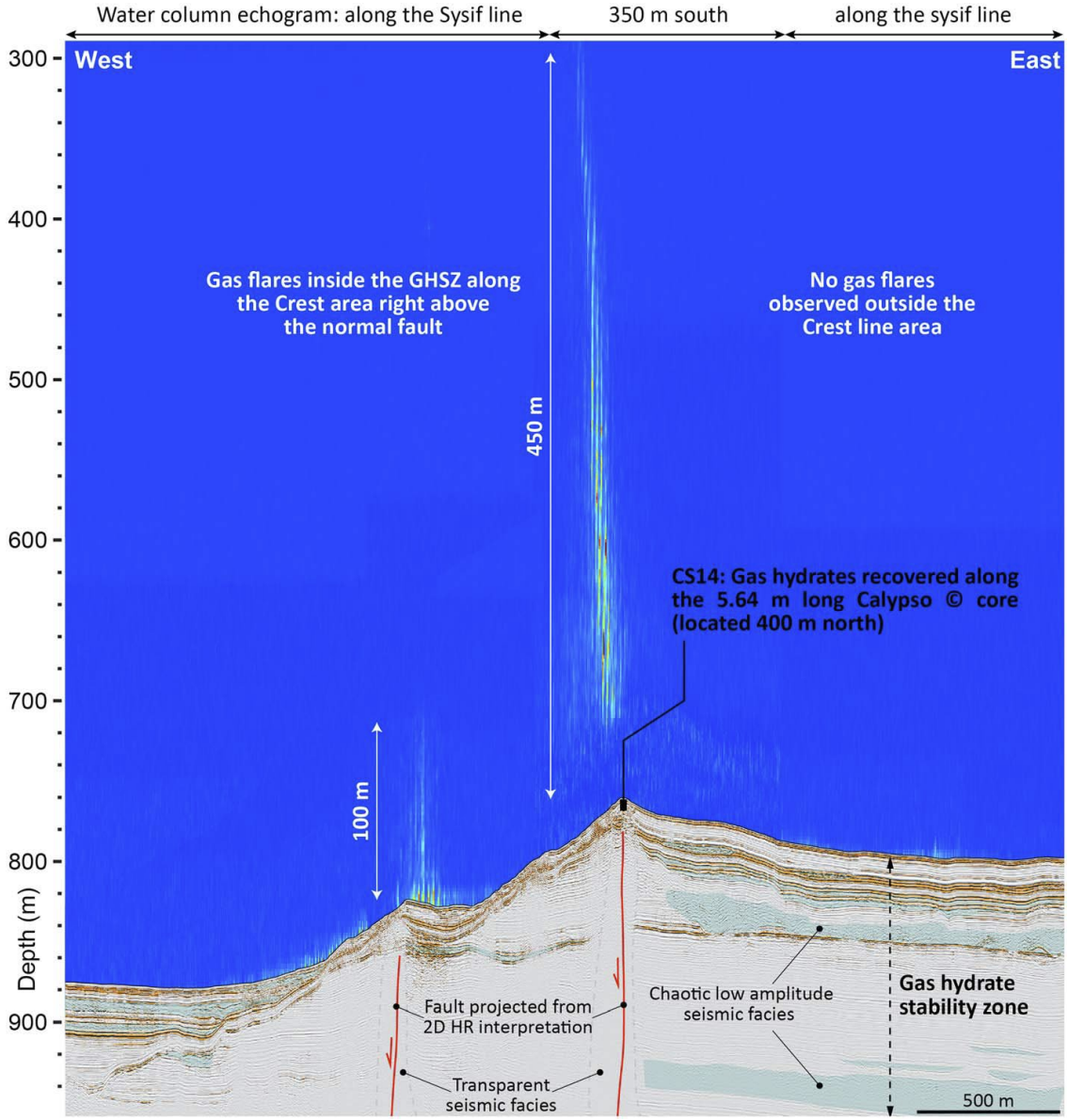


European Gas Hydrate Occurrences

Black Sea

Ker et al., 2019
Ifremer

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).

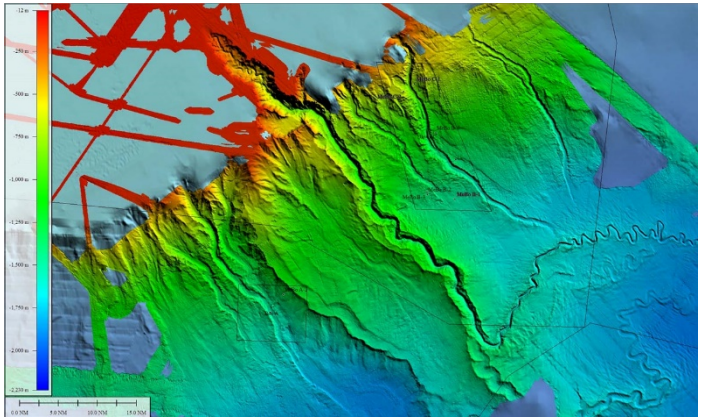
MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)

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

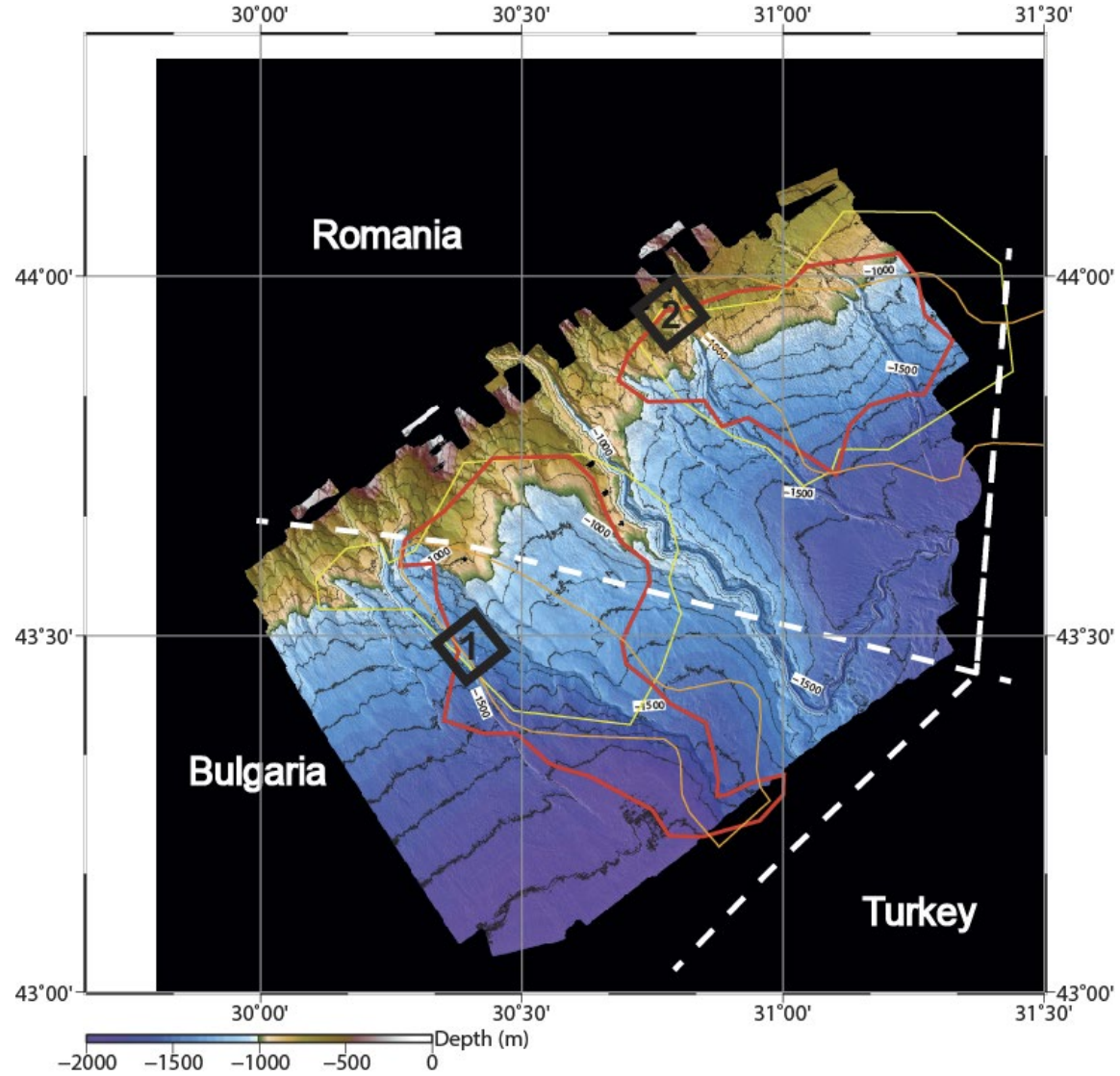
MARUM/SUGAR (GEOMAR/U.Bremen) – MeBo Black Sea (2017)

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)

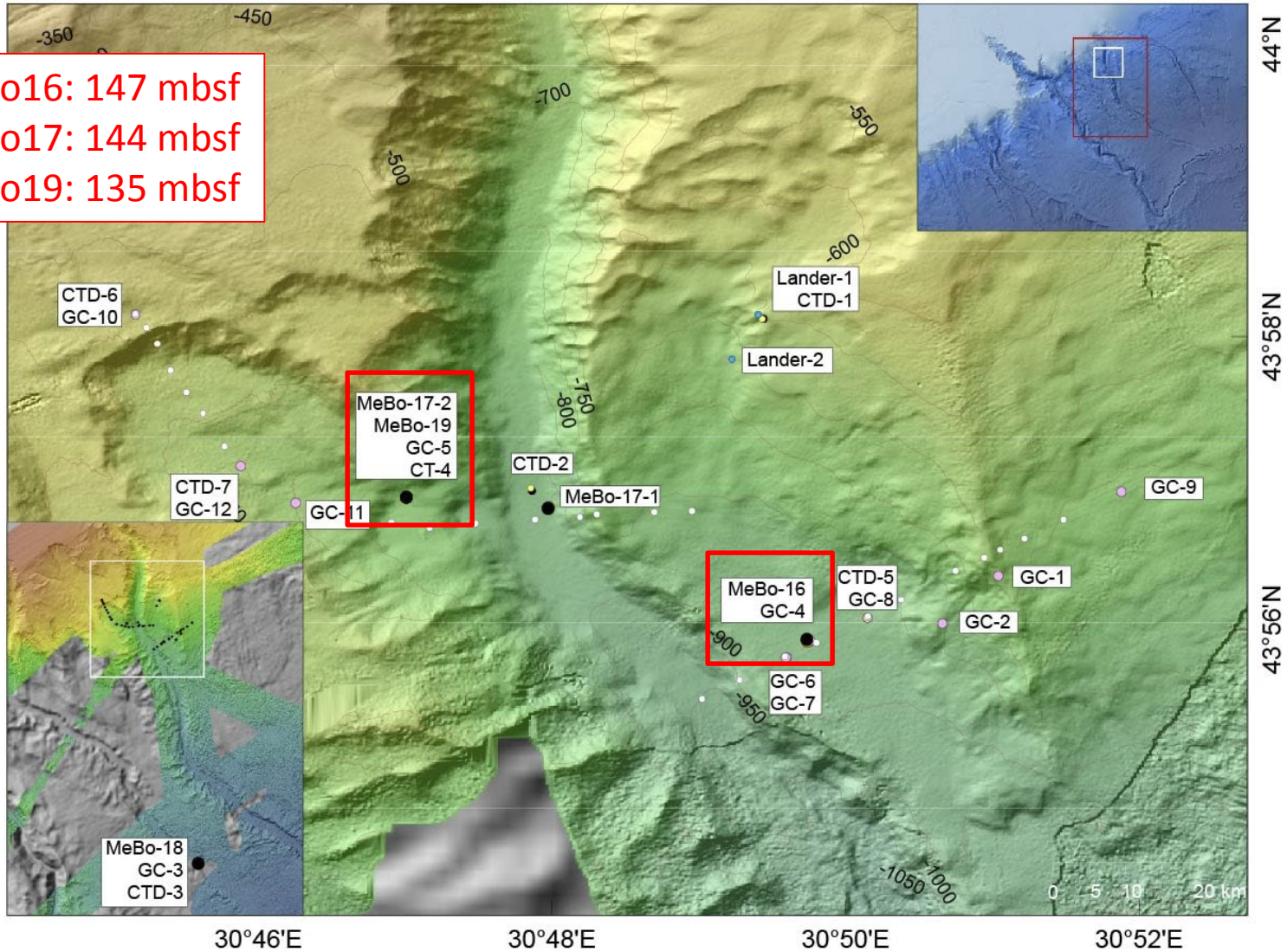
Center for Marine Environnemental Sciences (MARUM)

Submarine Gas Hydrate Reservoirs (SUGAR)

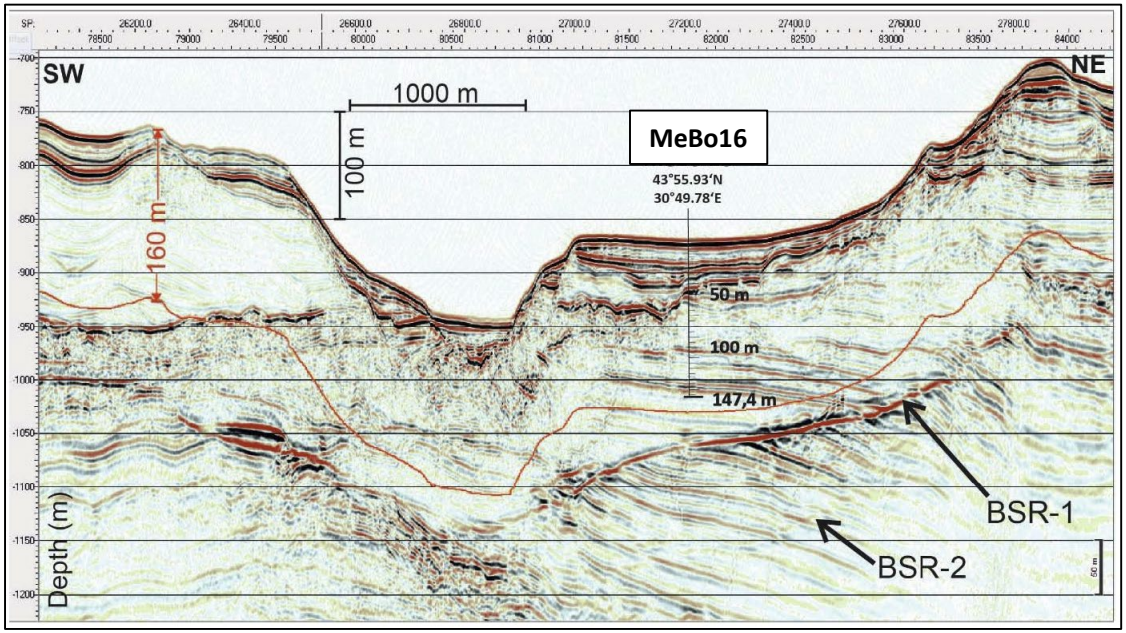
M142: R/V METEOR Cruise; 04.11.2017- 09.12.2017; Varna (Bulgaria) - Varna - Varna

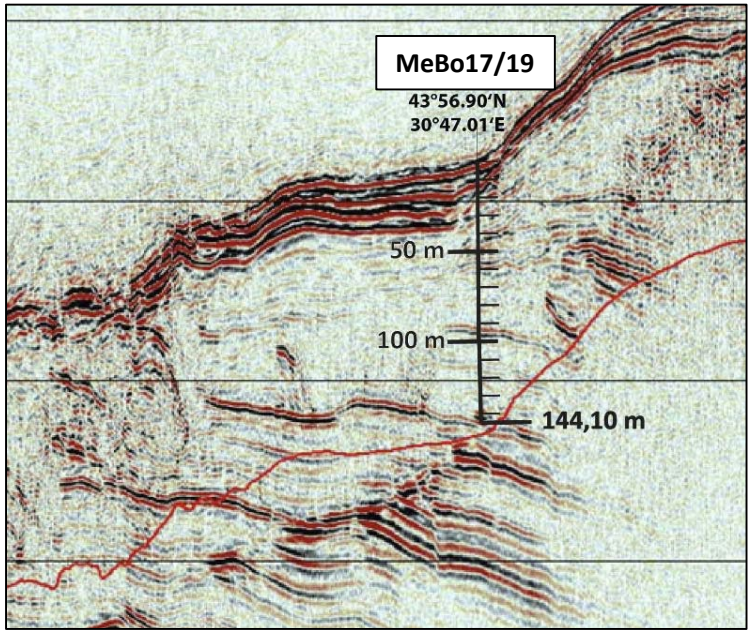
Drilling gas hydrates in sandy channel deposits in the Danube deep-sea fan, Black Sea

MeBo16: 147 mbsf
MeBo17: 144 mbsf
MeBo19: 135 mbsf



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.

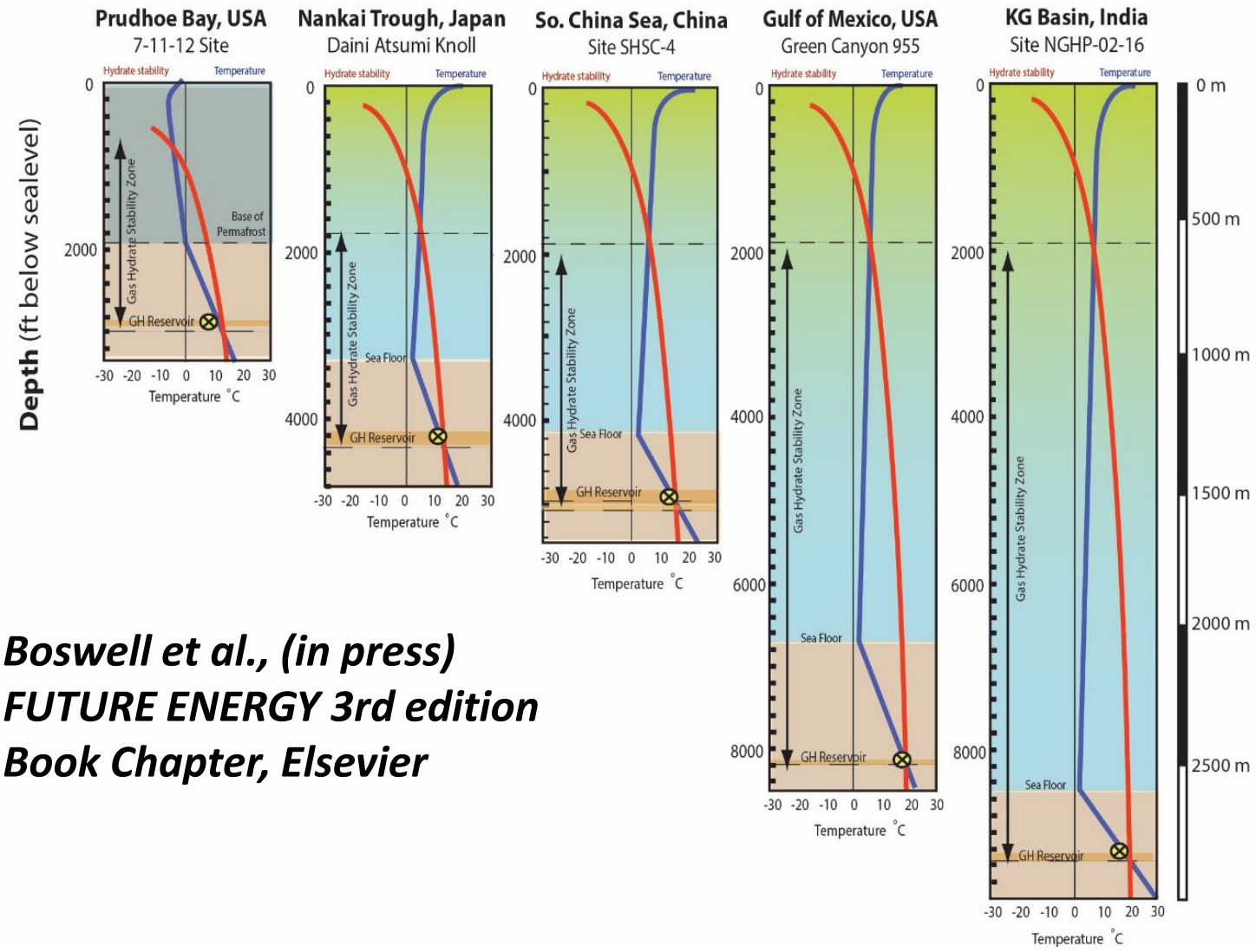
MeBo17: A negative anomaly with ΔT = -1°C has been observed in core barrel 29 with a thickness of about 15 cm, which was seen as dissociated gas hydrate. The liner has been on deck for one hour before the IR imaging was conducted. Gas voids were present in nearly all of the cores with positive temperature 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.

Gas Hydrate Production R&D

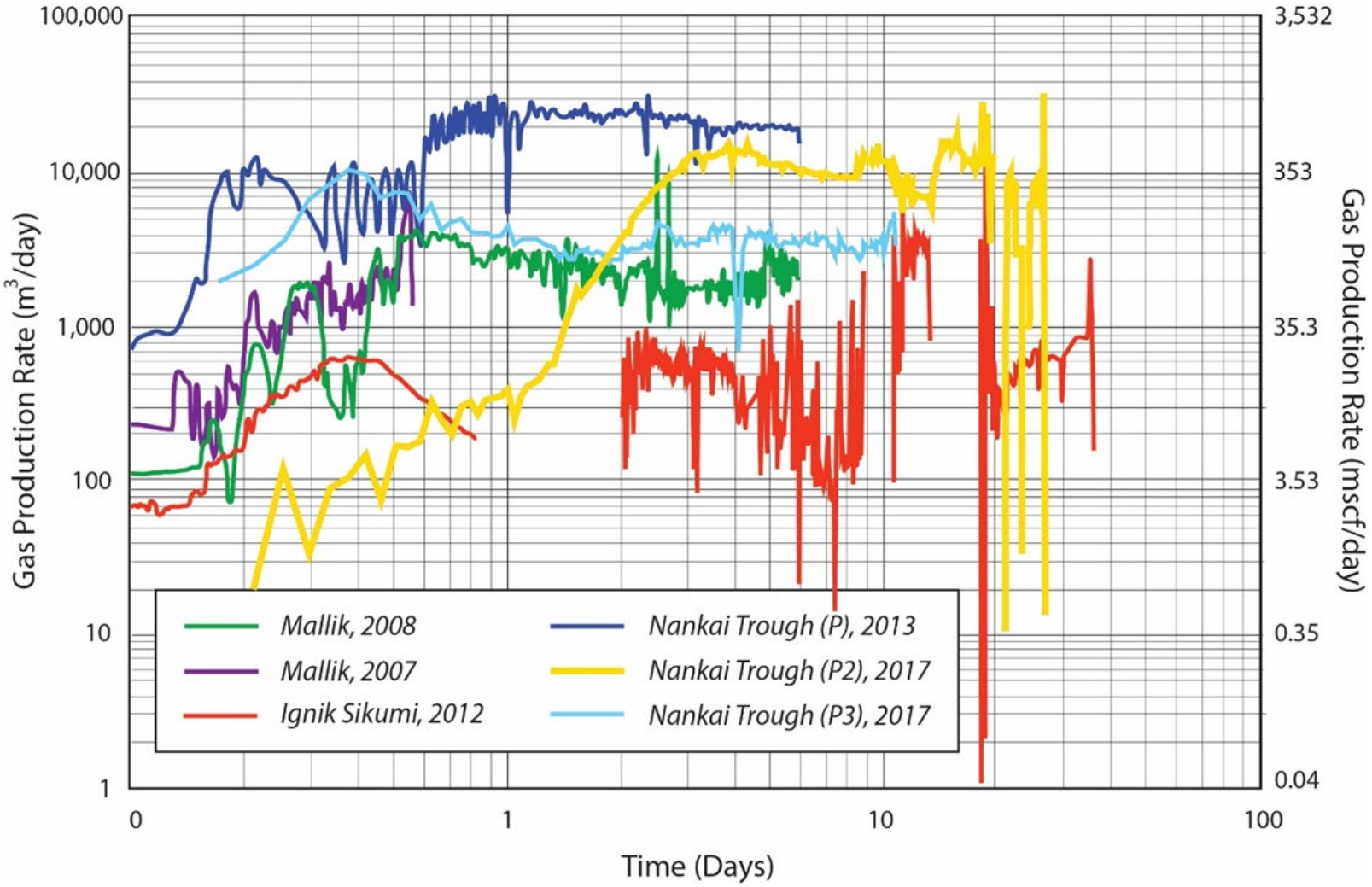
- **Messoyakha (Russia) in the 1970s**
  - Hydrate supported gas production (?)
- **Industry Drill-Stem Tests in the 1970s**
  - NW Eileen St 2; Mallik 1L-38
- **1998, 2002 Mallik (Canada)**
  - Thermal and formation pressure testing
- **2007 BP-DOE-USGS Alaska**
  - Formation pressure testing
- **2007 & 2008 Mallik (Canada)**
  - Depressurization test (6-days)
- **2011-2102 ConocoPhillips-DOE Alaska**
  - CH_4-CO_2 exchange & 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 (two test 10-30 days)
- ***2018-2022 DOE-JOGMEC Alaska***
  - Extended depressurization testing

Testing Considerations



Boswell et al., (in press)
FUTURE ENERGY 3rd edition
Book Chapter, Elsevier

Recent Test Results



Boswell et al., (in press), FUTURE ENERGY 3rd edition, Book Chapter, Elsevier

Republic of Korea

DOE-MKE MoU: NETL-TAMU-KIGAM CA: NETL-GHDO joint funding for NL FWPs

UBGH-01 (2007)/UBGH-02 (2010)

- USGS support
- DOE support for US scientist participation
- Special Volume publication in 2014

NETL, USGS, LBNL support for UBGH-03 planning*

- Site selection advisory committee
- Numerical prediction of production response

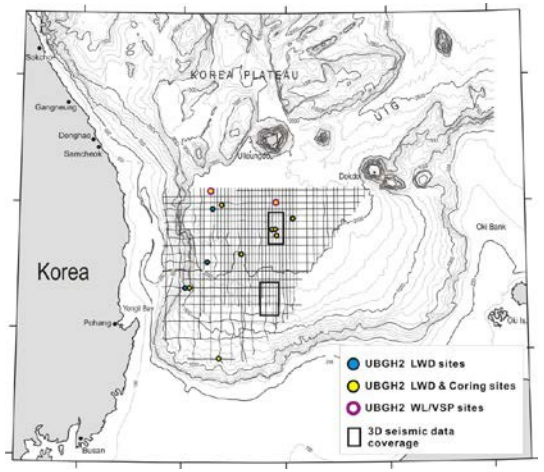
Numerical Simulation Studies

- Collaborations KIGAM, LBNL, PNL

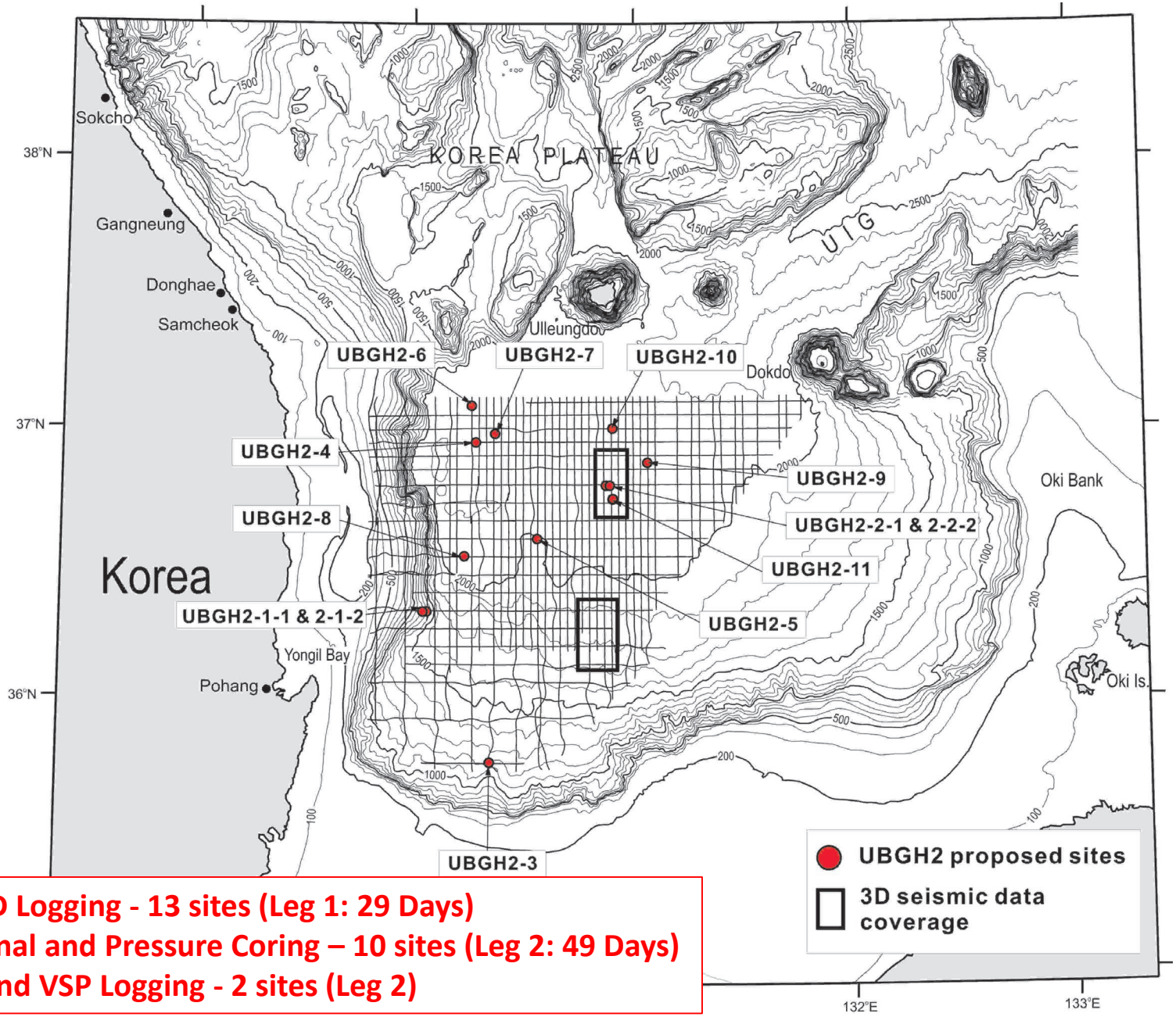
Collaboration with Texas A&M

- Data from KIGAMs unique large-scale reactors

***2nd GHDO R&D Master Plan for 2019-2028 under development**

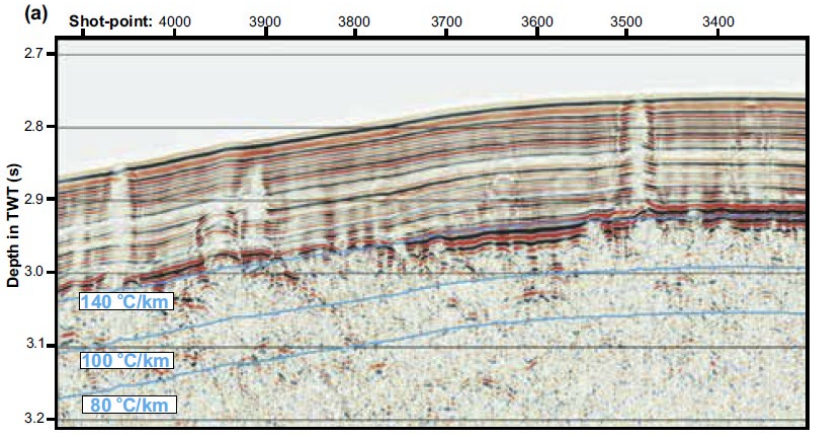


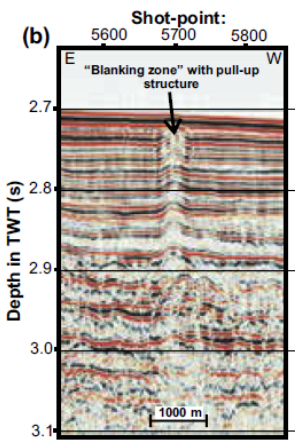
Ulleung Basin Gas Hydrate Drilling Expedition (UBGH2) 2010



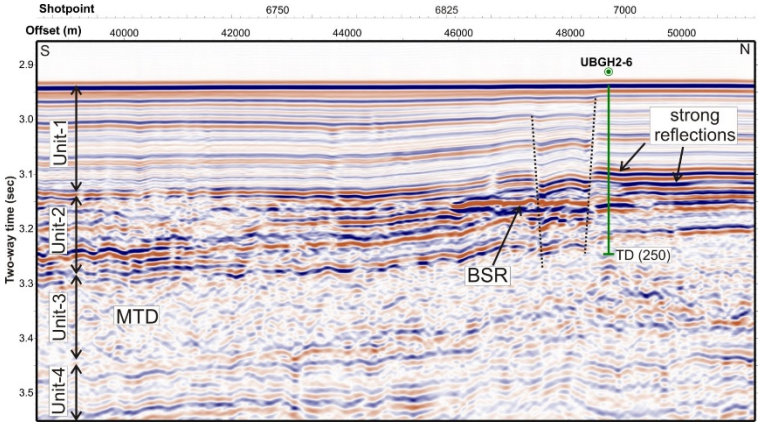
LWD-MWD Logging - 13 sites (Leg 1: 29 Days)
Conventional and Pressure Coring – 10 sites (Leg 2: 49 Days)
Wireline and VSP Logging - 2 sites (Leg 2)

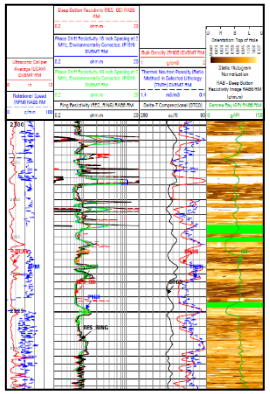
Ulleung Basin Gas Hydrate Prospects



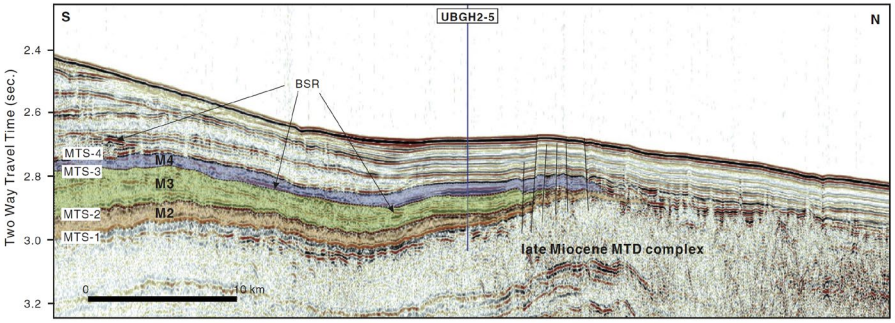


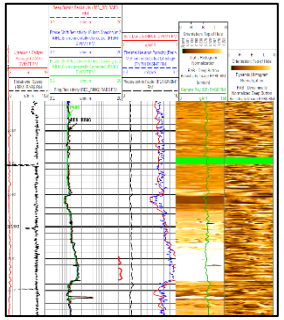
Chimney structures





Turbidite sands

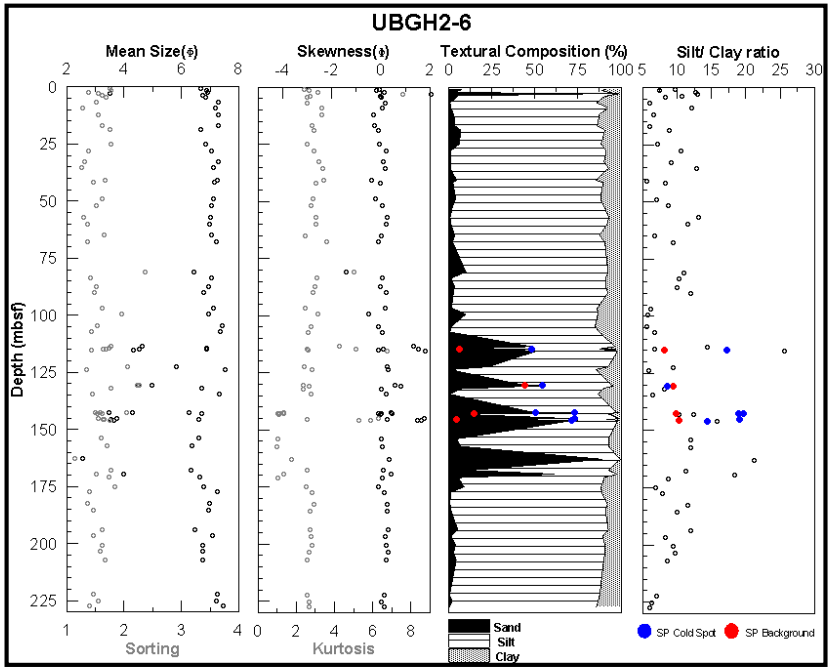


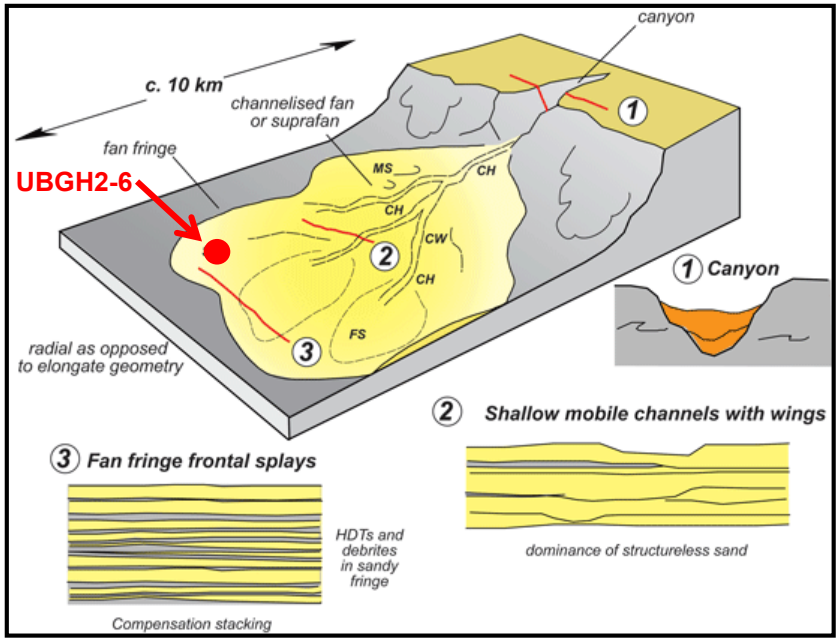


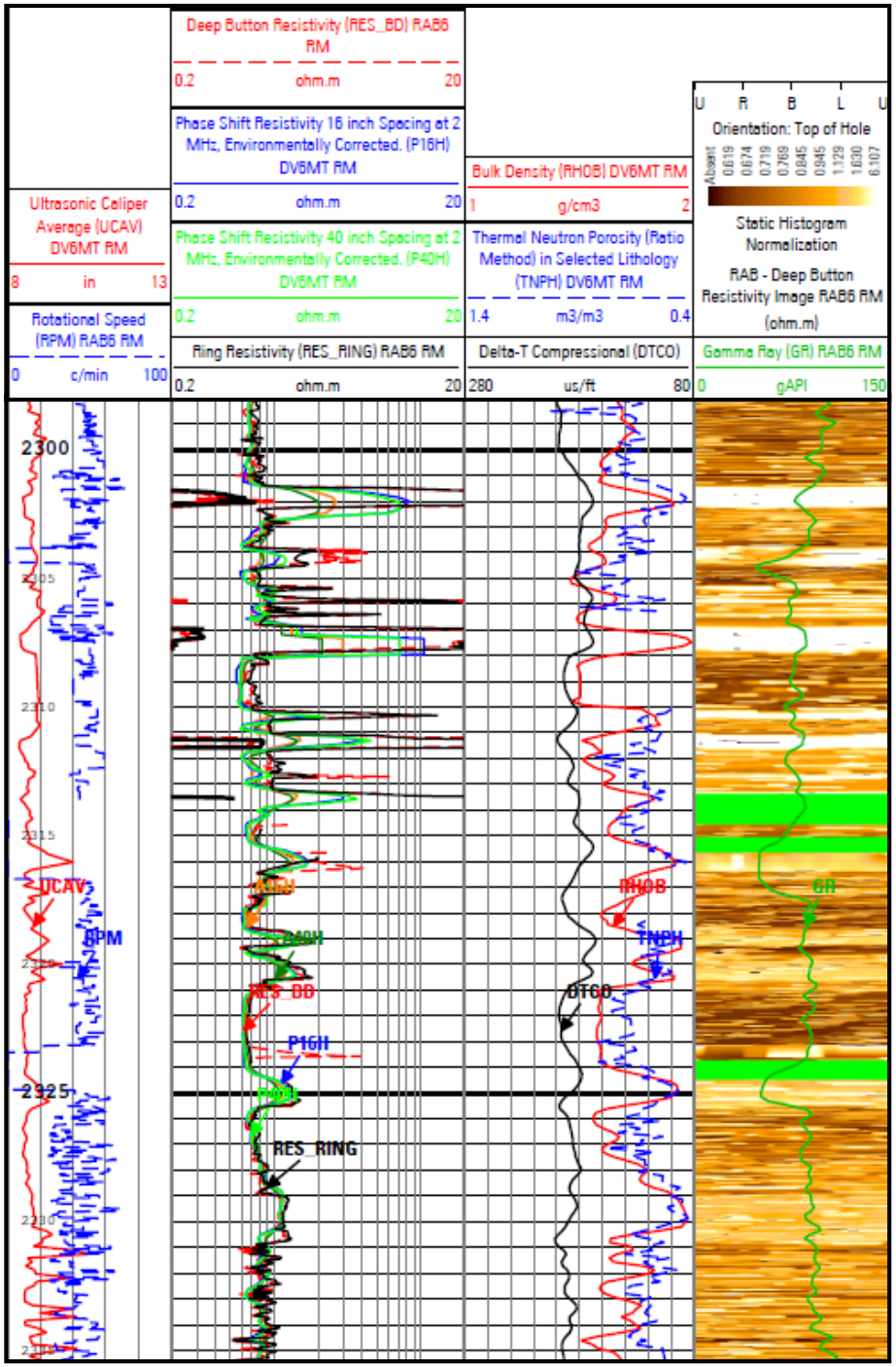
Sandy debris flows

LWD-MWD Logging - 13 sites (Leg 1)
Conventional and Pressure Coring – 10 sites (Leg 2)
Wireline and VSP Logging - 2 sites (Leg 2)

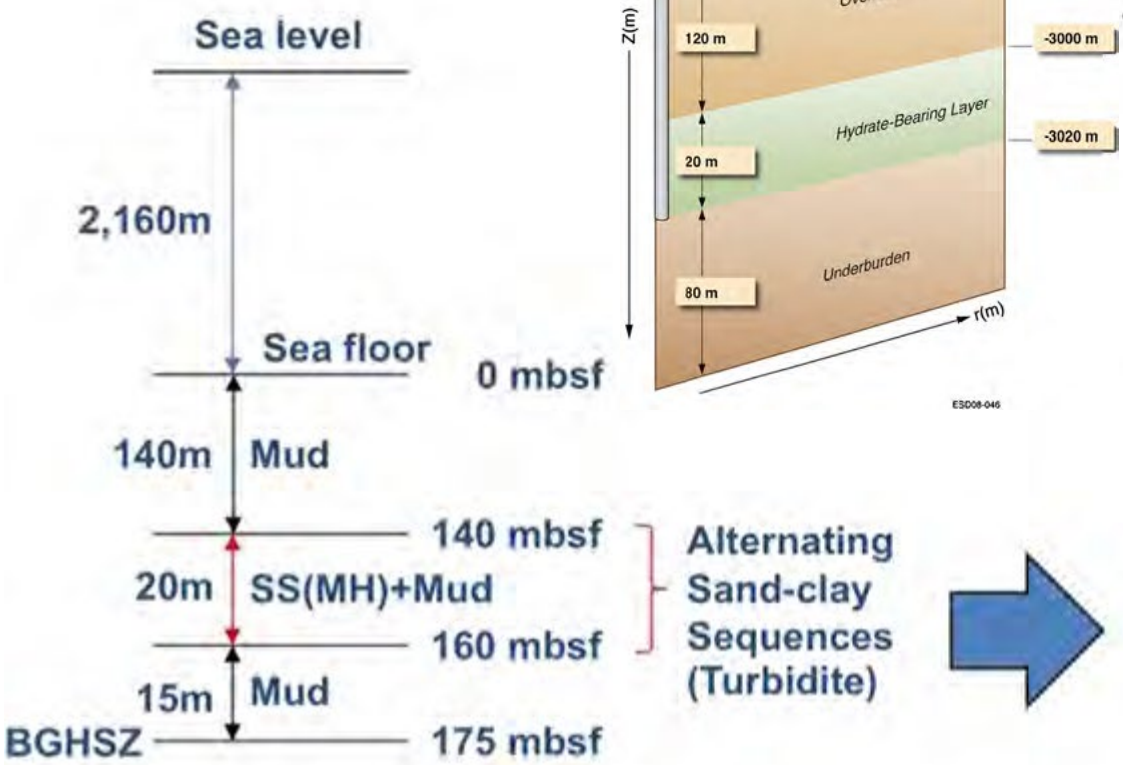
Ulleung Basin: UBGH2-6







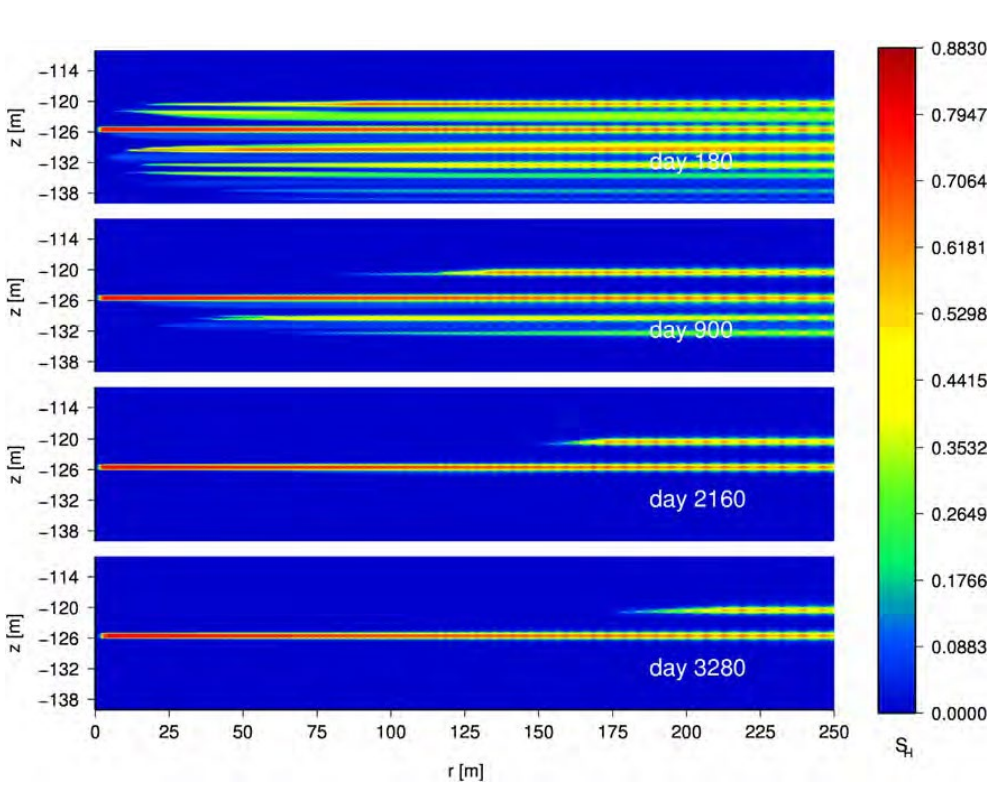
Site UBGH2-6 Gas Hydrate Production Modeling

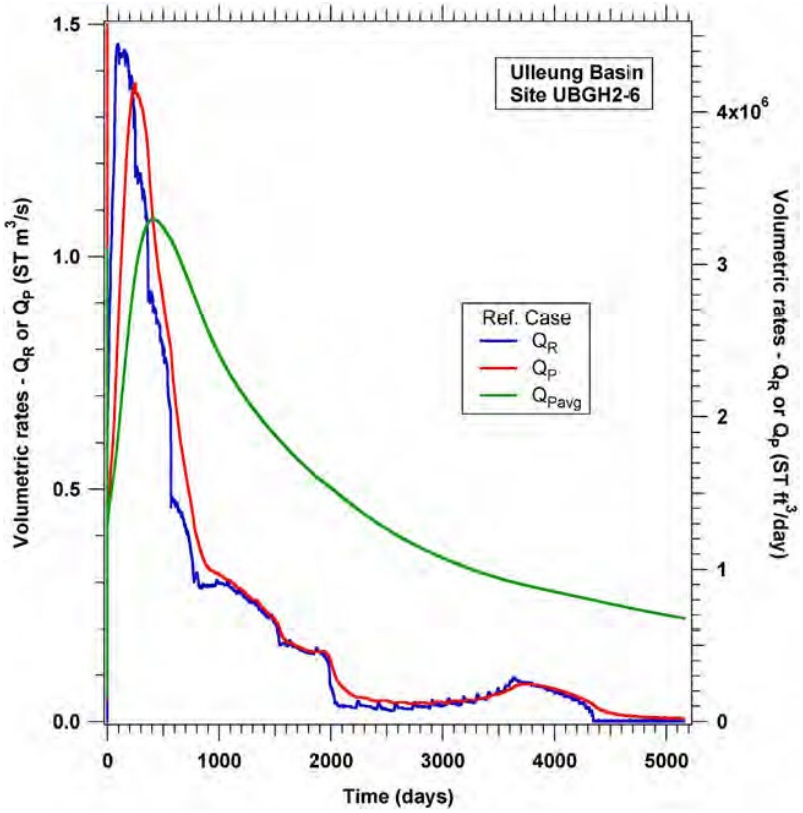


		S_H(%)	Por(%)	
140 mbsf	Layer 1-SS	70	65	1m
141	Layer 2-M	0	45	1m
142	Layer 3-SS	40	60	2m
144	Layer 4-M	0	50	1m
145	Layer 5-SS	75	70	1m
146	Layer 6-M	0	54	2m
148	Layer 7-SS	45	52	1m
149	Layer 8-SS	70	60	1m
150	Layer 9-M	0	55	2m
152	Layer 10-SS	60	65	1m
153	Layer 11-M	0	55	1m
154	Layer 12-SS	35	65	1m
155	Layer 13-M	0	53	2m
157	Layer 14-SS	30	60	1m
158	Layer 15-M	0	50	1m
159	Layer 16-SS	30	60	1m
160				

Moridis et al., 2013

Site UBGH2-6 Gas Hydrate Production Modeling





Production rate of 1.5 ST m^3 per sec ($4.5x10^6$ ST ft^3 per day).

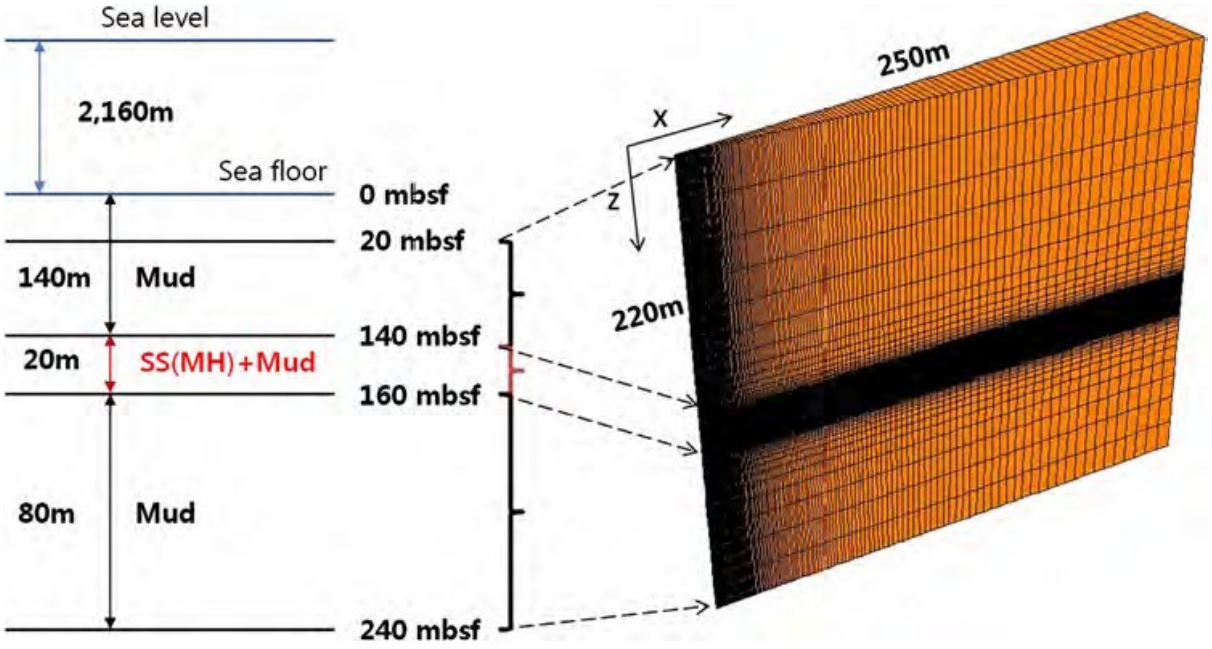
Total production of 10^8 ST m^3 ($3.5x10^9$ ST ft^3) in 5200 days (about 14 years)

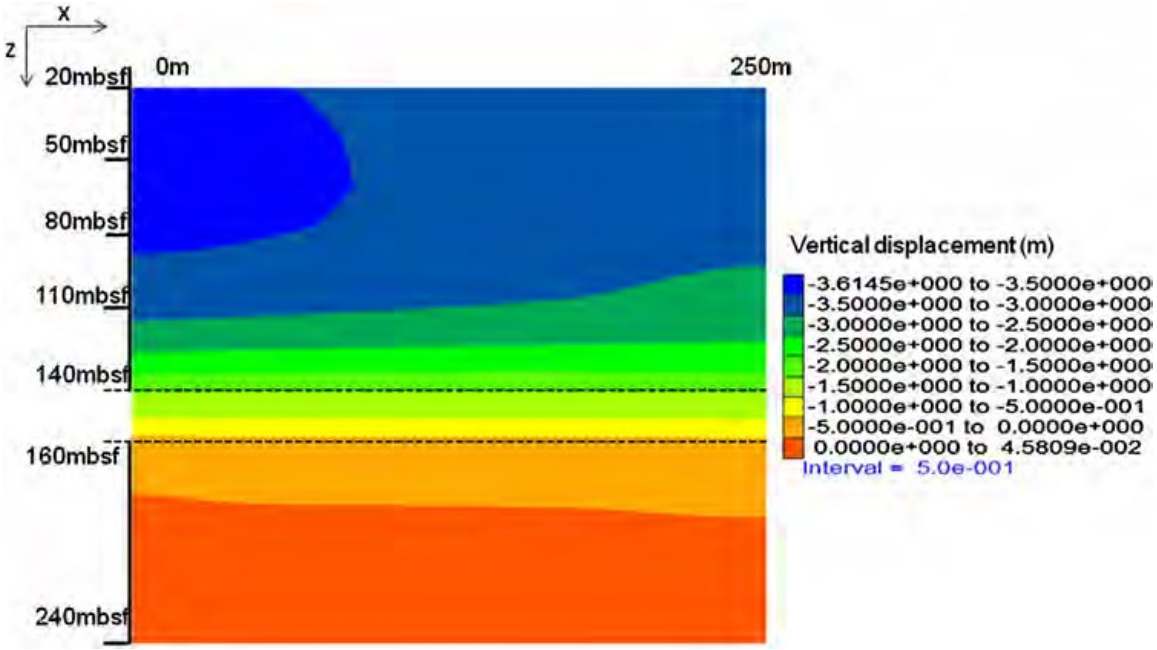
The low production rate is caused by the relatively low amount of the resource (10 m of hydrate-bearing strata) and the low overall permeability of the system with clay interlayers.

Moridis et al., 2013

Site UBGH2-6 Gas Hydrate Production Modeling

-Geomechanical Model





Subsidence at 140 mbsf (top of the hydrate-bearing system) increases overtime and reaches 1.67 m in 644 days.

Moridis et al., 2013

India

DOE-MoPNG MoU; USGS-DGH MoU

India-US Collaboration

- Planning, execution of NGHP-01 and NGHP-02
- Evaluation and publication of Scientific Results from NGHP-01 (USGS, NETL, LBNL, GT, Scripps, OSU)
- Geophysical site review for NGHP-02 exploratory drilling
- Evaluation of NGHP-02 pressure cores (USGS, AIST)
- Geomechanical production simulations for potential NGHP-03 sites (NETL, LBNL, USGS)
- Evaluation and publication of Scientific Results from NGHP-02 (USGS, NETL, LBNL)
- Operational planning for NGHP-03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journal homepage: www.elsevier.com/locate/marpetgeo

Research paper

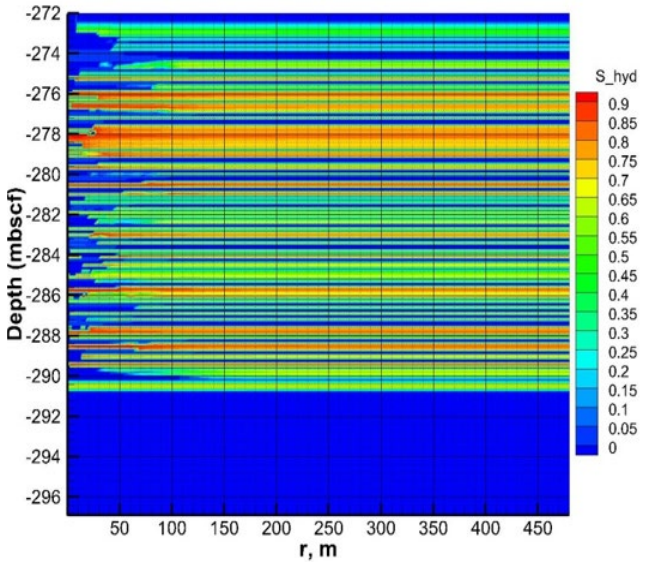
Geologic implications of gas hydrates in the offshore of India: Results of the National Gas Hydrate Program Expedition 01

Timothy S. Collett [a,*], Ray Boswell [b], James R. Cochran [c], Pushpendra Kumar [d], Malcolm Lall [e], Aninda Mazumdar [f], Mangipudi Venkata Ramana [g], Tammisetti Ramprasad [f], Michael Riedel [h], Kalachand Sain [i], Arun Vasant Sathe [j], Krishna Vishwanath [e], NGHP Expedition 01 Scientific Party

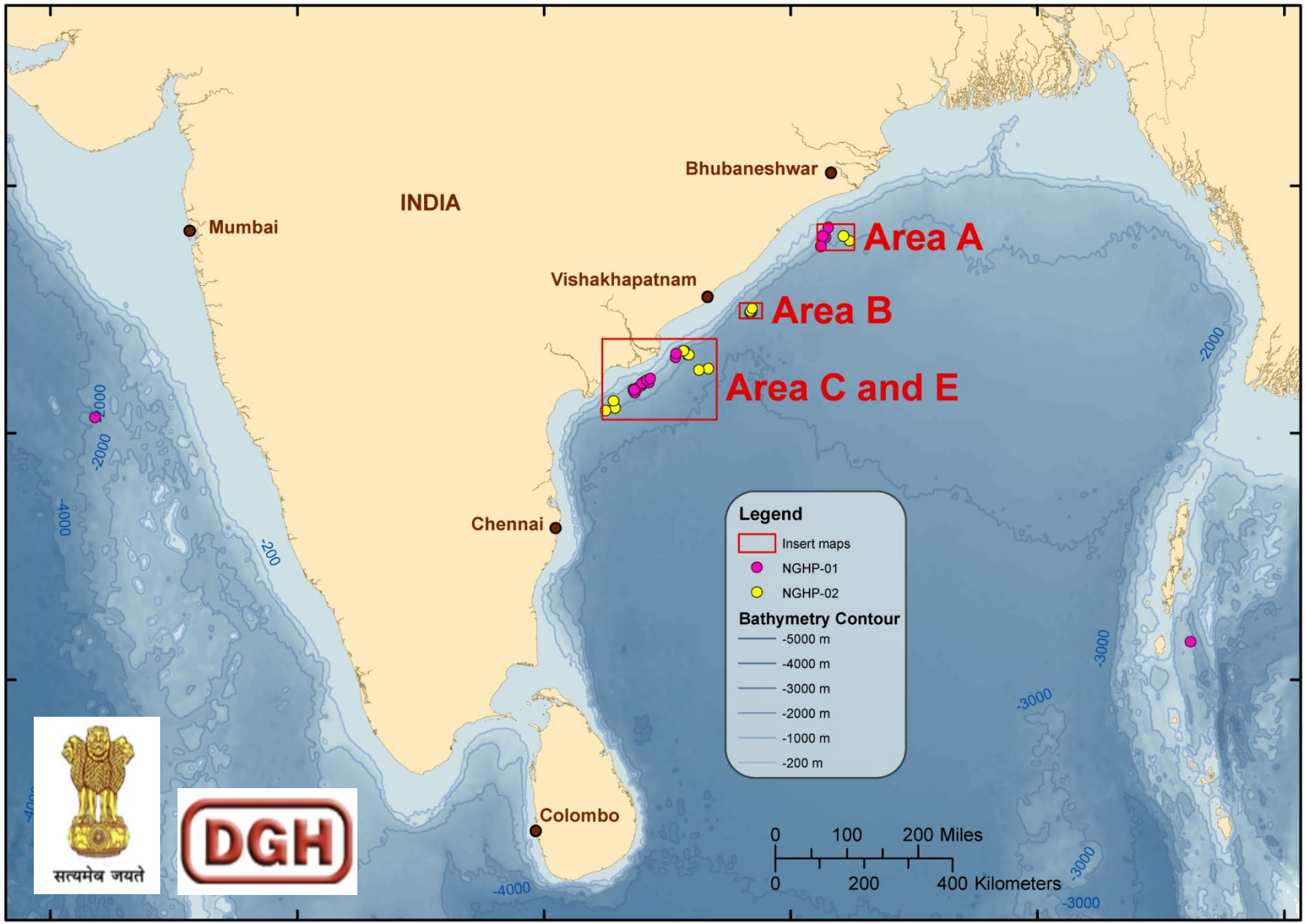
Science Results for NGHP-01

NGHP-02 p-cores arrive at USGS labs in Woods Hole

NETL modeling for potential NGHP-03 Site 16



India NGHP-01 (2006) and NGHP-02 (2015)



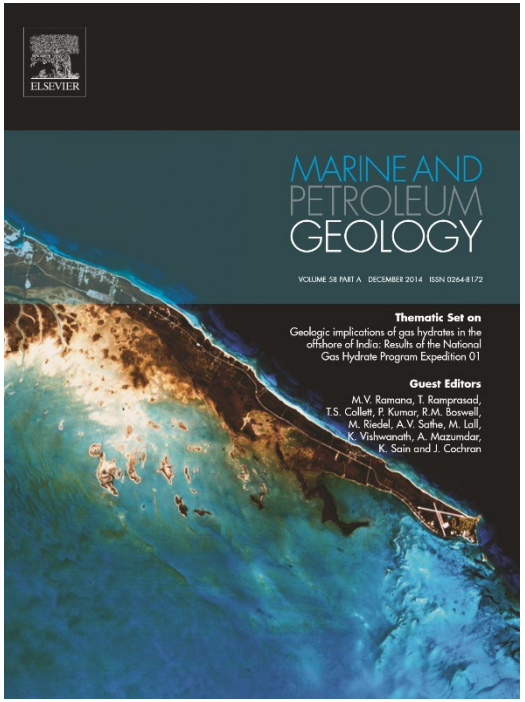
JOURNAL OF MARINE AND PETROLEUM GEOLOGY SPECIAL ISSUE

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

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

Contents

Status as of 14-OCT-2018 – Total of 47 Submissions



JOURNAL OF MARINE AND PETROLEUM GEOLOGY SPECIAL ISSUE

JMPG NGHP-02 Expedition Summary Papers

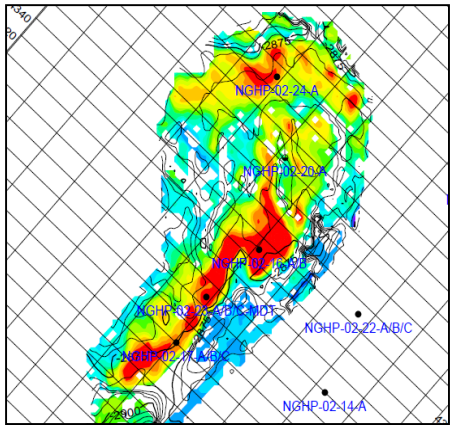
India National Gas Hydrate Program Expedition 02 Summary of Scientific Results: Gas Hydrate Systems along the Eastern Continental Margin of India
Timothy S. Collett, Ray Boswell, William F. Waite, Pushpendra Kumar, Mahendra Pratap, Sandip Kumar Roy, Krishan Chopra, Sunil Kumar Singh, Yasuhiro Yamada, Norio Tenma, John Pohlman, Margarita Zyrianova

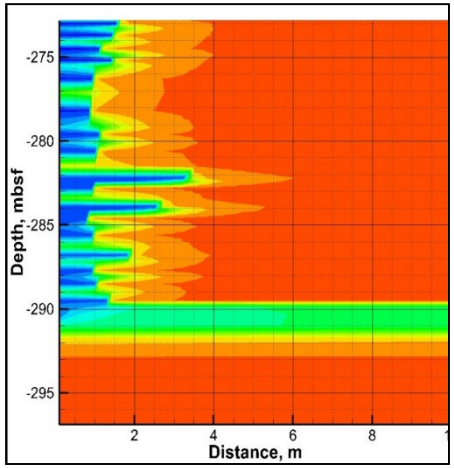
India National Gas Hydrate Program Expedition 02 Summary of Scientific Results: Evaluation of Natural Gas Hydrate-Bearing Pressure Cores
Ray Boswell, Jun Yoneda, William Waite

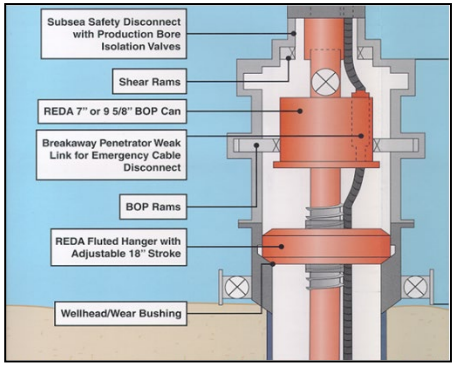
India National Gas Hydrate Program Expedition 02 Summary of Scientific Results: Numerical Simulations of Gas Hydrate Reservoirs
Ray Boswell, Evgeniy Myshakin, George Moridis, Yoshihiro Konno, Timothy S. Collett, Taiwo Ajayi, Yongkoo Seol

India National Gas Hydrate Program Expedition 02 Operational and Technical Summary
Pushpendra Kumar, Timothy S. Collett, K. M. Shukla, U. S. Yadav, M. V. Lall , Krishna Vishwanath

NGHP-03 Test Planning



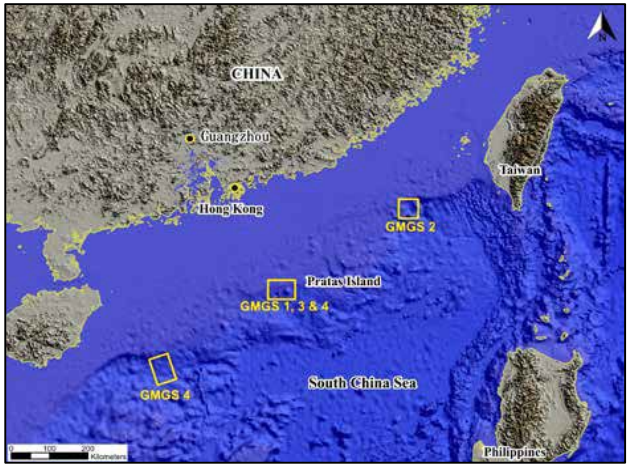




- **Test Site Review and Characterization**
  - **Inventory and assess candidate test sites with existing NGHP and industry data through an integrated G&G review effort.**
  - **Assess requirements for additional G&G data acquisition and analysis (geophysical data, logging/coring operations, etc).**
- **Production Test Design**
  - **Develop and refine production-mechanical models.**
  - **Numerical simulation of well performance during planned production tests, develop tests procedures and mitigation approaches.**
  - **Test design to prioritize insight toward field scale reservoir response and economics.**
- **Operational Planning**
  - **Flexibility: Project management plan and structure should anticipate and enable changes in operations.**
  - **Development of an integrated project risk analysis and management process.**

China

Very Active Program

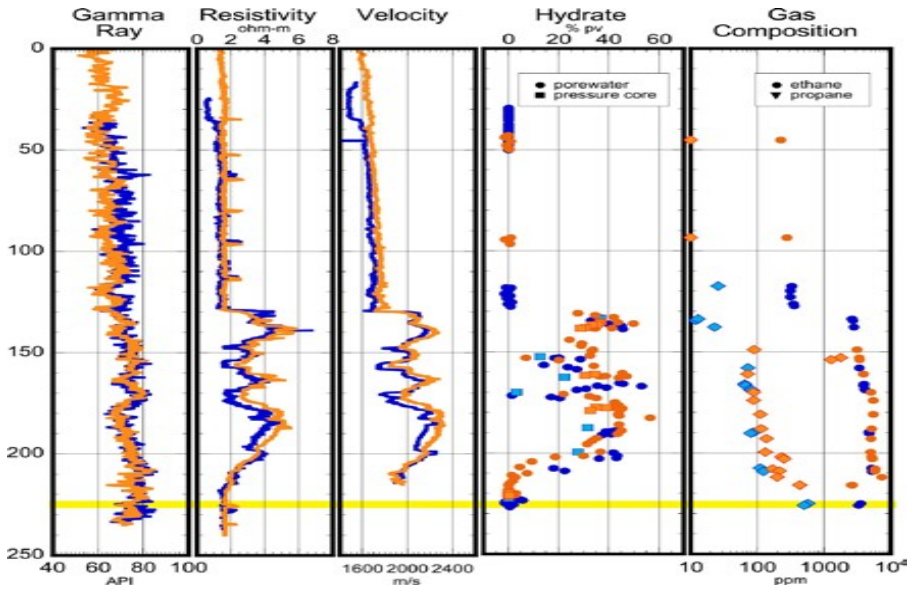


GMGS-1 (2007), GMGS-2 (2013), GMGS-3 (2015), GMGS-4 (2016), and GMGS-5 (2018)

- 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 Production Test

Bluewhale 1 & 2
CPOE Operator
CNPC Client
First deployment – SCS GH testing

Test site in South China Sea
Test zone ~250 mbsf
WD = 1,266 m

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

New gas hydrate center CNOOC-Beijing

GMGS-5 (2018) geoscience expedition

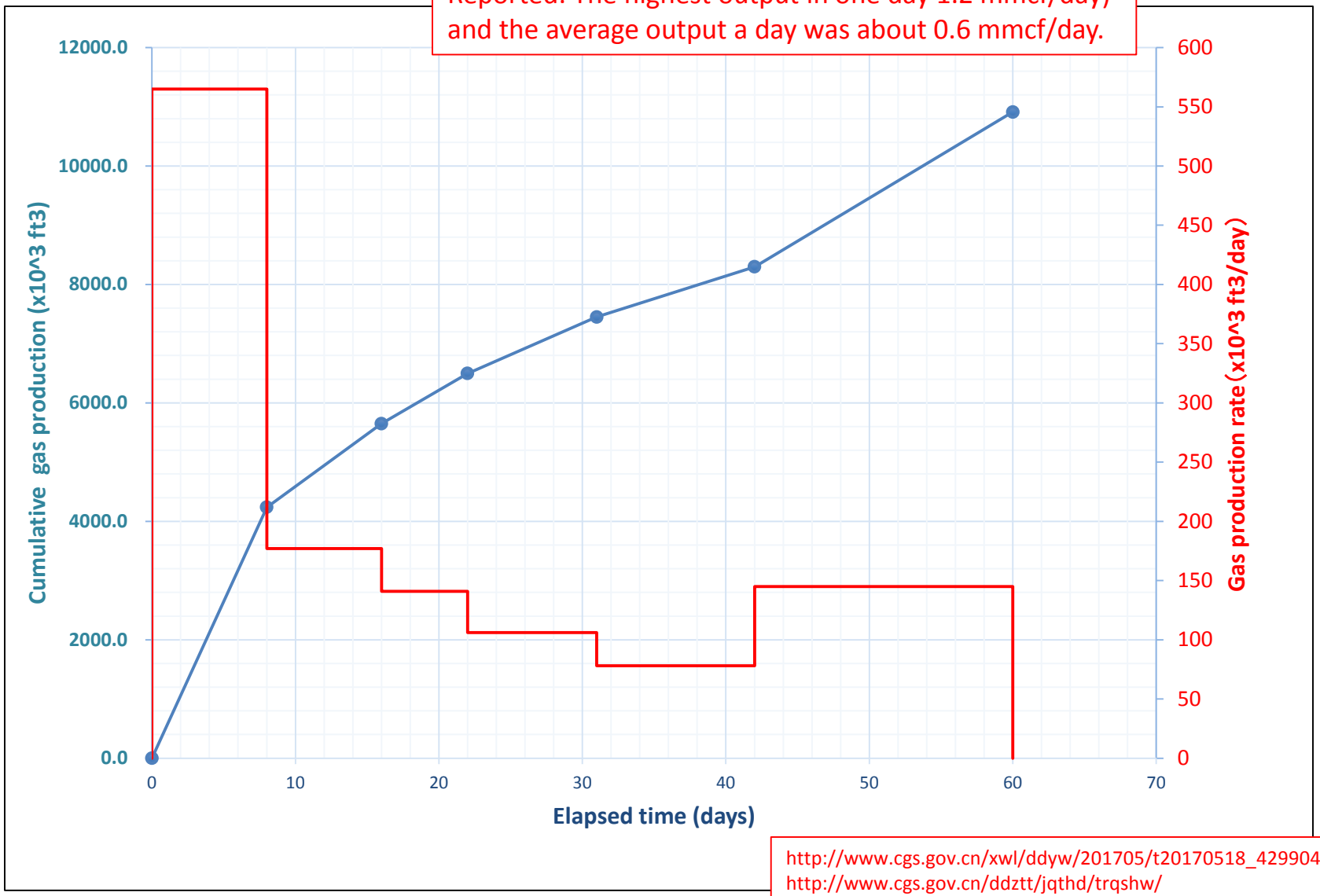
GMGS-6 (2019) geoscience expedition?

2020 second production test ?

China

2017 Production Test Results

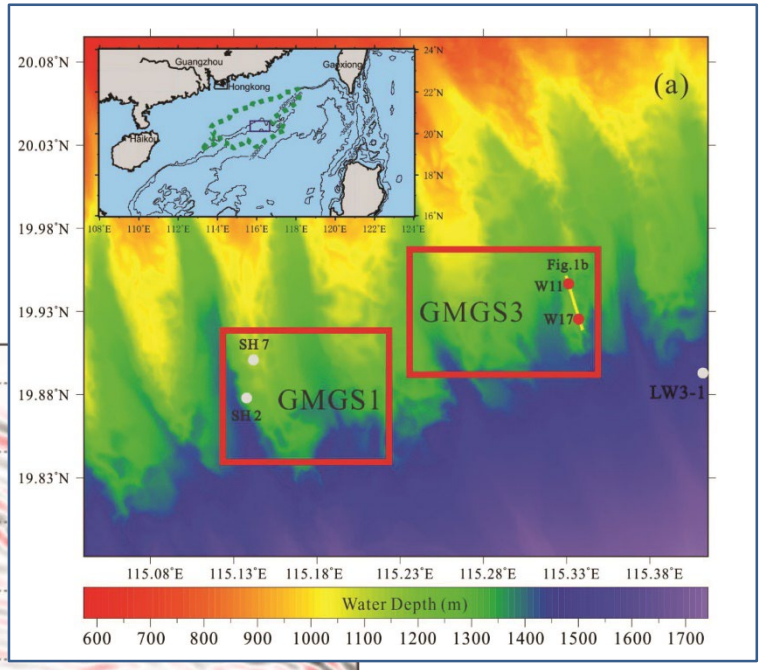
Reported: The highest output in one day 1.2 mmcf/day) and the average output a day was about 0.6 mmcf/day.

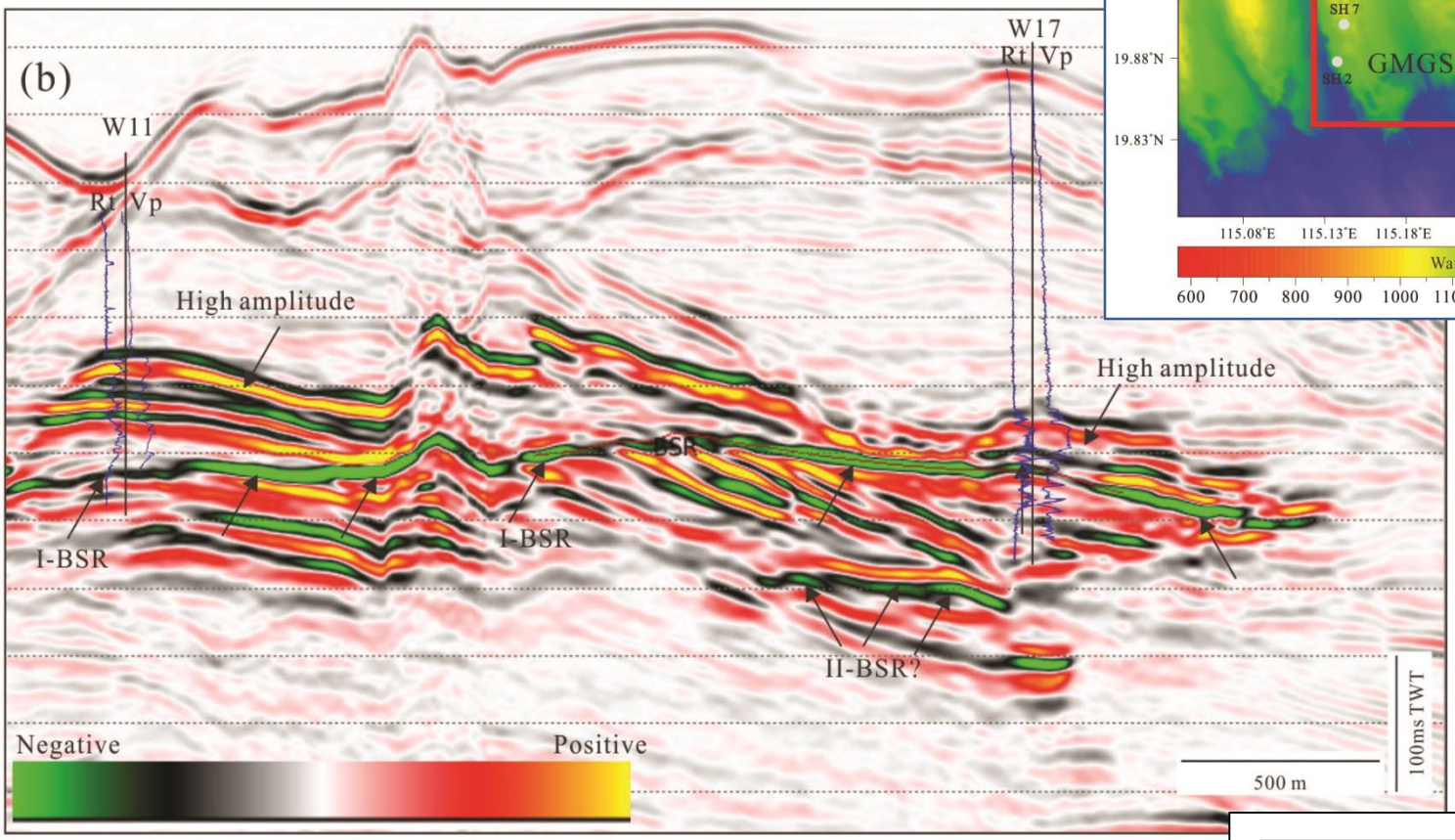


http://www.cgs.gov.cn/xwl/ddyw/201705/t20170518_429904.html
http://www.cgs.gov.cn/ddztt/jqthd/trqshw/
http://www.mlr.gov.cn/xwdt/jrxw/201707/t20170710_1524223.htm

GMGS-3 (2015) W11 & W17

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





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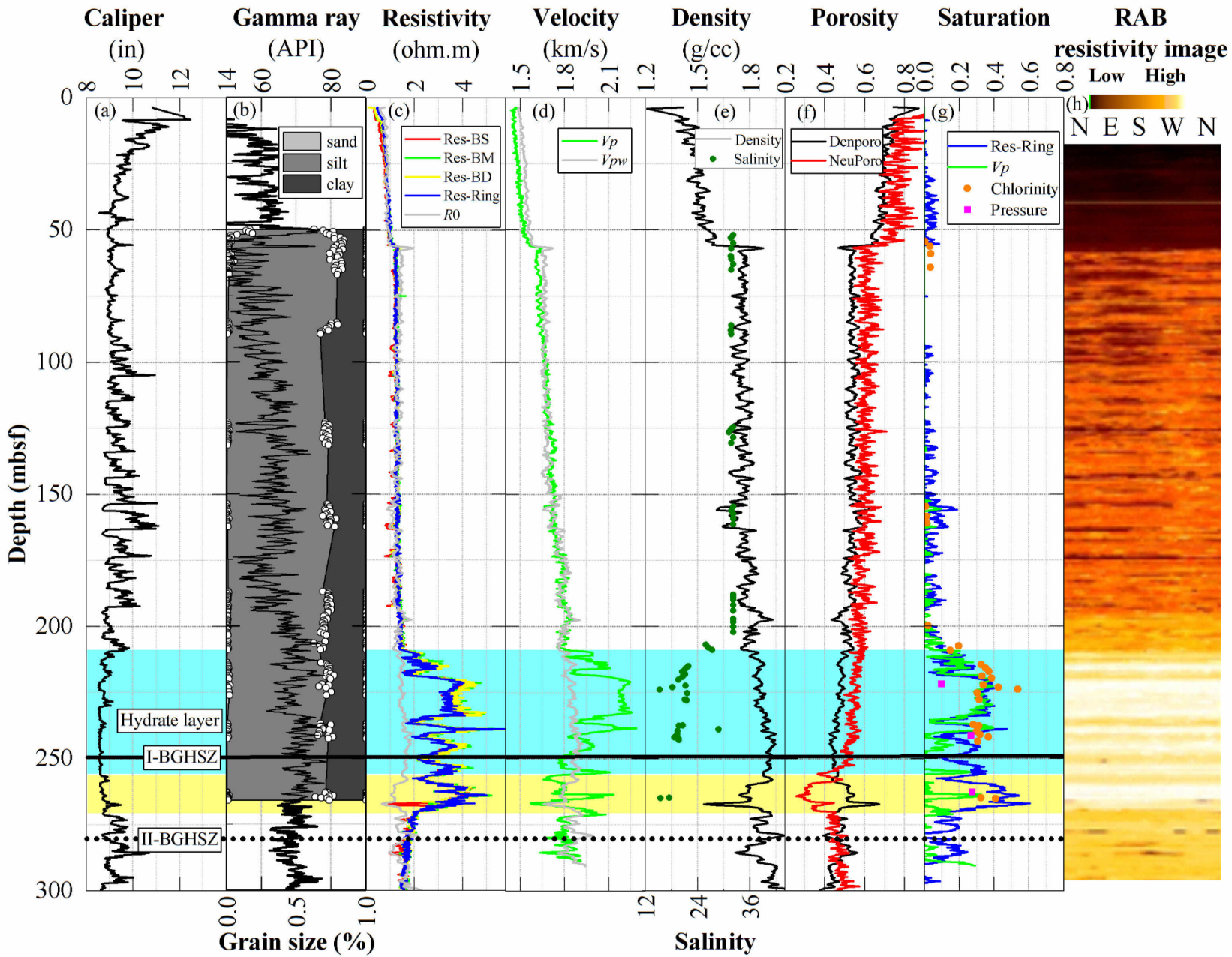
journal homepage: www.elsevier.com/locate/marpetgeo

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



Japan

Summary of R&D: Alaska and Nankai: 1995-2018

1998: First Mallik Well

1999: Nankai Discovery Well

2002: Mallik Thermal/Pressure Tests

2004: Nankai Exploration Program

2007: Mallik Depressurization Test #1

2008: Mallik Depressurization Test #2

2008: Nankai Trough Resource Assessment

2008: Exploration Approach Published

2012: Collaboration on Ignik Sikumi Program

2012: Preparatory drilling for Nankai Test

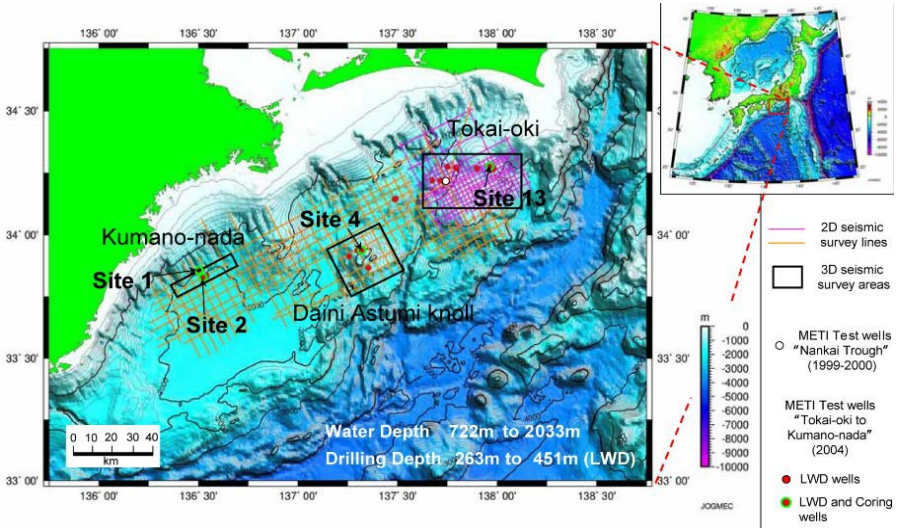
2013: First Nankai Production Test

2016: Preparatory drilling for second Nankai Test

2017: Second Nankai Production Test

2018: Nankai Test Site Characterization

2016-2019: Alaska Production Test



Japan

2013 and 2017 Production Tests in Nankai Trough

2013 Field Experiment

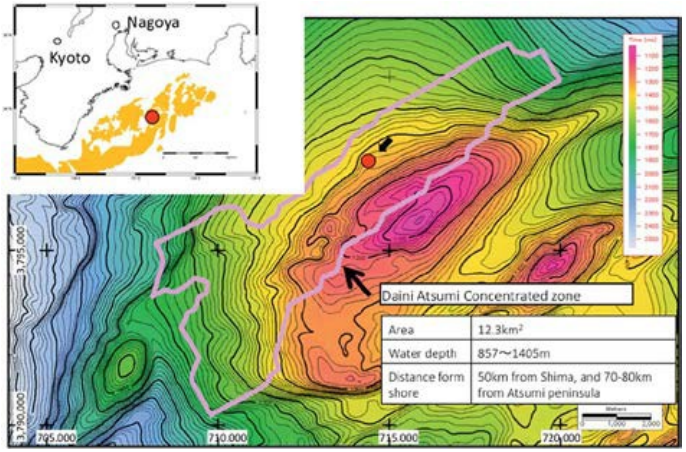
- Demonstration of technical recoverability
- 2 weeks planned: 1 week achieved
- Stable production obtained, but sand production issue

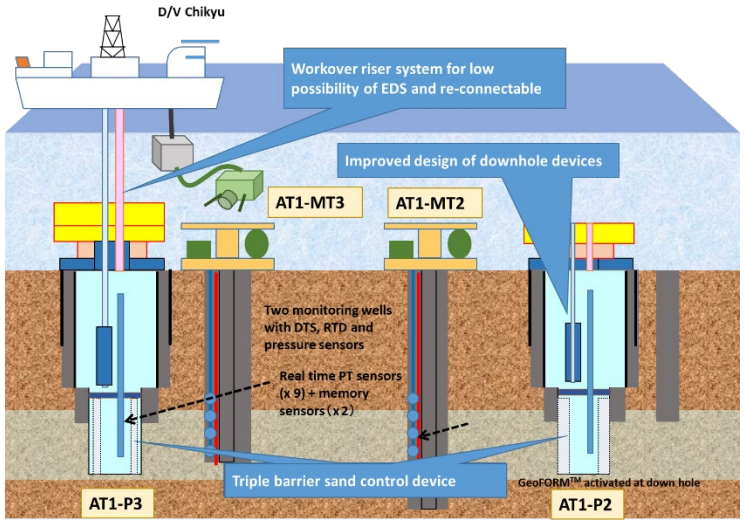
2017 Test

- 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
- Well #2: Approximately 200,000 m^3 in total in 24 days





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

2013 and 2017 Production Testing in Nankai Trough

METHANE HYDRATE NEWS

FIRE IN THE ICE

2019 Vol. 19, Issue 1

THE SECOND OFFSHORE PRODUCTION TEST OF METHANE HYDRATES IN THE EASTERN NANKAI TROUGH AND SITE CHARACTERIZATION EFFORTS

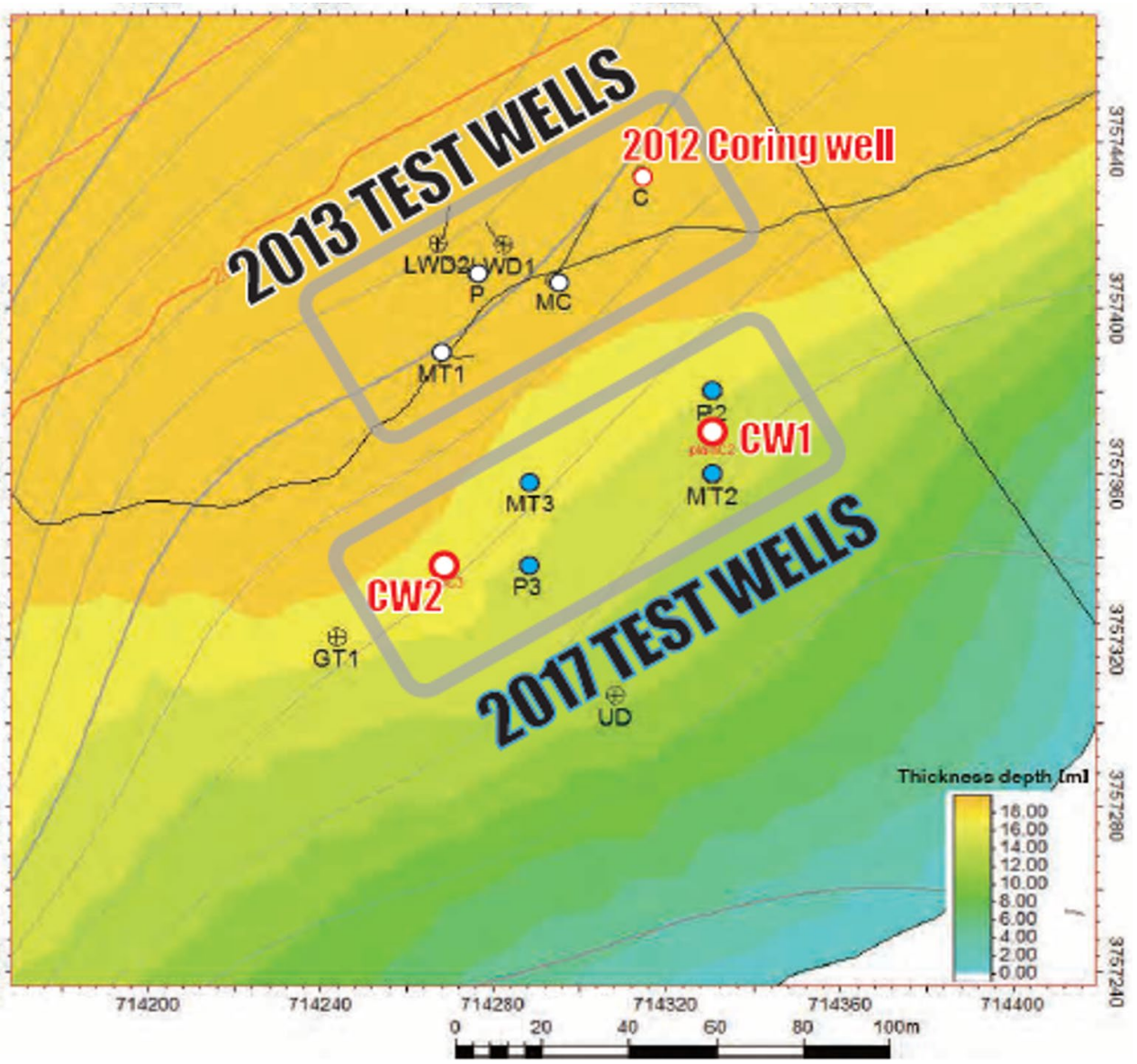
Koji Yamamoto[1], Kiyofumi Suzuki[1], Xiaoxing Wang[1], Tatsuya Matsunaga[1], Itoyuki Nishioka[1], Yoshihiro Nakatsuka[1], Jun Yoneda[2]

[1]Japan Oil, Gas and Metals National Corporation (JOGMEC)
[2]National Institute of Advanced Industrial Science and Technology (AIST)

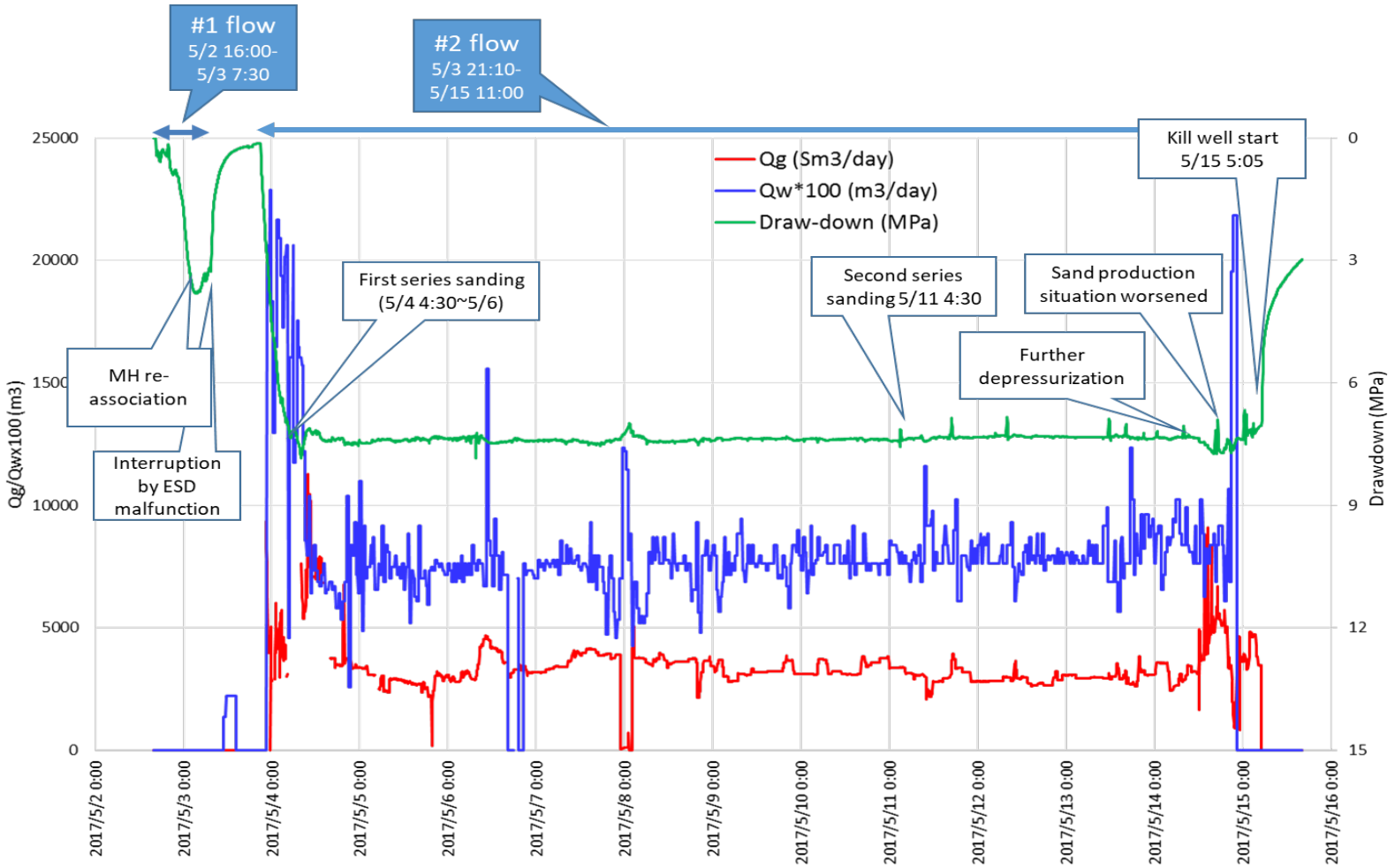
2013 and 2017 Production Testing in Nankai Trough

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



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

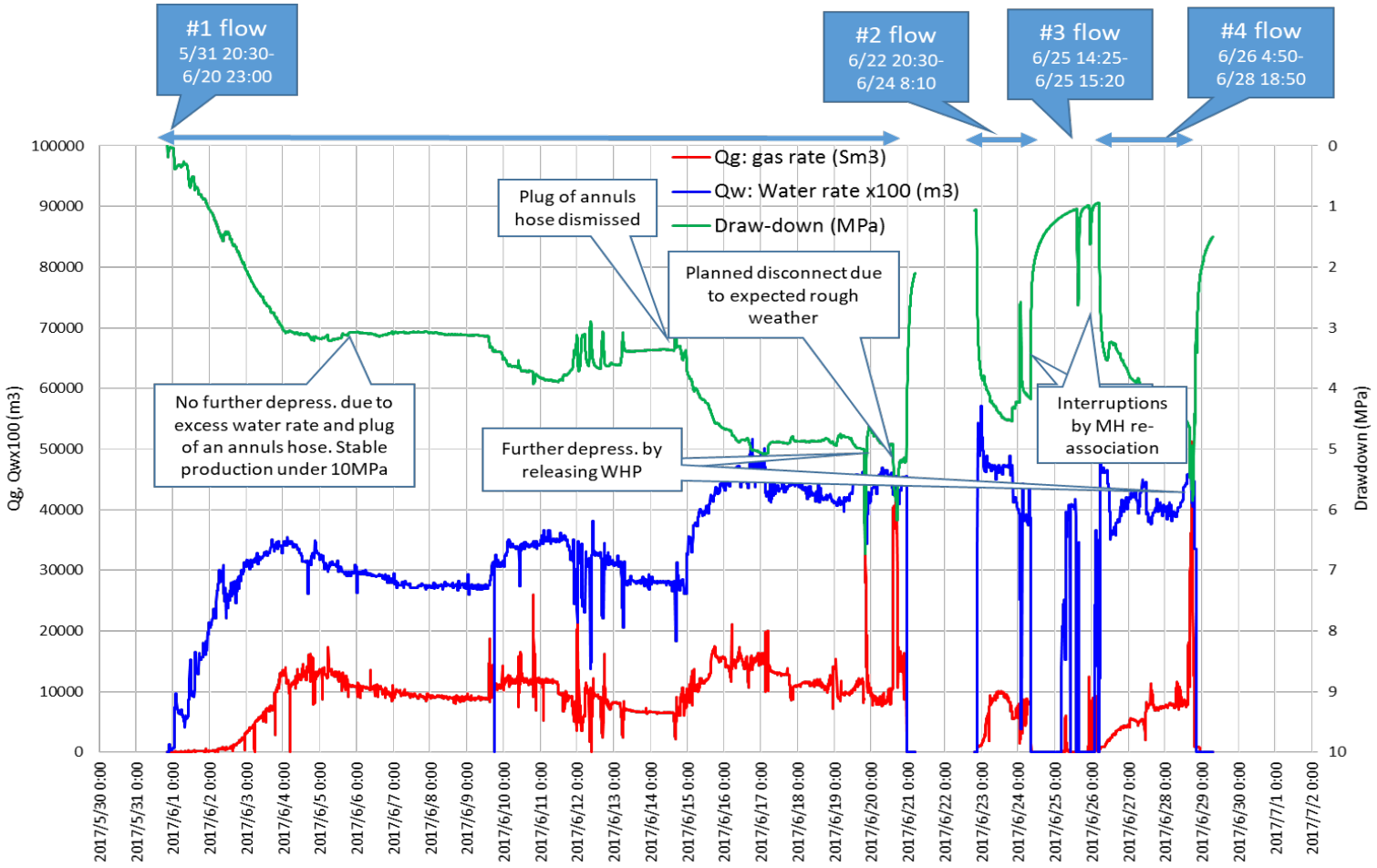
Events

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)
- Work on flow assurance issue

#4 flow 6/26 4:50 to 6/28 18:50 (2d14h0m)

Total flow duration: 24d4h5m5m

Level of Drawdown

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

Stable: 5MPa (13.0MPa – 8MPa)

Cumulative Production

Gas: 222,587.1 Sm^3

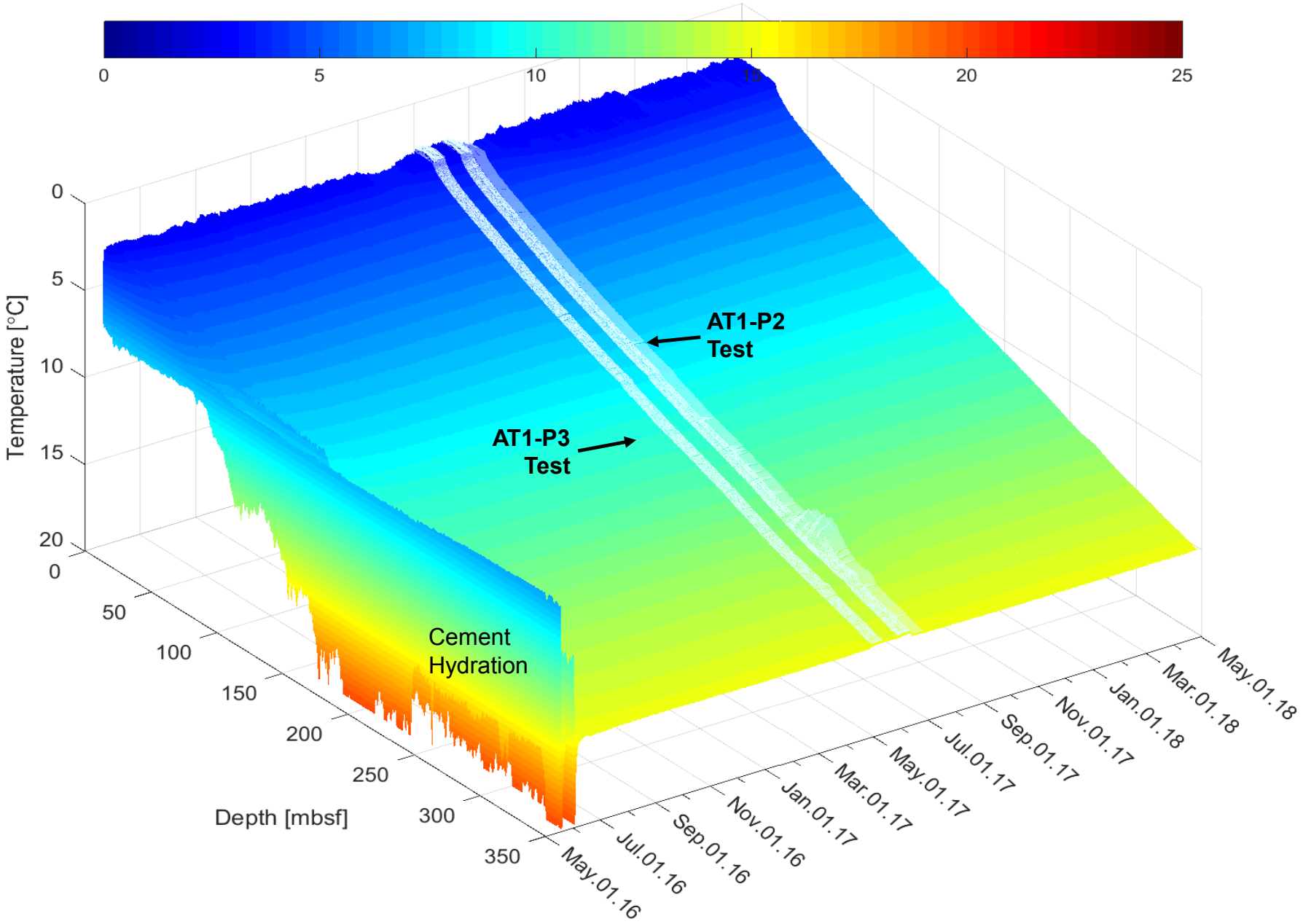
Water: 8246.9m^3

Events

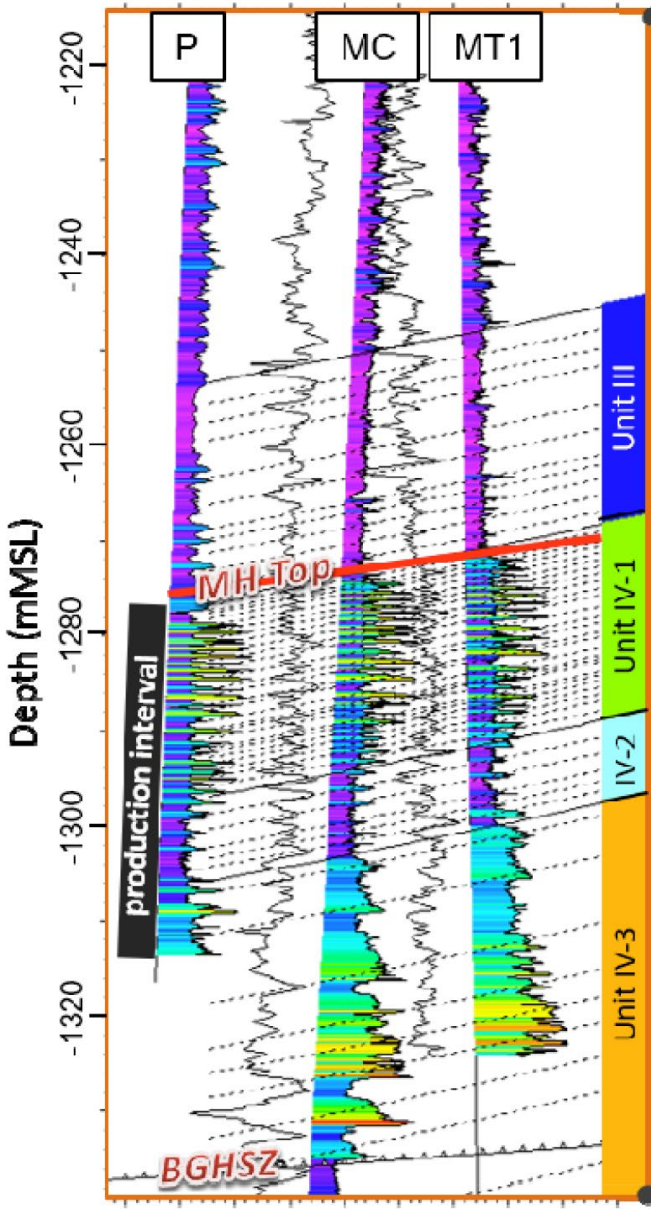
No sand production

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

2017 Production Testing in Nankai Trough



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.

Production Testing in Nankai Trough - Pressure Core Recovery Operations 2018

Wireline Pressure Coring Tools Description Matrix

Corer Name	Alternate Designation	Attribution	Configuration(s) Available	Core Length (m)	Core OD (mm)	Liner OD (mm)	Working Pressure (MPa)	PCATS Compatible	Use	Notes
HPTC	High Pressure Temperature Corer	JOGMEC (NC-PTCS)	Rotary/non-extended (face-bit design)	3.5	54	63.4	34.5	Yes	Texas field test Dec 2015, Nankai marine deployment in 2018	Designed to mate with PCATS, modified version of JOGMEC's NC-PTCS (which did not mate to PCATS). Requires special drill pipe and BHA with a 5.906" bore.

Hole	AT1-CW1	AT1-CW2
Date	4/7 - 4/12/2018	3/30 - 4/4/2018
Drilled interval (below rotary table	1,280.0m-1,330.9m and 1,339.8m-1,350.9m	1,286.5m-1,343.7m and 1,356.6m-1,362.7m
Total drilled Interval	61.9m	63.3m
Number of cores	24 (20 + 4)	25 (23 + 2)
Number of successful pressure boost > bottom-hole pressure > PT inside of GH stability	 23 24	 23 25
Total length of cores recovered	46.1m	50.3m
Recovery rate	74.5%	79.1%

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.

Methane Hydrate Resources Development Research Consortium

MH21 Research Consortium

For printing

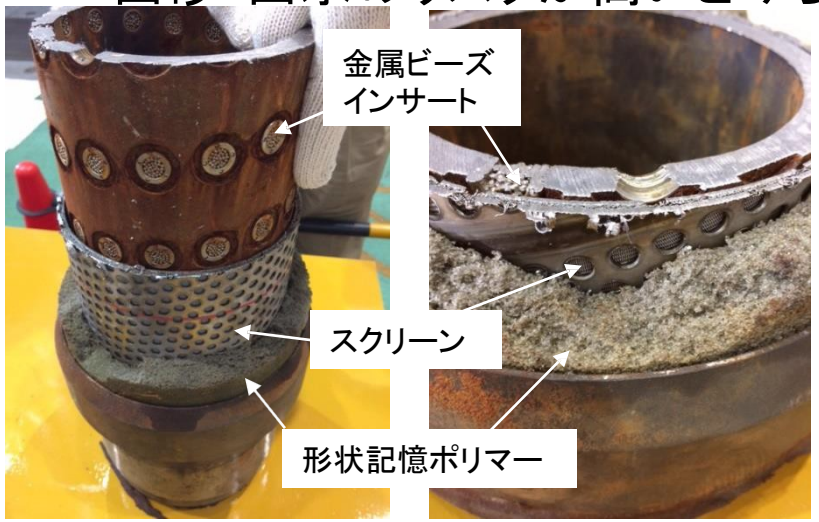
Materials Phase 2 and 3 Summary Report

Cover, summary, table of contents (PDF 832KB)
to I. Introduction (PDF 135KB)
II. Status of research and development of methane hydrate (PDF 831KB)
III. Resource Assessment of MH surrounding Japan (PDF 1.1MB)
IV.1-2 Gas production technology from methane hydrate (1/2) (PDF
4.8MB) IV.3-5. Gas production technology from methane hydrate (2/2) (PDF
4.8MB) V.1-4. Infrastructure Development of technology (1/2) (PDF
5.3MB) V.5-7. Development of basic technology (2/2) (PDF 3.5MB)
VI. Development system and economics / energy balance (PDF 1.1MB)
VII. research and development on environmental impact assessment (PDF 3.5MB)
VIII. Consortium promotion business (PDF 595KB)

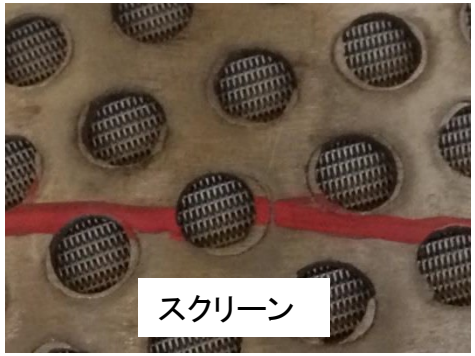
Page Top

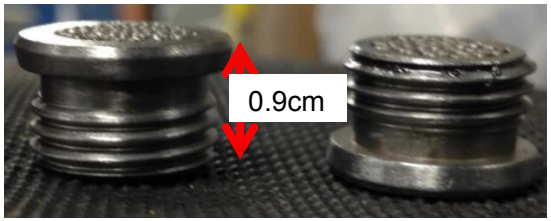
選定された出砂対策装置

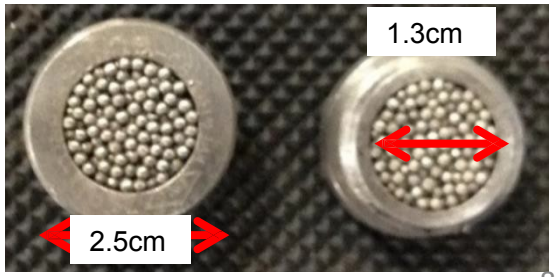
- グラベルのように流出・移動する恐れがなく、変形やエロージョンにも強い形状記憶ポリマーを使った出砂対策装置GeoFORM（Baker Hughes Inc.）に、金属ビーズインサートを追加。
  - 金属ビーズインサート：0.6mm程度のステンレスボールを拡散接合にて固めたもの。仕上げ区間内に8,000個程取り付ける。
  - 過去に比較的低温の環境で使用された実績があり、８例中７例で成功、１例は設置作業中の損傷で失敗。
- 坑底で膨張させるタイプと、膨張させたものを設置するタイプの2タイプを使用。
- 低温用の活性化剤を検討して選定。
- 出砂・出水のリスクが高いとみられる層があれば、パッカーで隔離する。



形状記憶ポリマーを使用した3重防護の出砂対策装置を耐久性を確かめるための実験に供した様子。

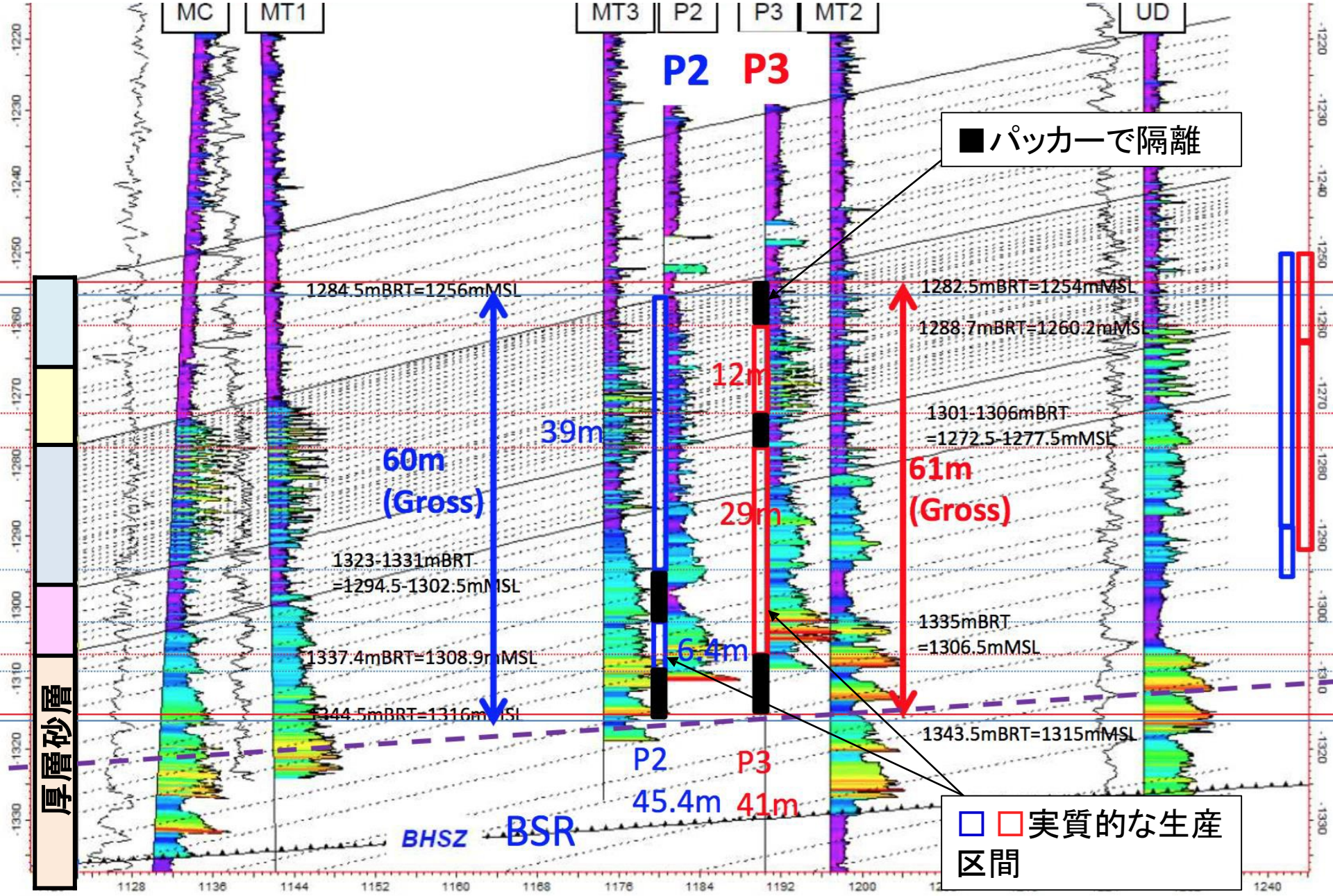


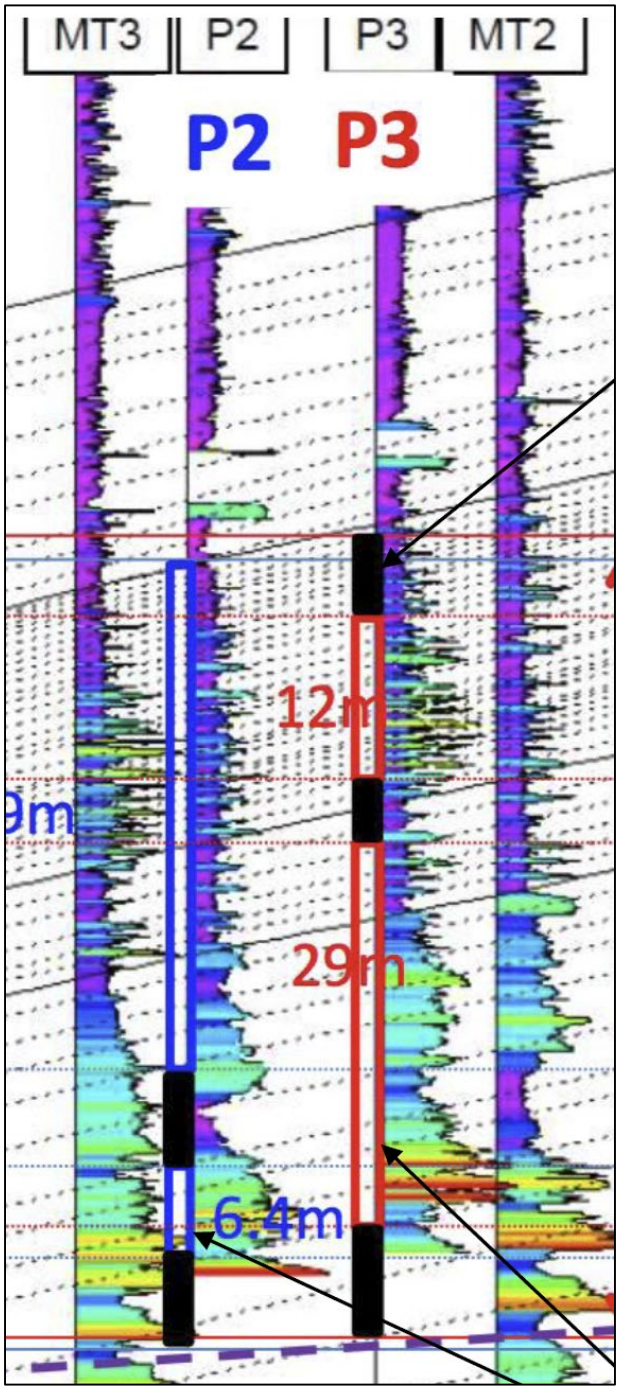


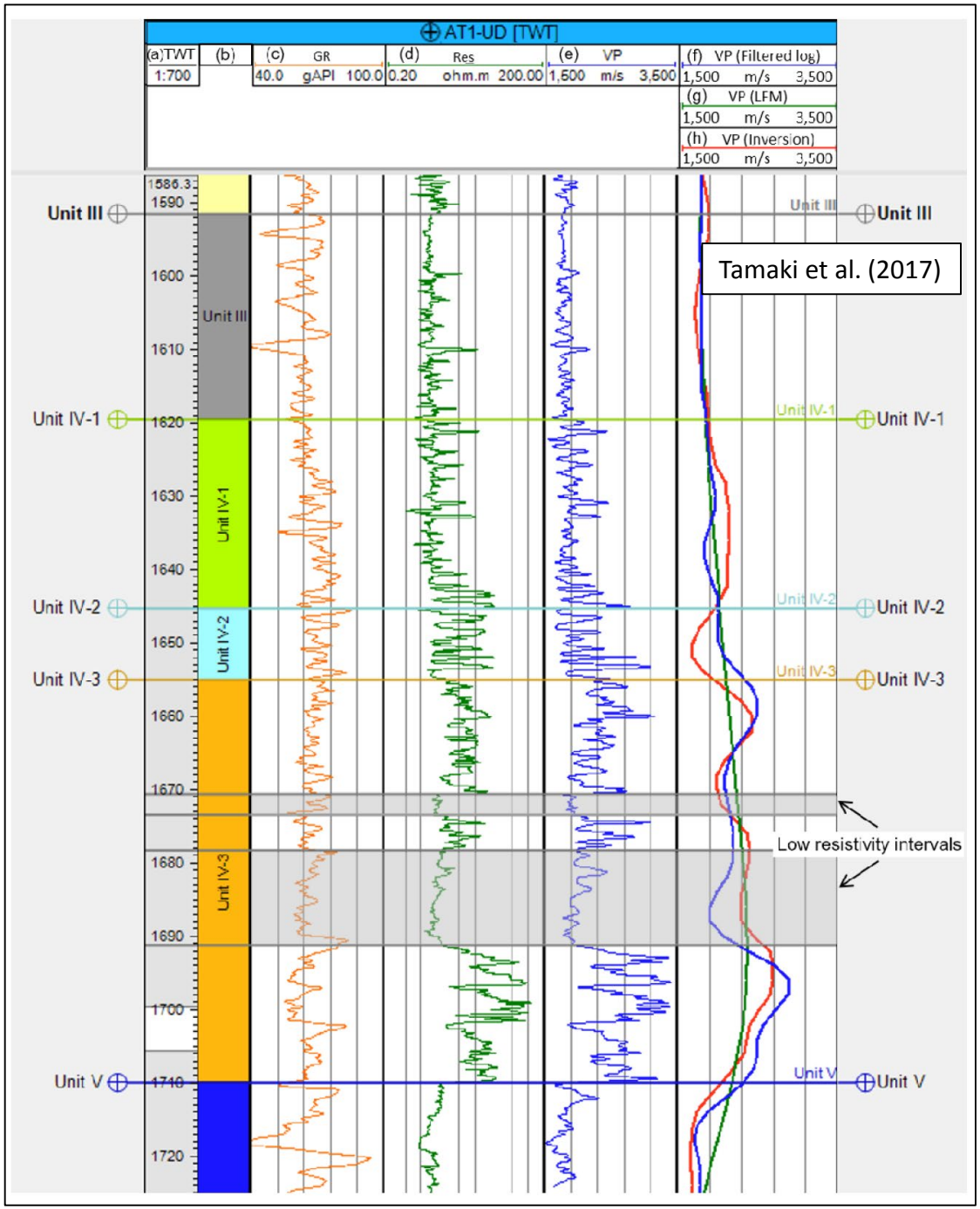


金属ビーズインサート

比抵抗検層ログ（ハイドレート濃集状況）と坑井の仕上げ区間




MT3
P2
P3
MT2
P2
P3
12m
9m
29m
6.4m


AT1-UD [TWT]
(a)TWT
1:700
(b)
(c) GR
40.0 gAPI 100.0
(d) Res
0.20 ohm.m 200.00
(e) VP
1,500 m/s 3,500
(f) VP (Filtered log)
1,500 m/s 3,500
(g) VP (LFM)
1,500 m/s 3,500
(h) VP (Inversion)
1,500 m/s 3,500
1586.3
1590
1600
1610
1620
1630
1640
1650
1660
1670
1680
1690
1700
1710
1720
Unit III
Unit IV-1
Unit IV-2
Unit IV-3
Unit V
Tamaki et al. (2017)
Low resistivity intervals

生産井とモニタリング井の温度データの比較