

International Gas Hydrate Research Activities - Update

Timothy S. Collett
U.S. Geological Survey

*US-DOE Methane Hydrate
Advisory Committee Meeting
October 19, 2016*



Discussion Outline

1. International Research Activities - Overview

2. Energy Related National Gas Hydrate Projects

- *Canada Mallik Mackenzie Delta, Drilling & Testing*
- *Alaska North Slope, Drilling & Testing*
- *Gulf of Mexico, JIP Leg I & Leg II*
- *Japan – Japan Sea, Drilling*
- *Japan Nankai Trough, Drilling & Testing*
- *India Ocean, NGHP-01 & NGHP-02; NGHP-03*
- *South China Sea, GMGS1 – GMGS4; GMGS5*
- *Korea Ulleung Basin, UBGH1 & UBGH2*

3. Summary

Discussion Outline

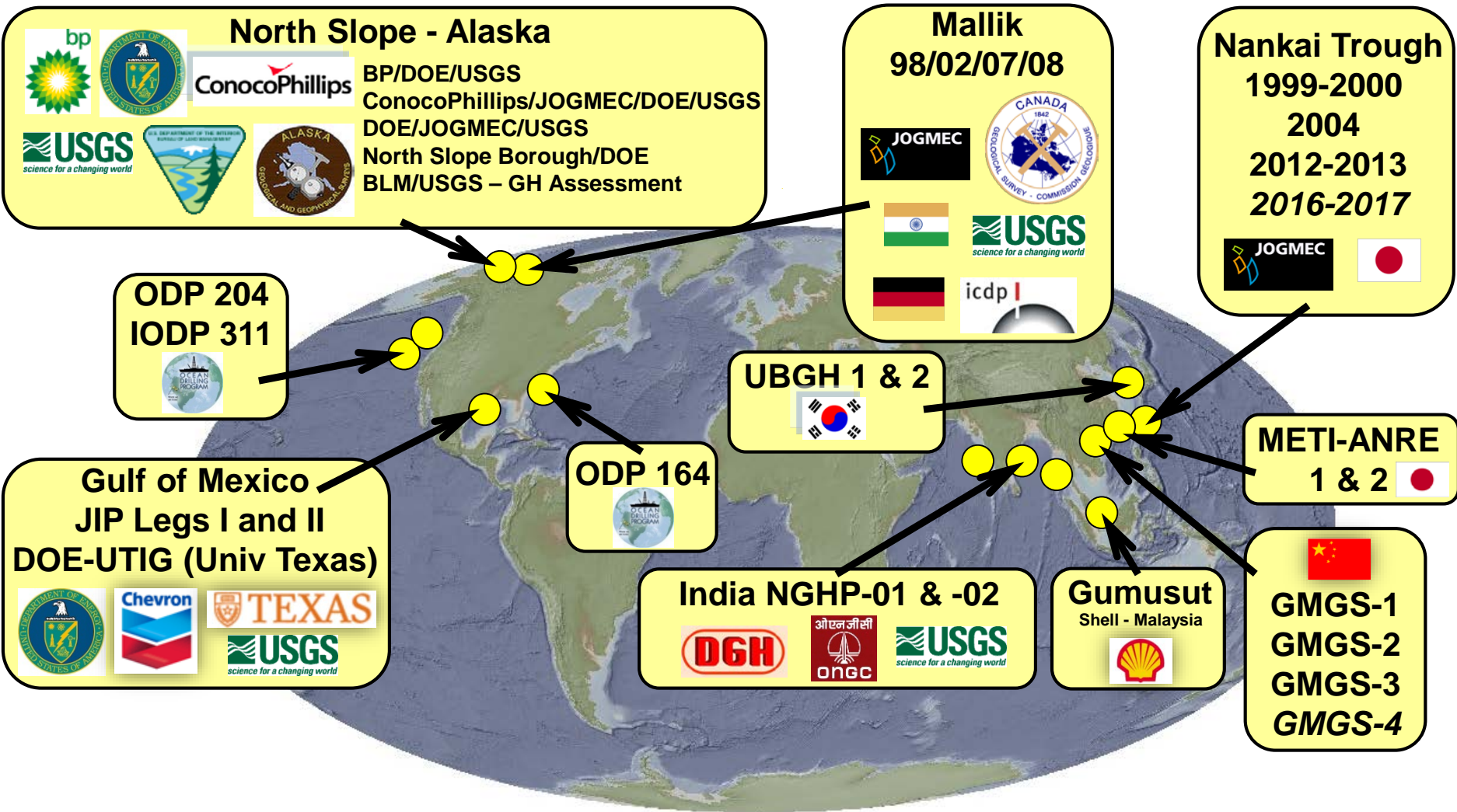
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Gas Hydrate Scientific and Industry Drilling



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Gas Hydrate Production Testing

North Slope - Alaska

BP/DOE/USGS 2007 – *Mount Elbert*
ConocoPhillips/JOGMEC/DOE/USGS 2011/2012 – *Ignik Sikumi*
DOE/JOGMEC/USGS 2017-2019



Mallik 2007/2008



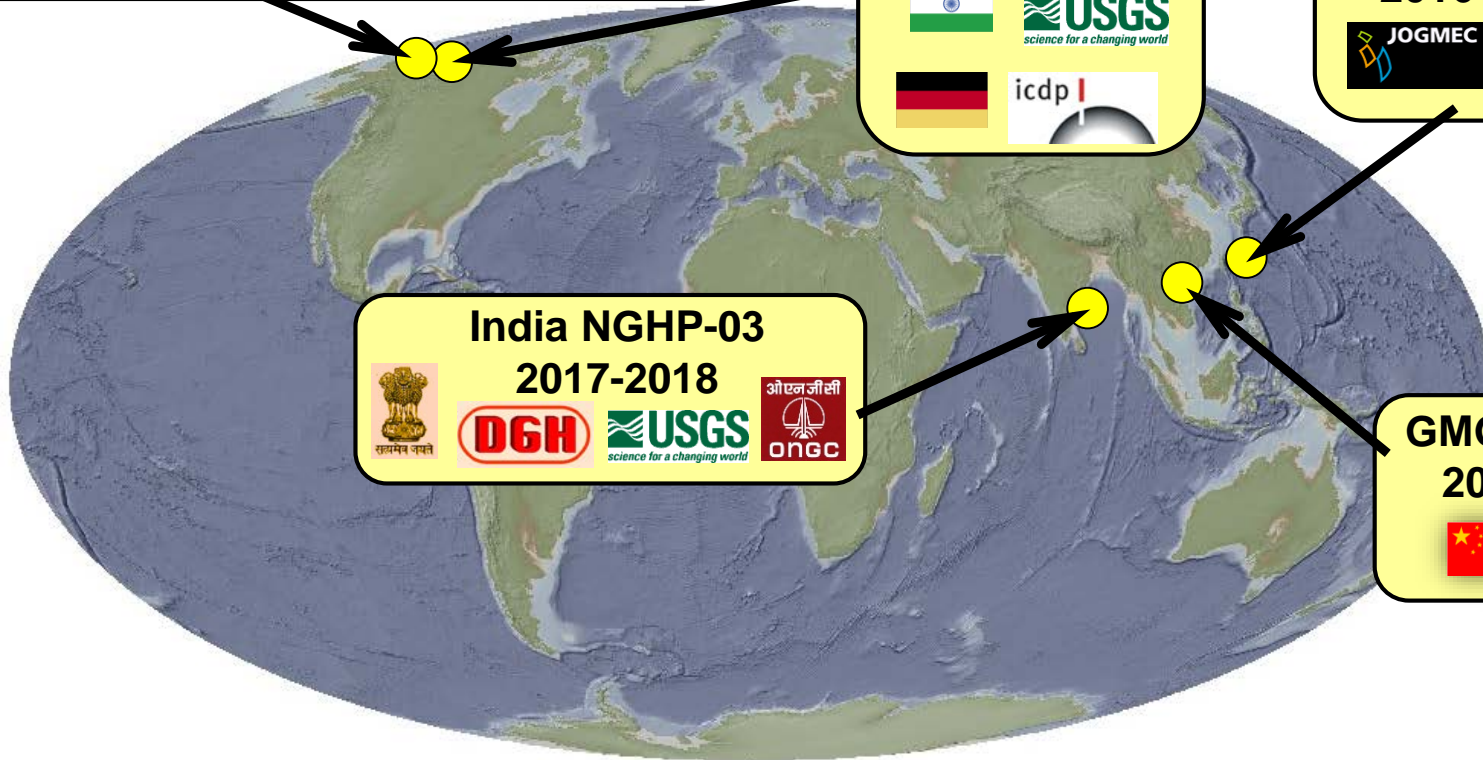
Nankai Trough 2012-2013 2016-2017



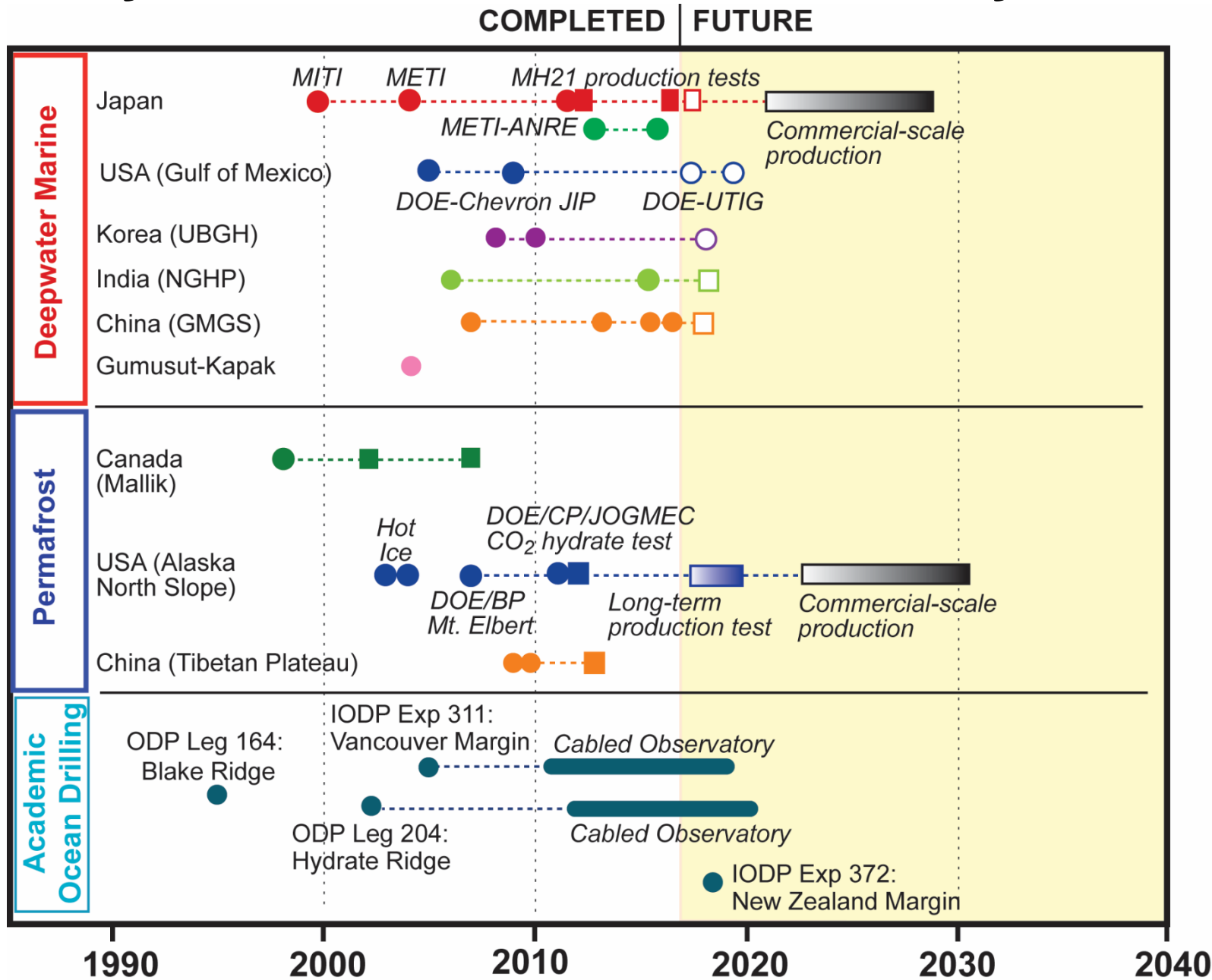
India NGHP-03 2017-2018



GMGS-5 2017



Gas Hydrate Scientific and Industry Drilling



International R&D



- **Japan**
 - 1998-2016: Collaboration on Arctic and marine international projects
 - 2013: One-week marine production test
 - **2016/17: “Extended” (one month) marine production test**
 - 2014/2015: METI-ARNE new Japan Sea project



- **United States**
 - DOE, DOI, DOC, DOD, NSF; BP, ConocoPhillips, JIP; Academia; Internat.
 - Resource potential and role in the natural environment
 - Arctic Alaska production studies, marine R&D, laboratory/modeling studies



- **China:**
 - 2007 & 2013 & 2015: GMGS-1 & GMGS-2 & GMGS-3 expeditions
 - 2016 GMGS-4 expedition
 - **2017 GMGS-5 expedition with possible production testing**
 - 2007 through 2014: Onshore “tests”



- **India**
 - 2006: NGHP-01 expedition
 - 2009-2014: Site review collaboration
 - 2015: NGHP-02 expedition
 - **2017-2018: NGHP-03 gas hydrate production testing (2-3 months)**

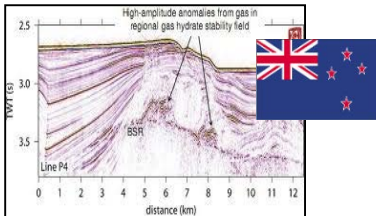
International R&D



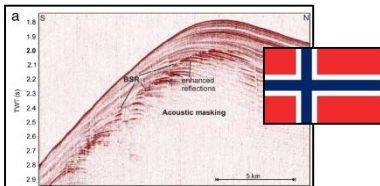
- **Korea**
 - 2007 & 2010: *UBGH-1 & UBGH-2 expeditions*
 - 2018: *Reprogramming - Marine production test ?*



- **European Union**
 - *GEOMAR marine gas hydrate research, marine surveys*
 - *SUGAR Energy Assessment Project*
 - *MIGRATE Project – EU hydrate research coordination effort*
 - *MARUM MeBo (sea floor drill rig) drilling research*



- **New Zealand**
 - *Gas hydrates on the Hikurangi Margin, GNS, Univ. of Auckland*
 - *Energy/Environment, surveys, IODP Expedition 372 (geomechanical)*

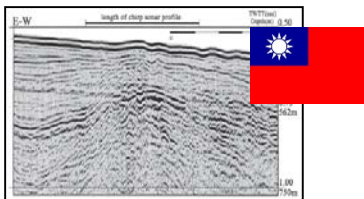


- **Norway**
 - *Gas hydrate global screening, Statoil*
 - *Onshore long-duration production test (canceled), Statoil*
 - *CAGE impact on marine environment and climate systems*



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

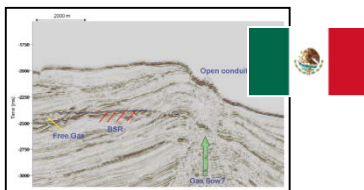
International R&D



- **Taiwan**
 - Marine gas hydrate research, marine surveys
 - Central Geologic Survey and the National Taiwan University
 - Energy focus, marine surveys, drilling – deferred



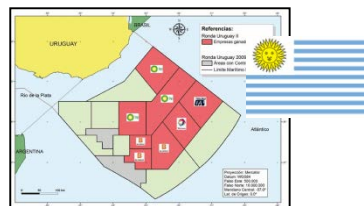
- **Brazil**
 - Petrobras
 - Energy and Geohazard focus studies



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



- **Colombia**
 - Ecopetrol SA
 - Energy focus studies

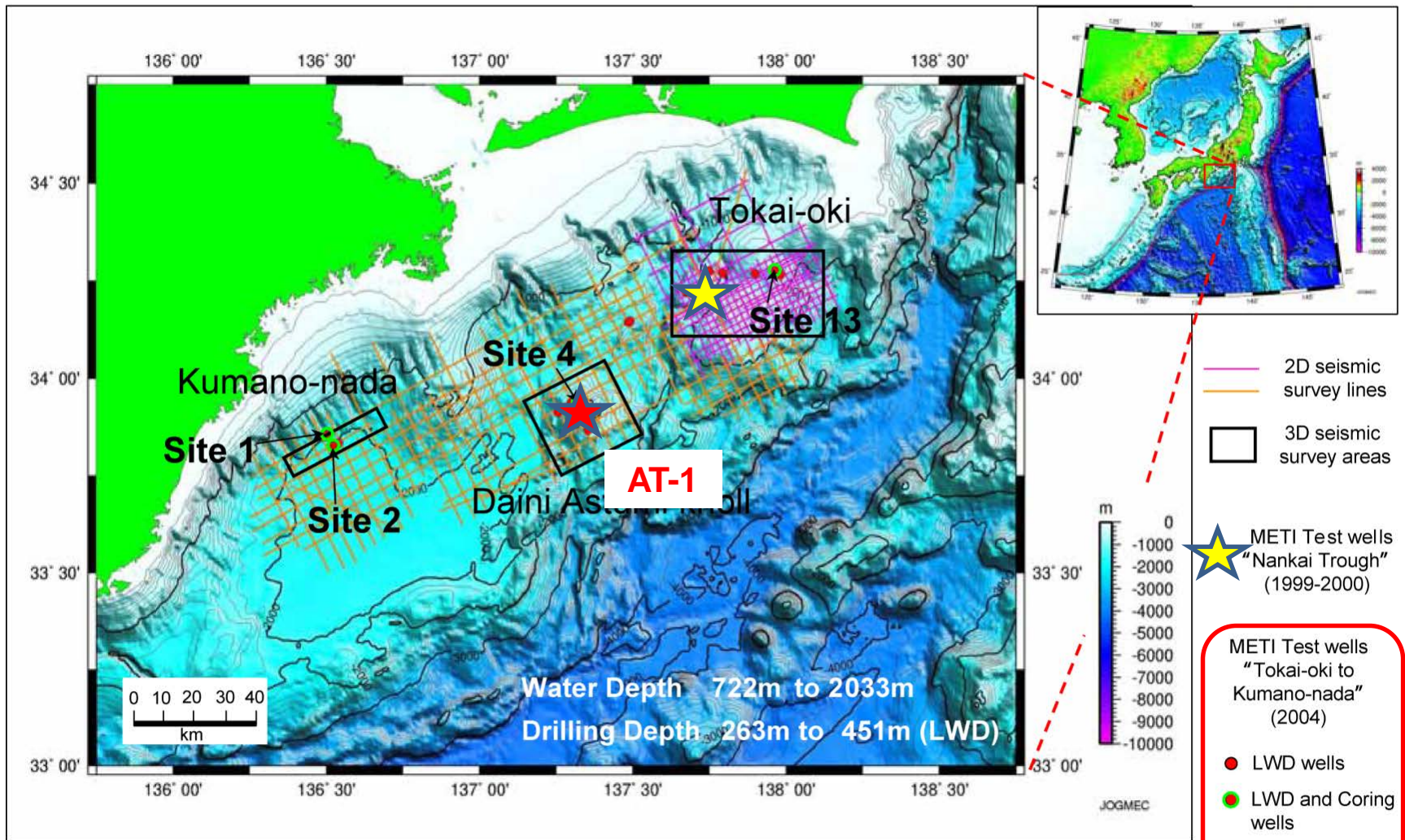


- **Uruguay**
 - Uruguay's National Oil Company ANCAP
 - Energy focus studies

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- **Japan, Nankai Trough Drilling and Testing**

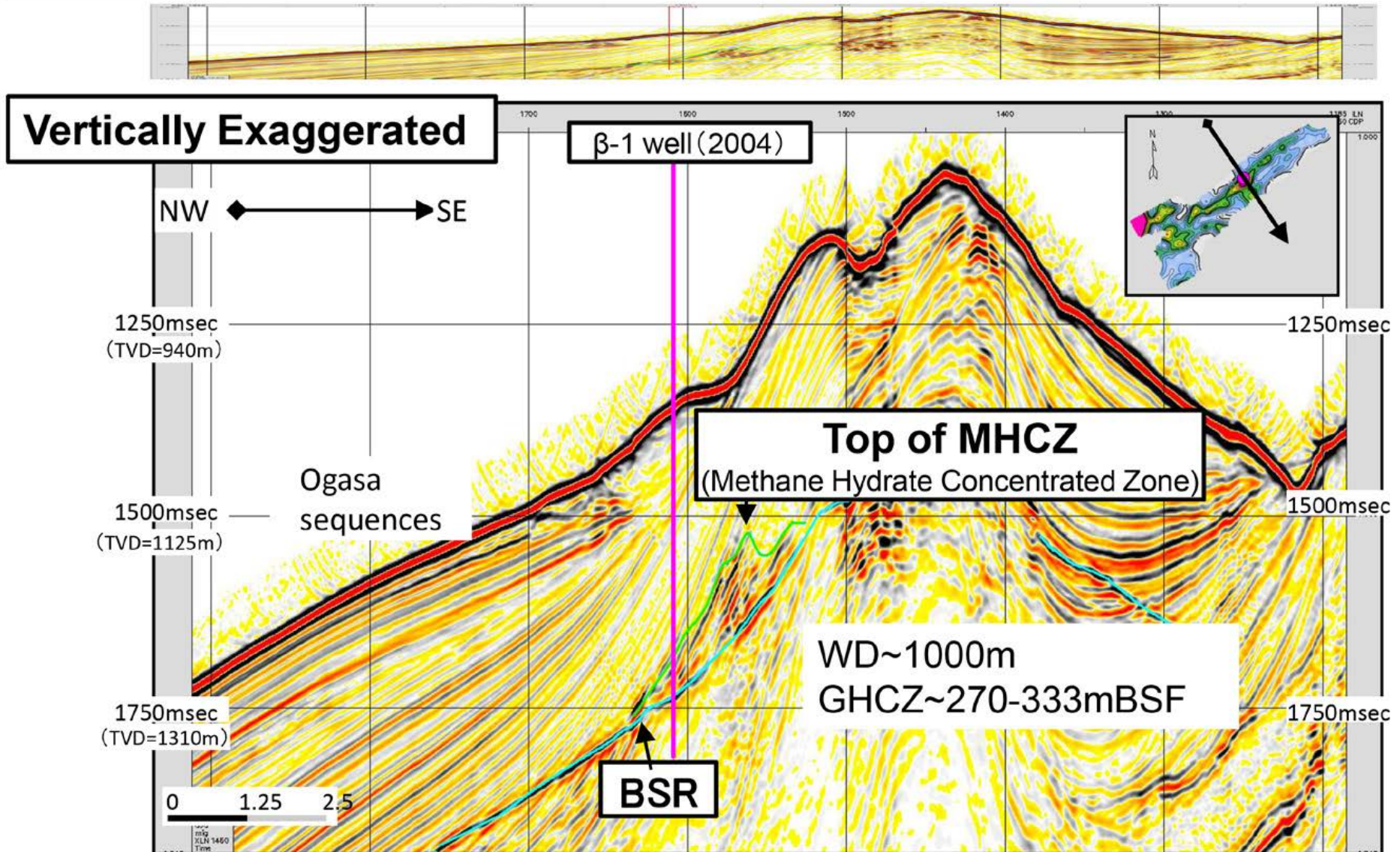
National R&D Program for Methane Hydrate Resources in Japan

-Seismic Research and Drilling-



JOGMEC Gas Hydrate Production Test

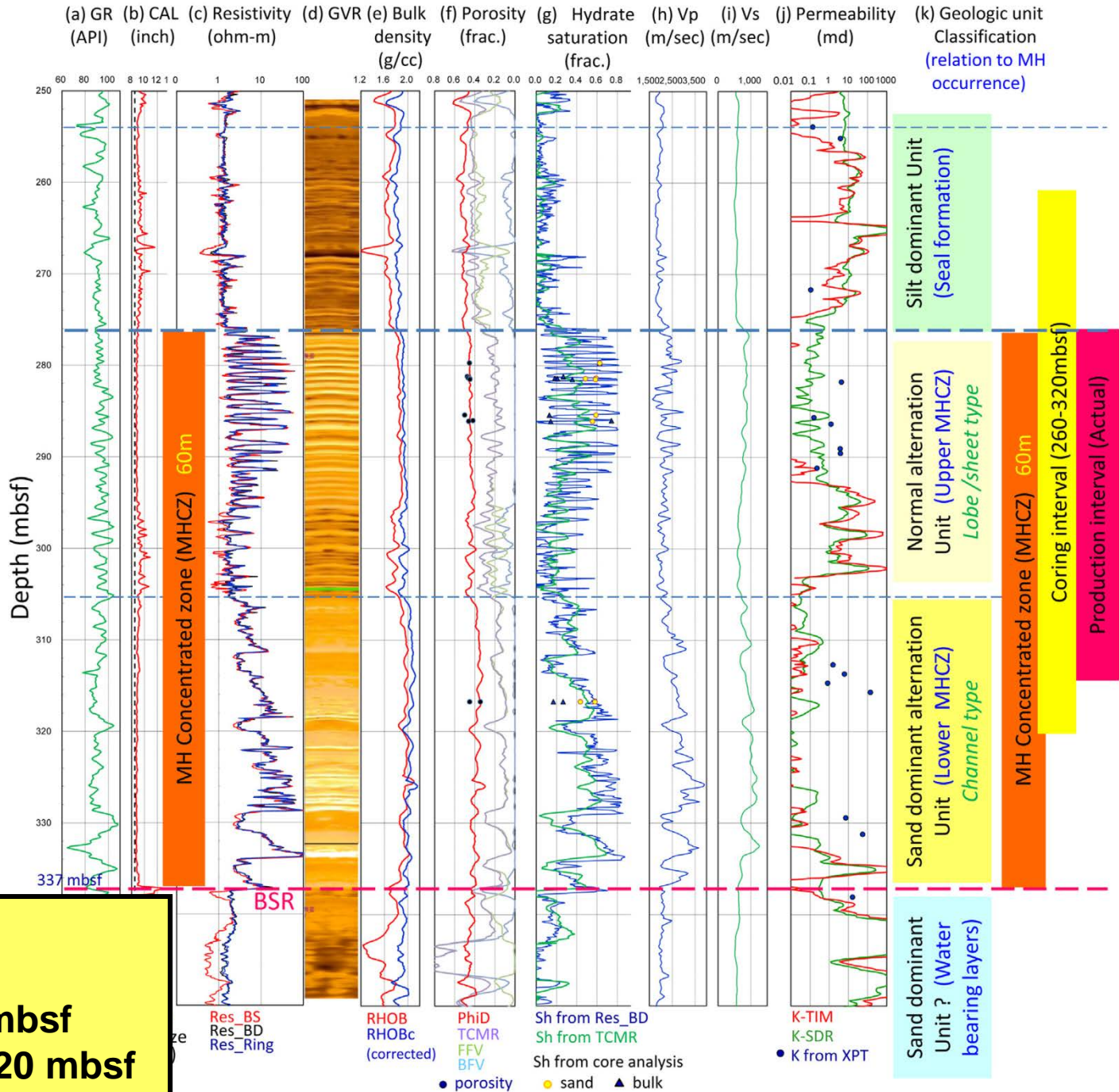
Site AT1



JOGMEC AT1-MC Log and AT1-C Core Data

Fujii et al, 2015

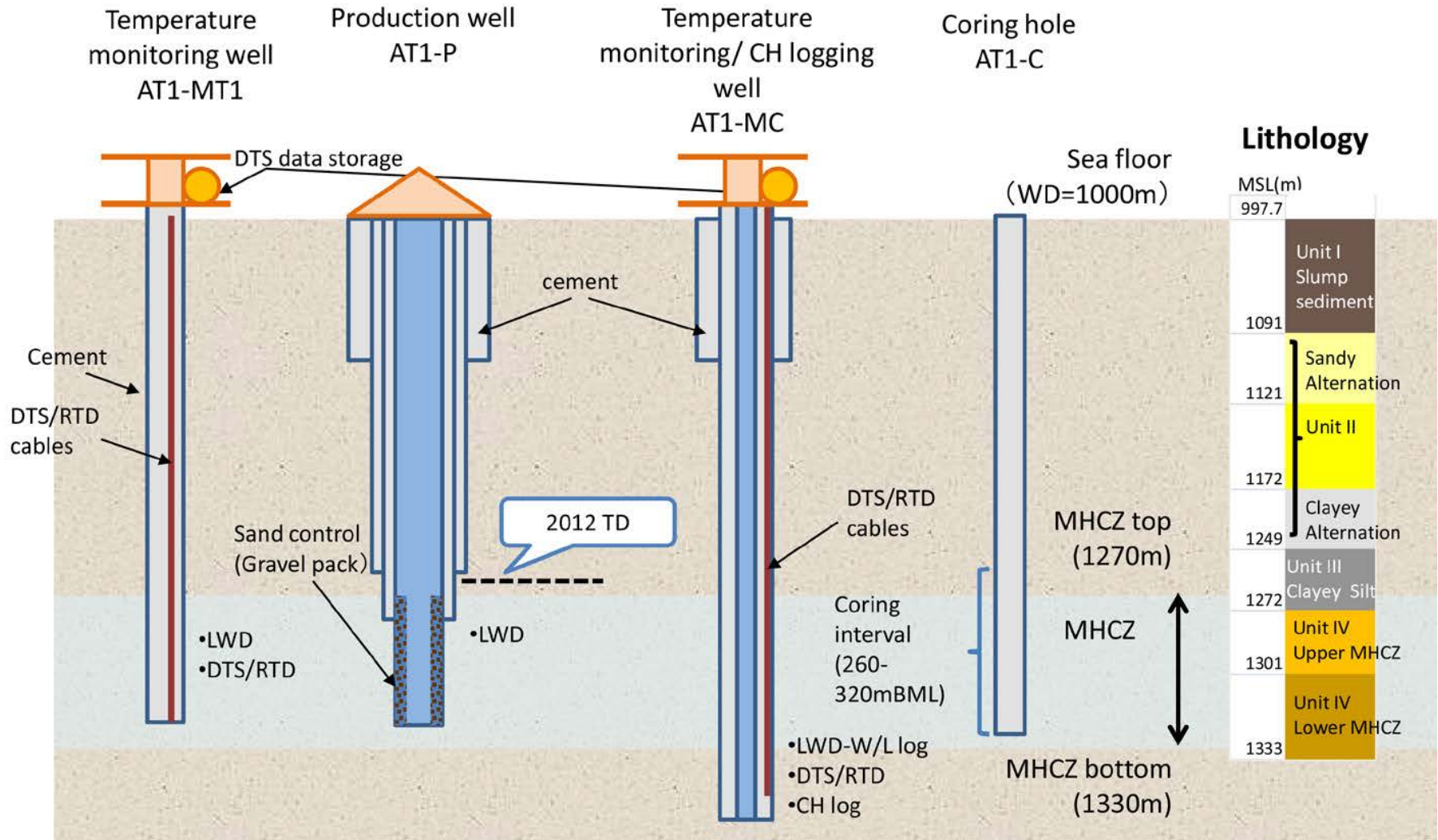
Water depth: 997.7m



Test Site:
Water depth 998 m
Reservoir top 277 mbsf
Core interval 260-320 mbsf

JOGMEC Gas Hydrate Production Test Test Site Configuration

Kawamoto (CSIS, 2014)



One production well (AT1-P), two monitoring wells (AT1-MC and MT1), and one core well (AT1-C) were established.

JOGMEC Gas Hydrate Production Test

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

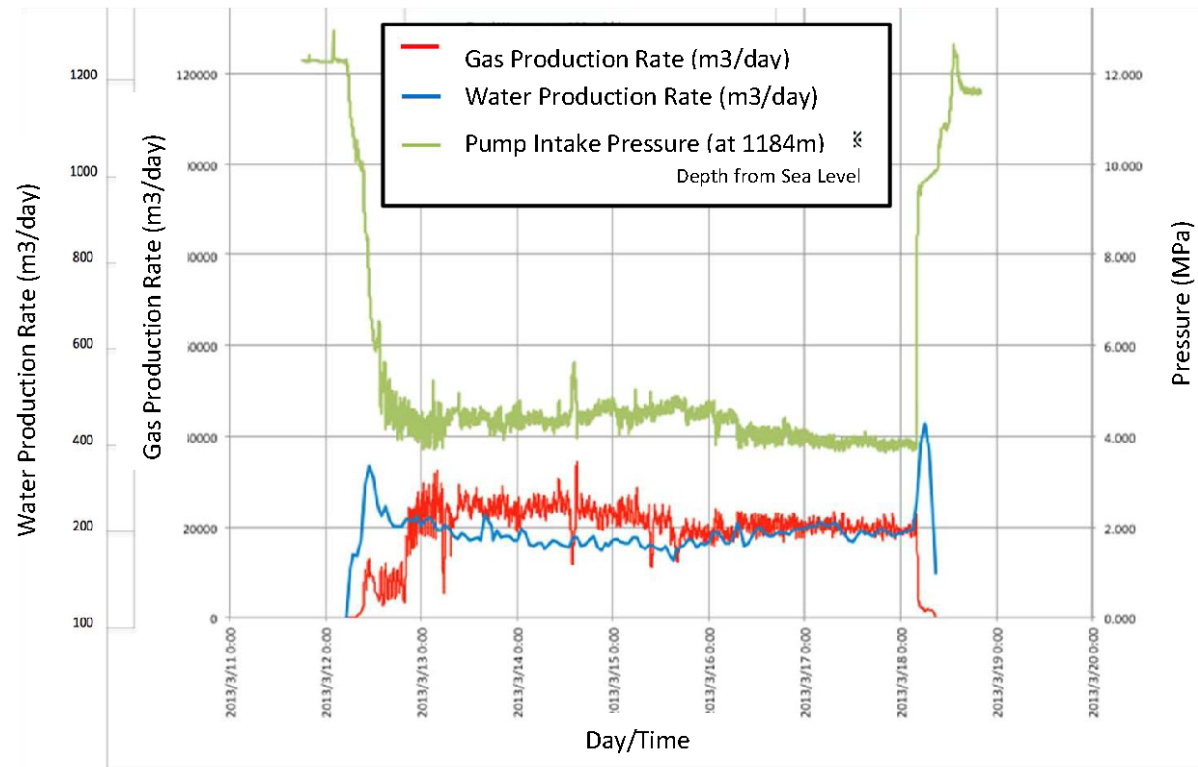
15:00: Completed kill well

Gas Production

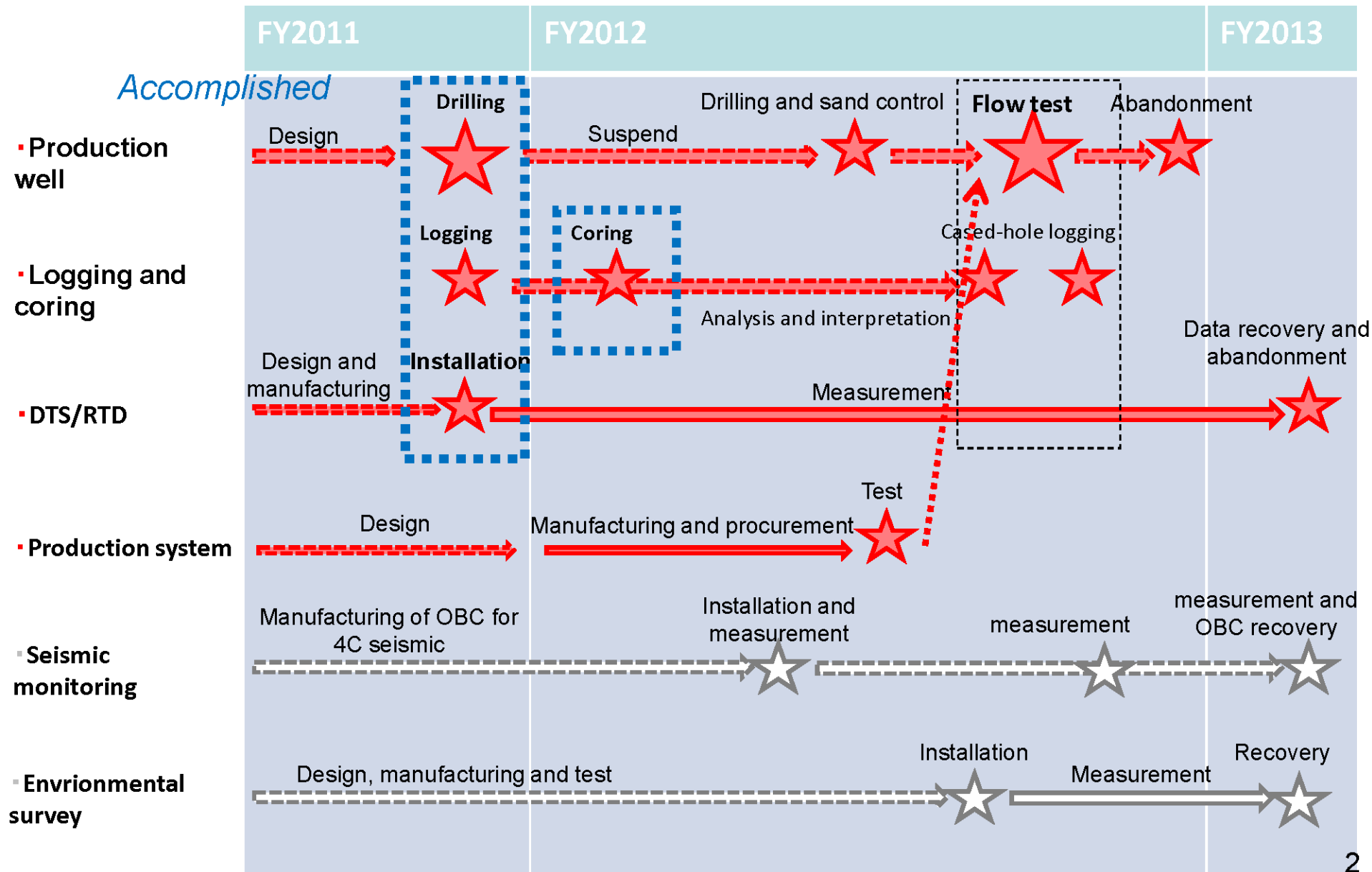
▪ Duration: approx. **6 days**

▪ Cumulative gas production:
approx. **120,000m³**

▪ Average gas production:
approx. **20,000m³/day**



JOGMEC Gas Hydrate Production Test



Japan Progresses Methane Hydrate Project RIGZONE July 11, 2016

Ahead of a planned month-long offshore production test next year, JOGMEC and operator Japan Methane Hydrate Operating Co. Ltd. (JMH) reportedly deployed the *Chikyu* deepwater drilling vessel 50 miles off the Atsumi Peninsula, the site of the previous test, to complete preparatory work.

We have drilled one well for geological survey, two monitoring wells and part of two production wells, “Dr. Yoshihiro Nakatsuka (JOGMEC’s Methane Hydrate Research & Development Group) told Rigzone. The preparation work was carried out to study technical issues such as sand control, gas water separation and monitoring that had emerged during the first production test. “The objective of this second test is to verify the effectiveness of countermeasures from the first production test,” Nakatsuka said.

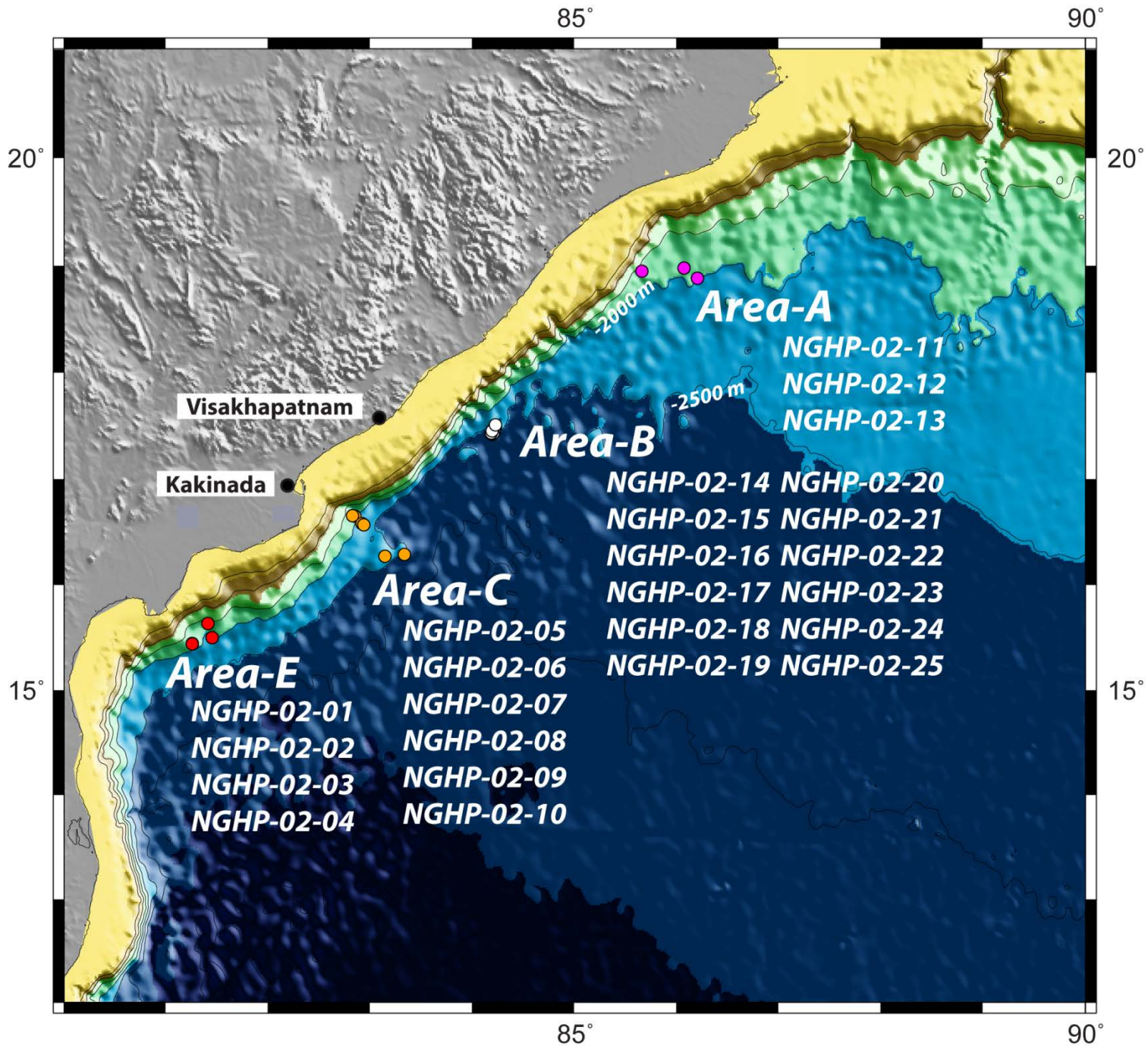
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- ***India Ocean, NGHP-01 & NGHP-02;
NGHP-03 Production Test Planning***

Operational Highlights of NGHP-02

- Total of 42 holes were completed in 147 days. Water depths 1,519-2,815 m; sub-sea completions 239-567 mbsf.
- Total of 25 LWD holes. Drilled/logged section of 6659 m.
- Conventional wireline and pressure cores were acquired in 16 wells, with a total of 390 conventional core runs and 104 pressure core runs.
- Wireline logging conducted in 10 holes.
- Wireline (MDT – Modular Dynamic Tester) formation pressure and flow tests successfully conducted in 2 holes.

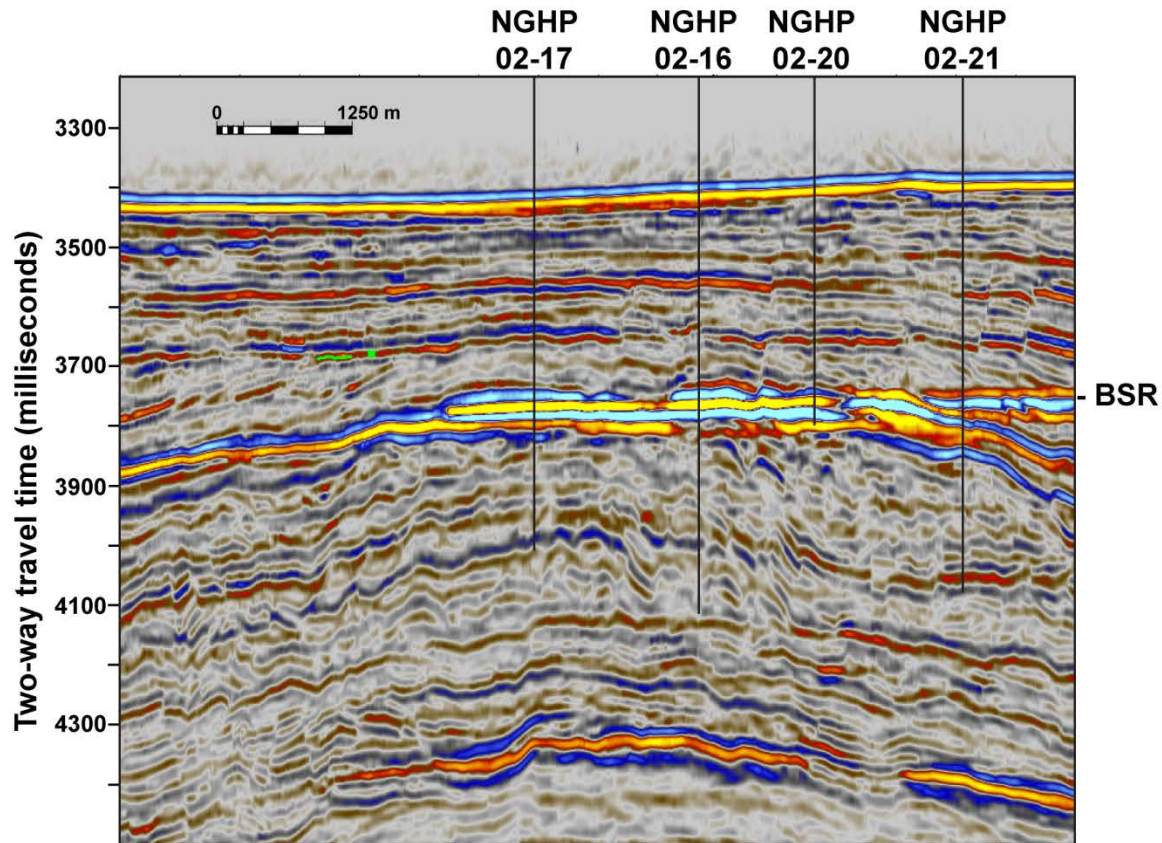


NGHP-02 Drill Sites

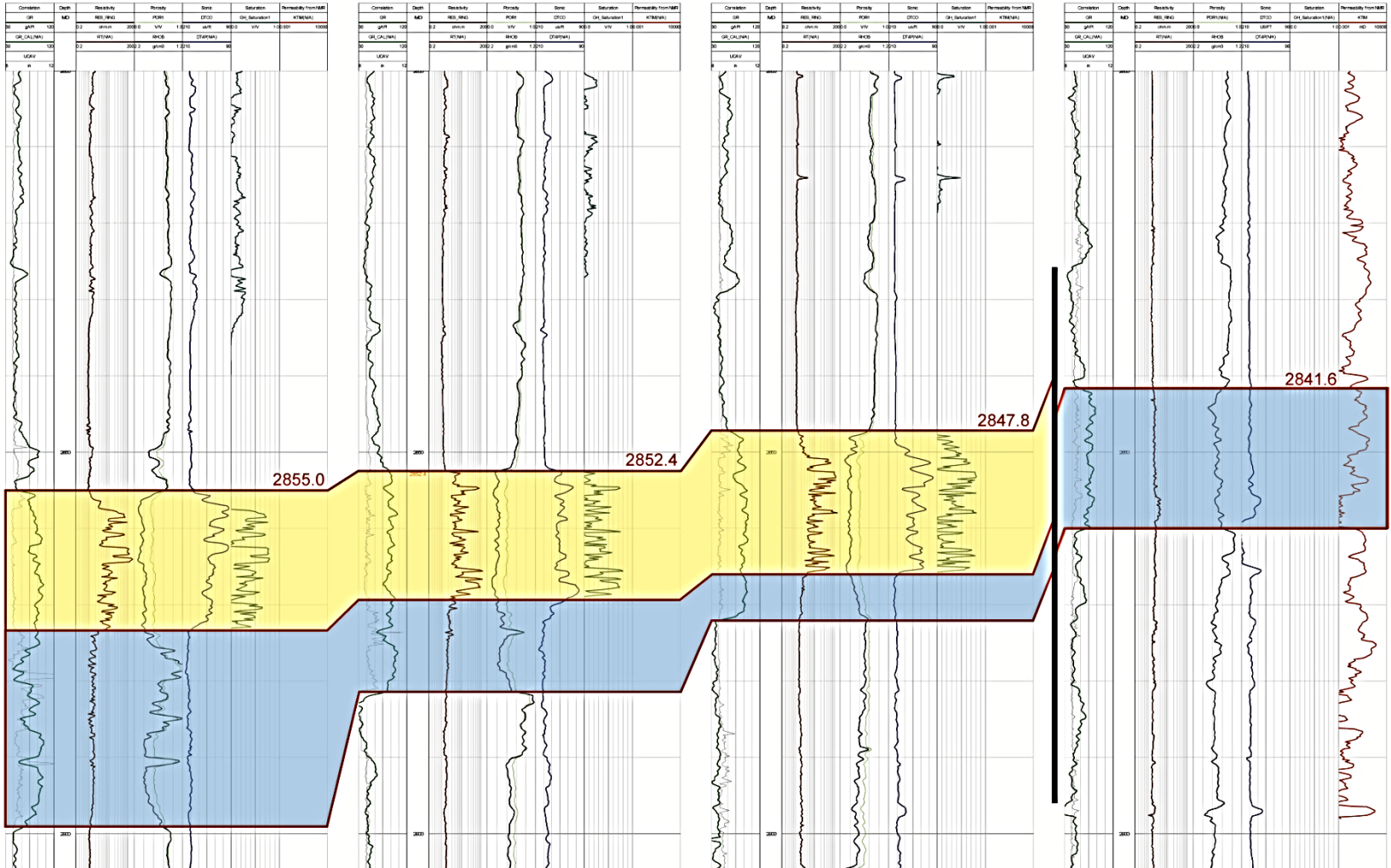
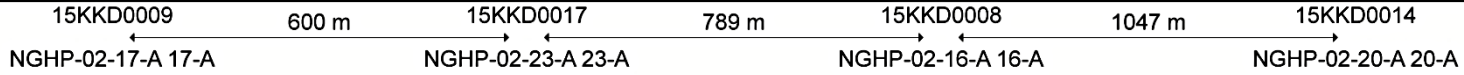


NGHP-02 Area-B Gas Hydrate Accumulation

Lower (R2) Reservoir

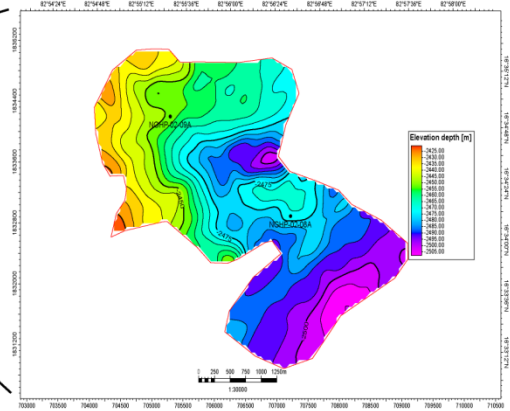
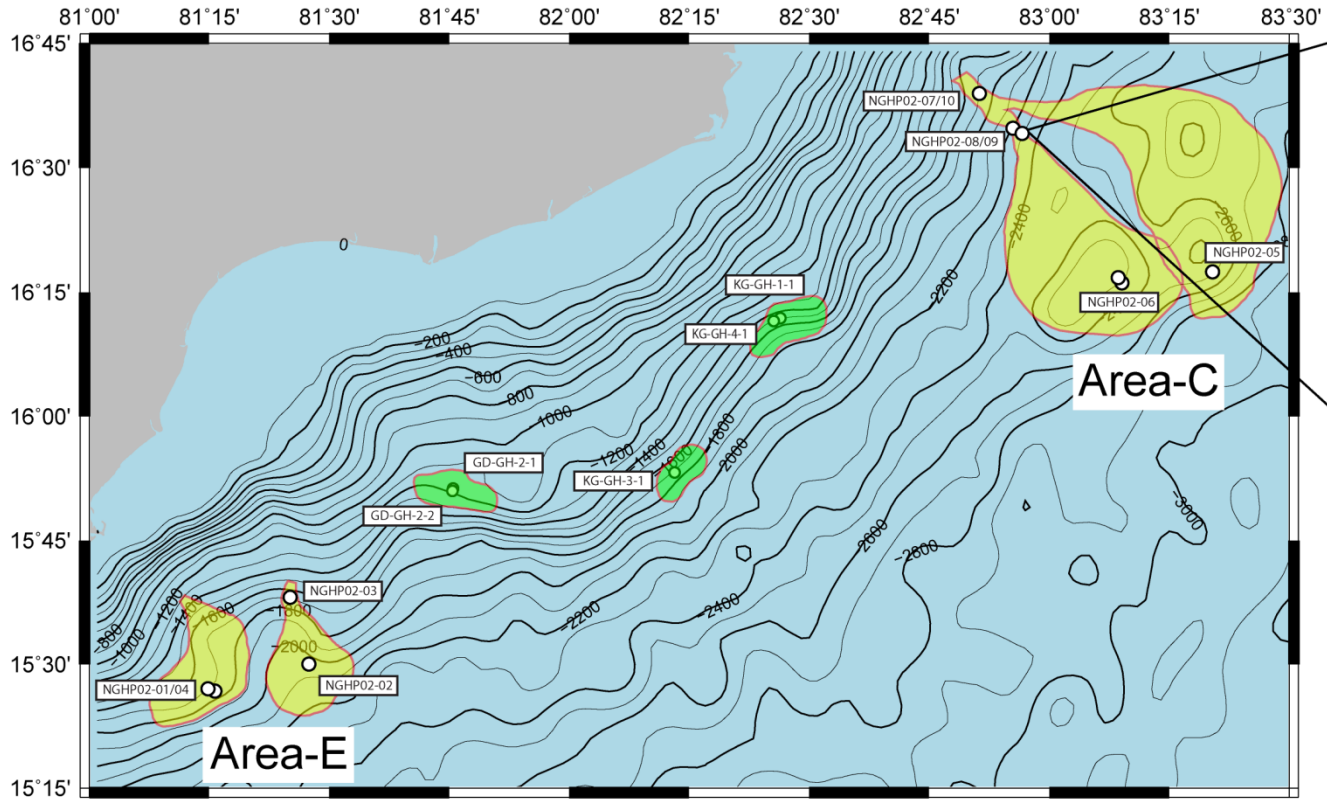


NGHP-02 Area-B Lower (R2) Reservoir Composite Well Log Section Holes NGHP-02-17A -23A -16A -20A



Krishna-Godavari Gas Hydrate Petroleum System

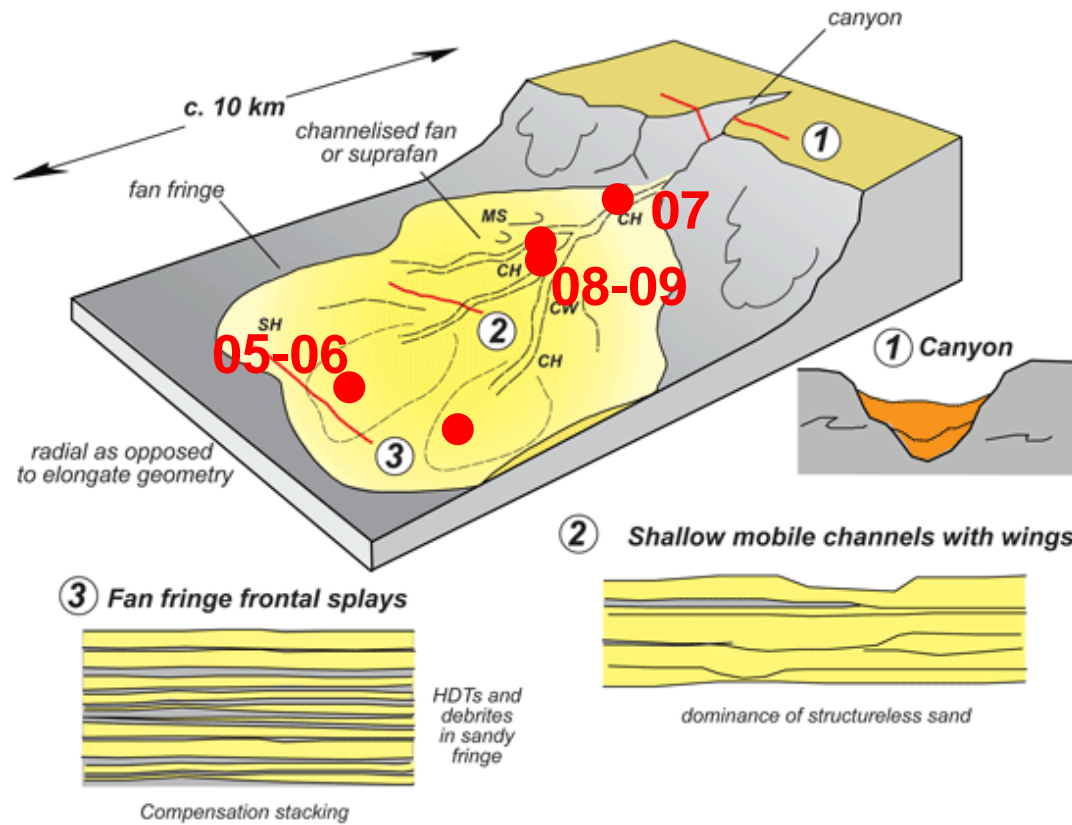
Slope-Rise Channel-Levee System



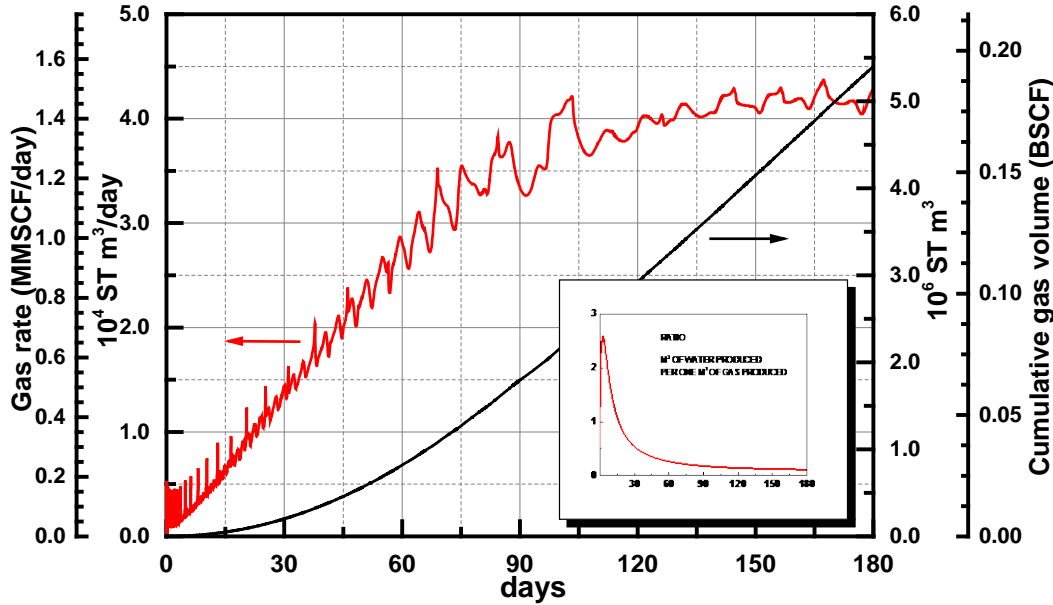
NGHP-02-08/09 Gas Hydrate Accumulation

Area C: Krishna-Godavari Gas Hydrate Petroleum System

Slope-Rise Channel-Levee System

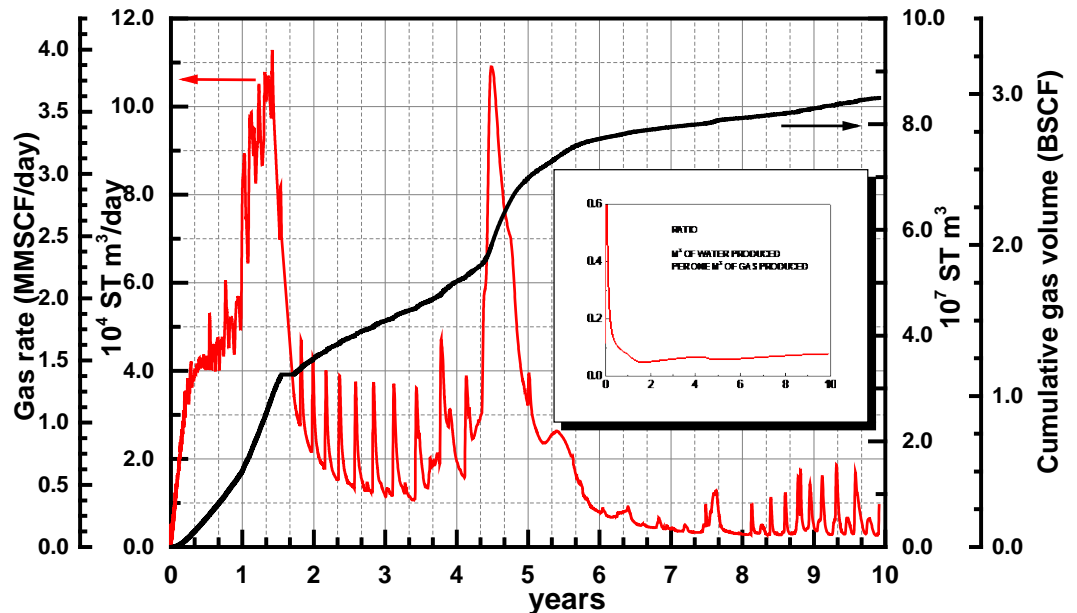


Site NGHP-02-16 Preliminary Numerical Simulation of Production Potential and Geomechanical Stability



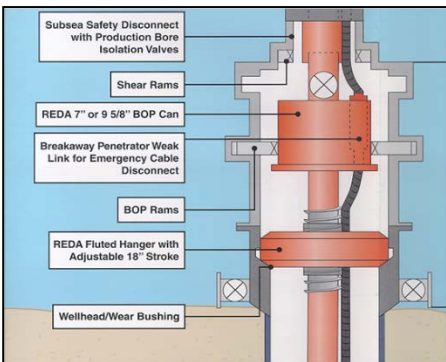
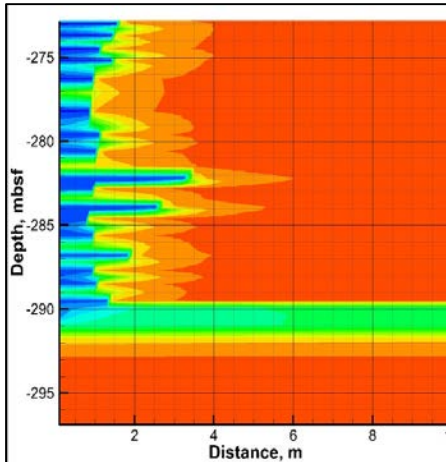
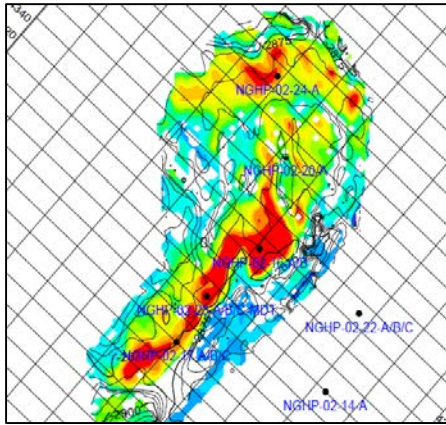
Gas hydrate production at 180 days

Gas hydrate production at 10 Years



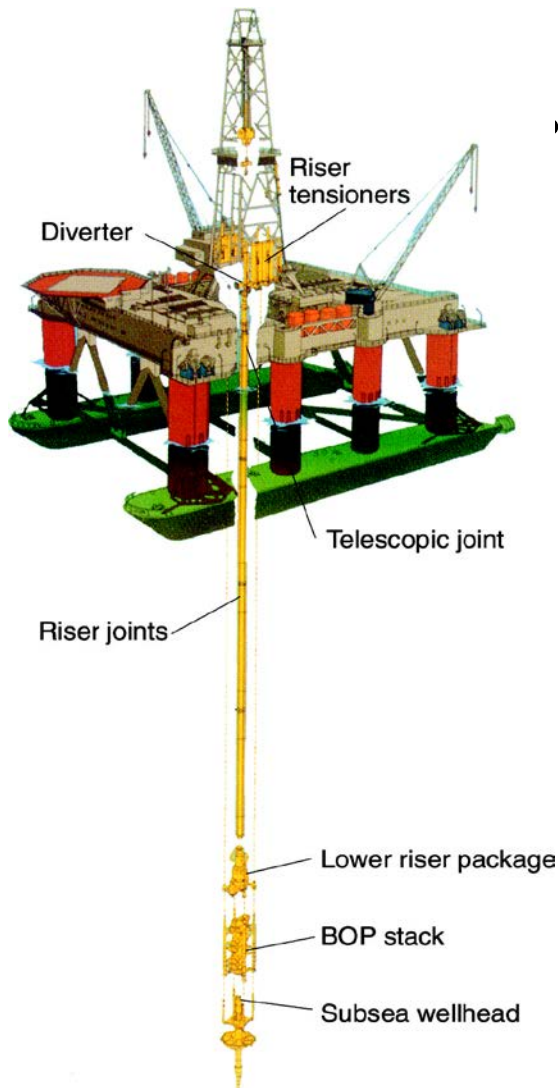
USDOE-NETL, Yongkoo Seol

NGHP-03 Test Planning



- **Reservoir Response**
 - Develop and refine production-mechanical models.
 - Monitoring production response with offset observation wells and 4D seismic technology.
 - Test design to prioritize insight toward field scale reservoir response and economics.
- **Operations**
 - Numerical simulation of well-bore and near-wellbore behavior during planned and unplanned shut-ins, test developed procedures and mitigation approaches.
 - **Flexibility:** Project management plan and structure should anticipate and enable changes in operations.
 - Development of an integrated project risk analysis and management process.

NGHP-03 Test Plan

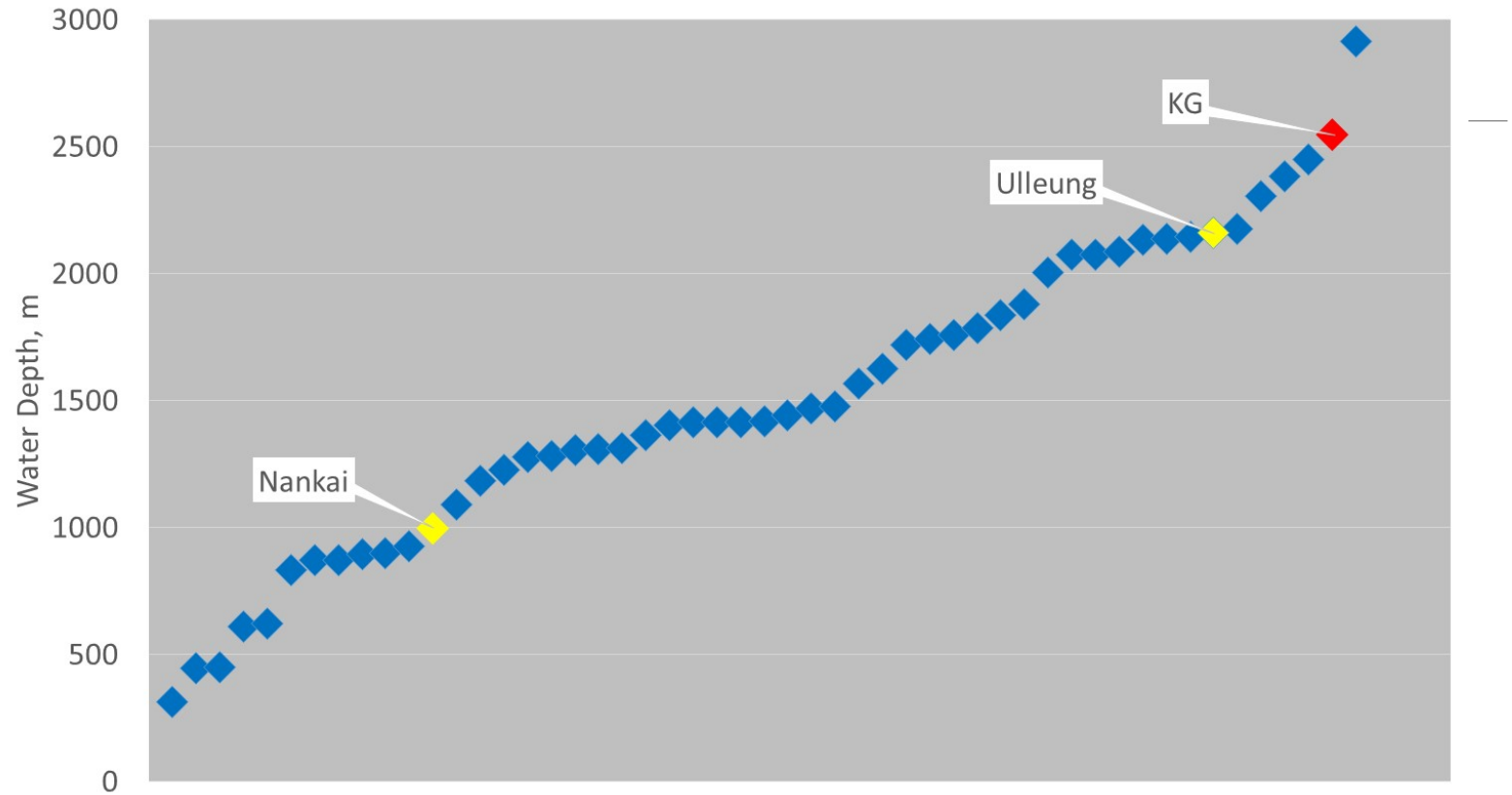


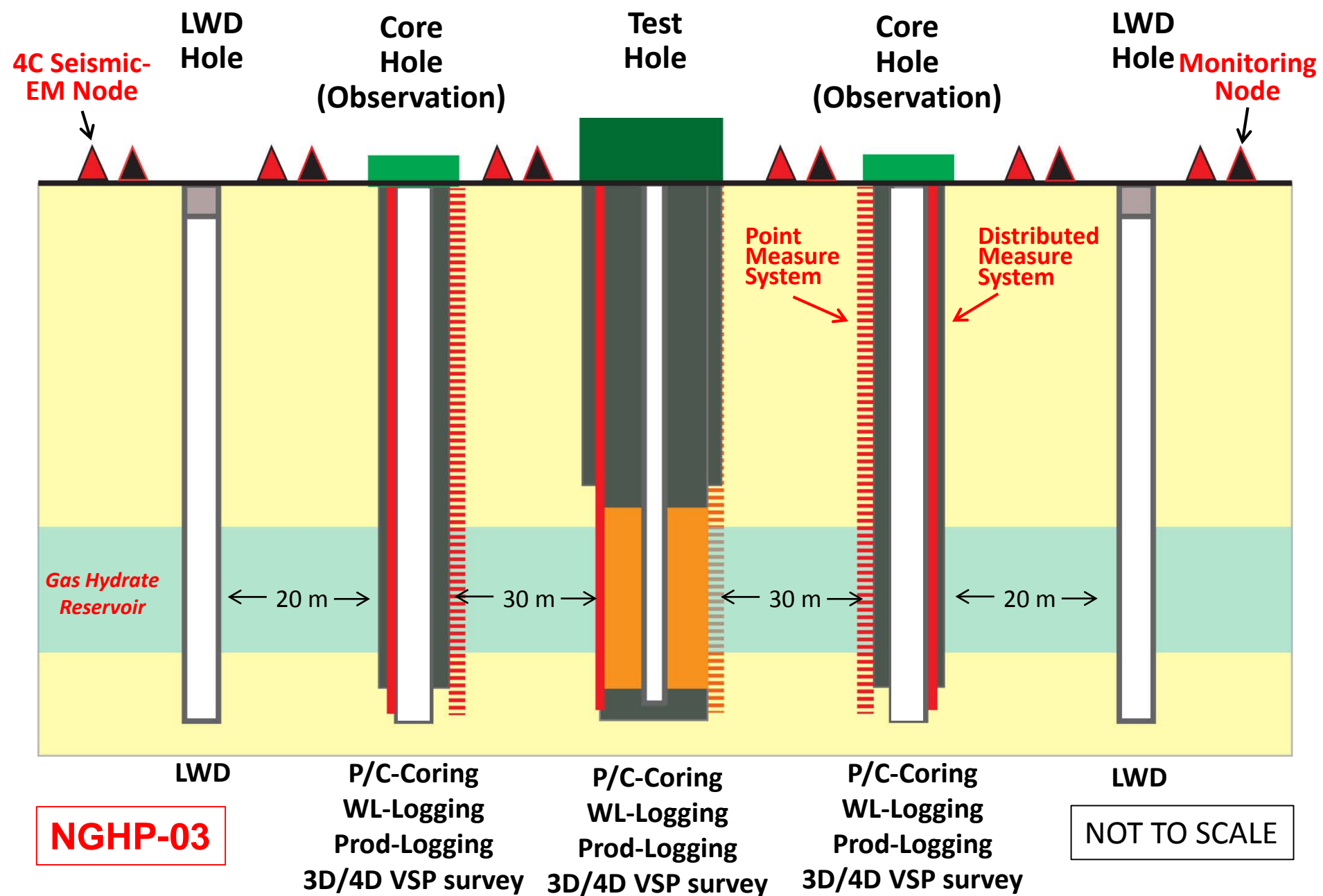
Operations

- Drill (LWD), advanced wireline logs, and instrument two observation holes at the Area B Test Site.
- Drill and core two pressure core holes at the Area B Test Site with 10 or more PCTBs in each hole.
- Drill (LWD), advanced wireline log, and instrument main production hole at the Area B Test Site.
- 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.

Current GOM Deepwater Activity

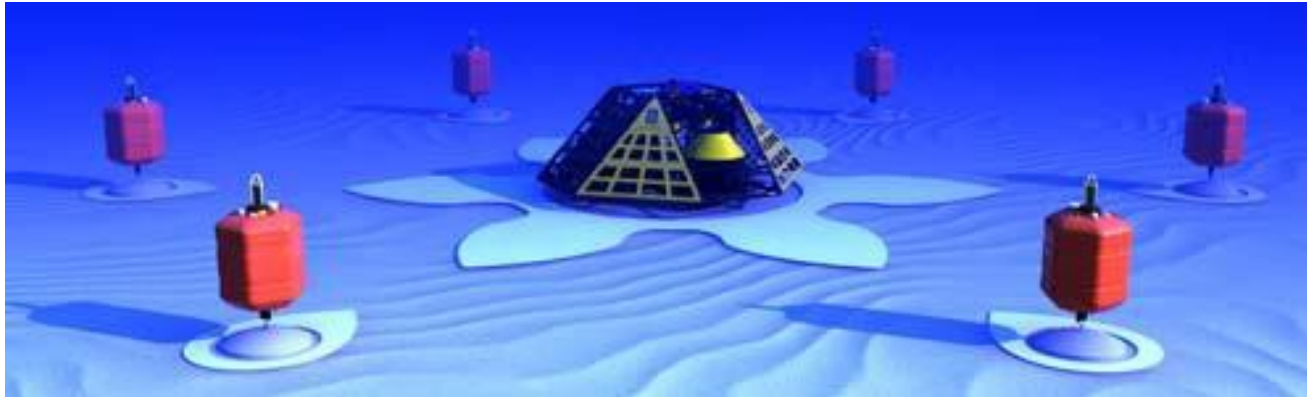
NGHP-03 Test Site (KG) Water Depth





*Seismic (3D/4C/4D) permanent monitoring (PRM); Repeat (3D/4C/4D) seismic survey monitoring;
Repeat (3D/4D) VSP monitoring; Repeat or permanent EM/CSEM 4D survey*

Modular Subsea Monitoring Network



KM Sensors

- SIMRAD Singlebeam / Splitbeam / Multibeam Echosounders for marine life and gas detection
- MESOTECH Scanning Sonars for gas detection in bubbles form
- Subsea Cameras
- Listening devices / Hydrophones for gas leakage detection
- Hydrocarbon Sniffers
- Dissolved Oxygen sensors

3rd Party Sensors

- Temperature
- Current profilers
- Pressure
- Inclinometers
- Vibration
- Mechanical Stress
- Fluorometer / Turbidity
- Various oceanographic sensors
- Biosensors



- **Summary**



Summary: Gas Hydrate R&D Opportunities

- Testing to constrain potential production rates are required. A variety of tests are needed (different geologic conditions – different approaches).
- First: “scientific” tests designed to maximize scientific insight then “production” tests designed to maximize rates.
- Testing needs to include advance monitor programs to identify and assess environmental response/impacts.
- US-DOE, JOGMEC, and USGS are developing plans for an extended hydrate production test pilot in Alaska.
- JOGMEC gas hydrate production test in Nankai Trough in 2016/2017.
- India planning for gas hydrate production test in KG Basin 2017/2018.
- China-GMGS is considering plans for a 2017 gas hydrate production test in the South China Sea.