UNCONVENTIONAL HYDROCARBONS:

GAS HYDRATES

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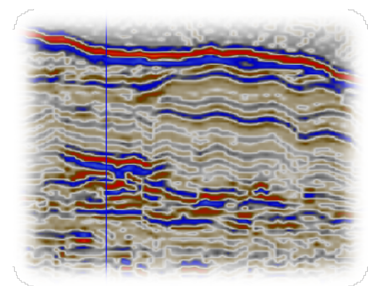

GAS HYDRATE SYSTEM

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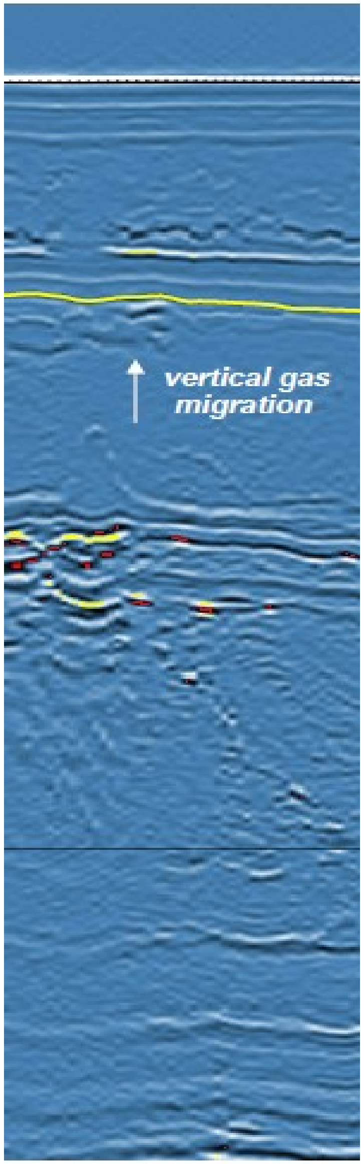
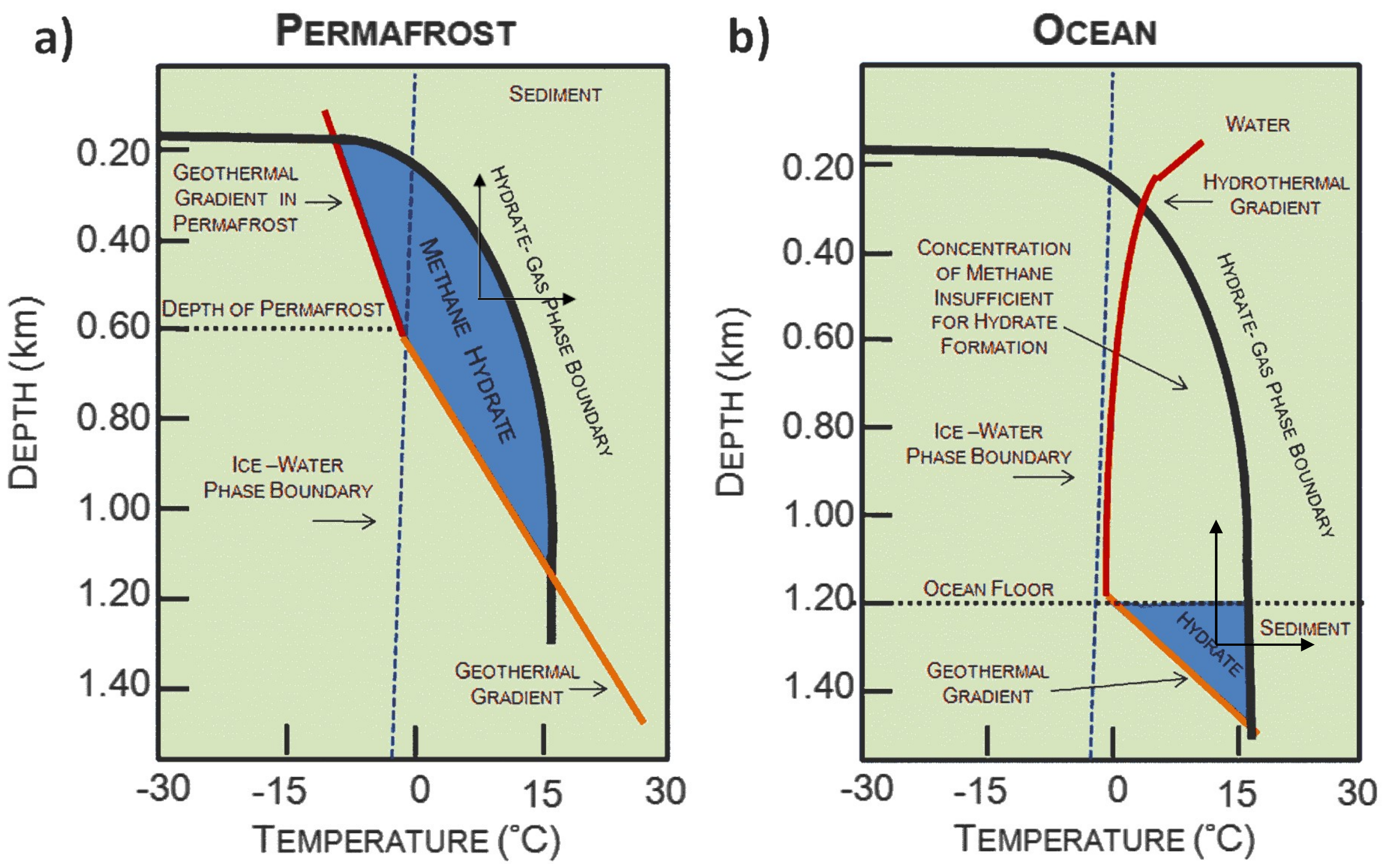


- **Crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of water molecules**
  - **One volume hydrate typically equivalent to 160-180 volumes methane gas**
- **Occur abundantly in nature**
  - **Arctic regions and in marine sediments**
- **Extent of GH Stability Zone**
  - Formation temperature
  - Formation pressure
  - Pore water salinity
  - Gas chemistry
- **Gas Source and Migration - Charge**
  - Availability of gas and water (source)
  - Gas and water migration pathways

Stability of Gas Hydrates



GAS HYDRATE- PRODUCTION

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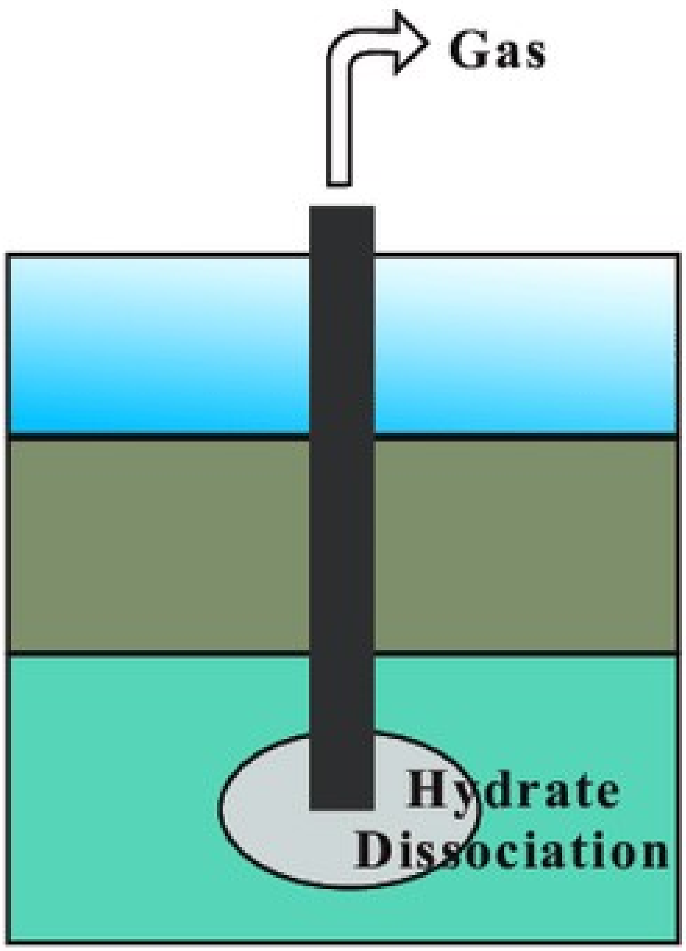

Depressurization

- Increase in permeability by hydrate dissociation helps depressurization.
- Depends on the heat from the surrounding formation.
- Longer and more efficient production is expected, but control is difficult.

Thermal Stimulation

- Active heat injection to the formation. Heat source is controllable.
- Energy should be injected continuously

Primary Gas Hydrate R&D Issues

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Geohazards

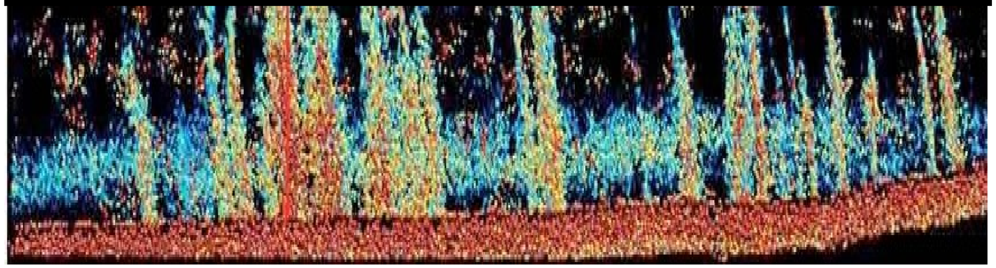
1. Surficial hydrate hazards to sea-floor structures?
2. “Conventional” well drilling/production in areas of gas hydrate?
3. Can hydrate destabilization cause sea-floor instability?

Energy Resource Potential

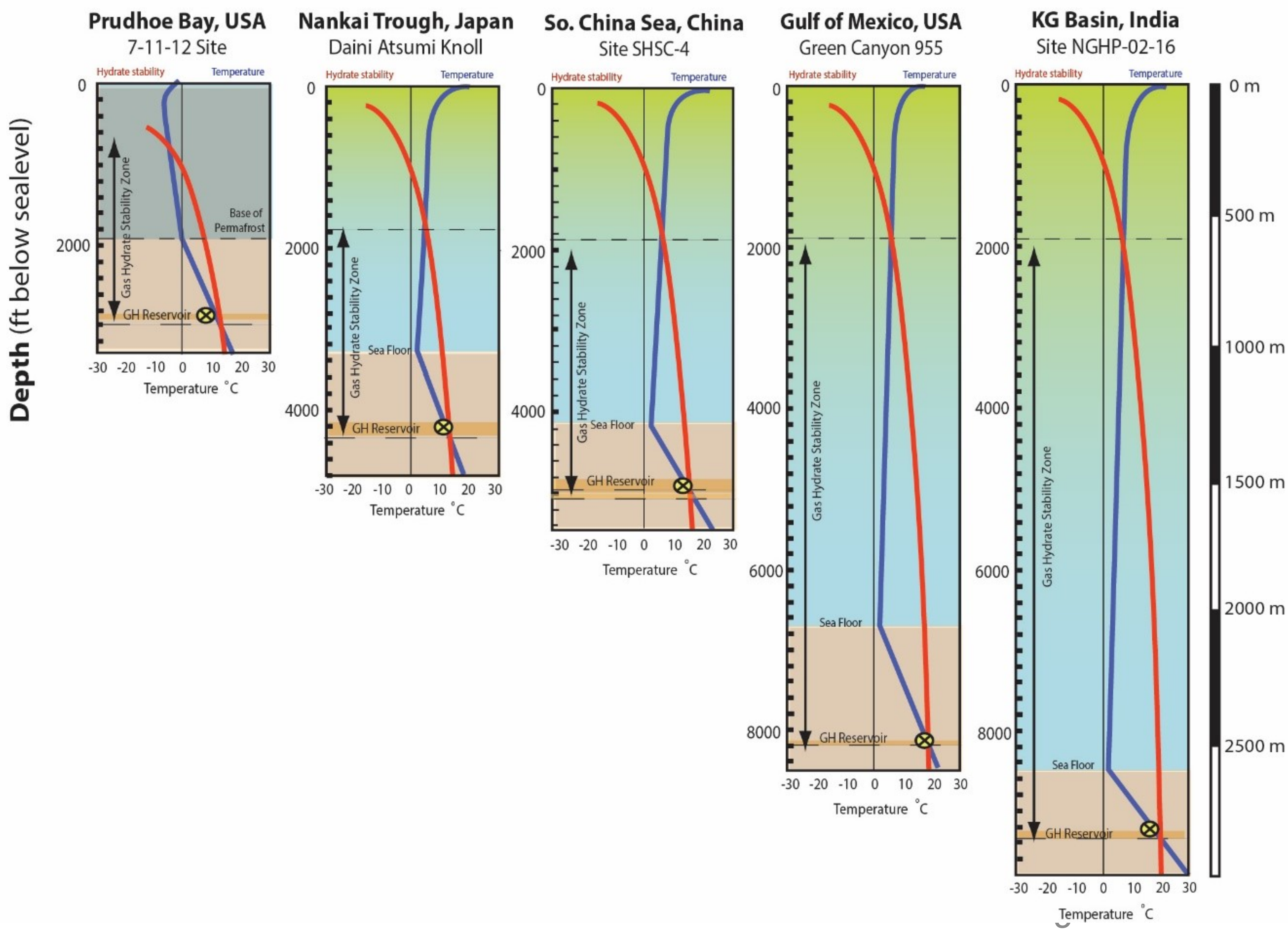
1. What types of deposits are the feasible targets?
2. How can they be found?
3. Can they be produced at viable rates?
4. What are the environmental impacts and how can they best be minimized?

Global Environmental

1. Hydrate linkages to biological communities?
2. What role does destabilized hydrates play in the carbon cycle over long time-scales?
3. What is the present/near-term future response of hydrate to ongoing global climate change?



Global Occurrences of Gas Hydrate bearing sands



GAS HYDRATE R&D- WORLD SCENARIO

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2017: **Nankai Trough - **Ist test- Produced 35,000 m3 of gas in 12 days and IInd test- Produced 200,000 m3 in 24 days
2017: **South China Sea - **309,000 m3 of gas in 60 days

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

2017 Nankai Trough Test (Japan)

- Marine GH production test (2-test 10 & 30 days)

2018-2023 DOE-JOGMEC Alaska

- *Extended depressurization testing*

Recent Test Results

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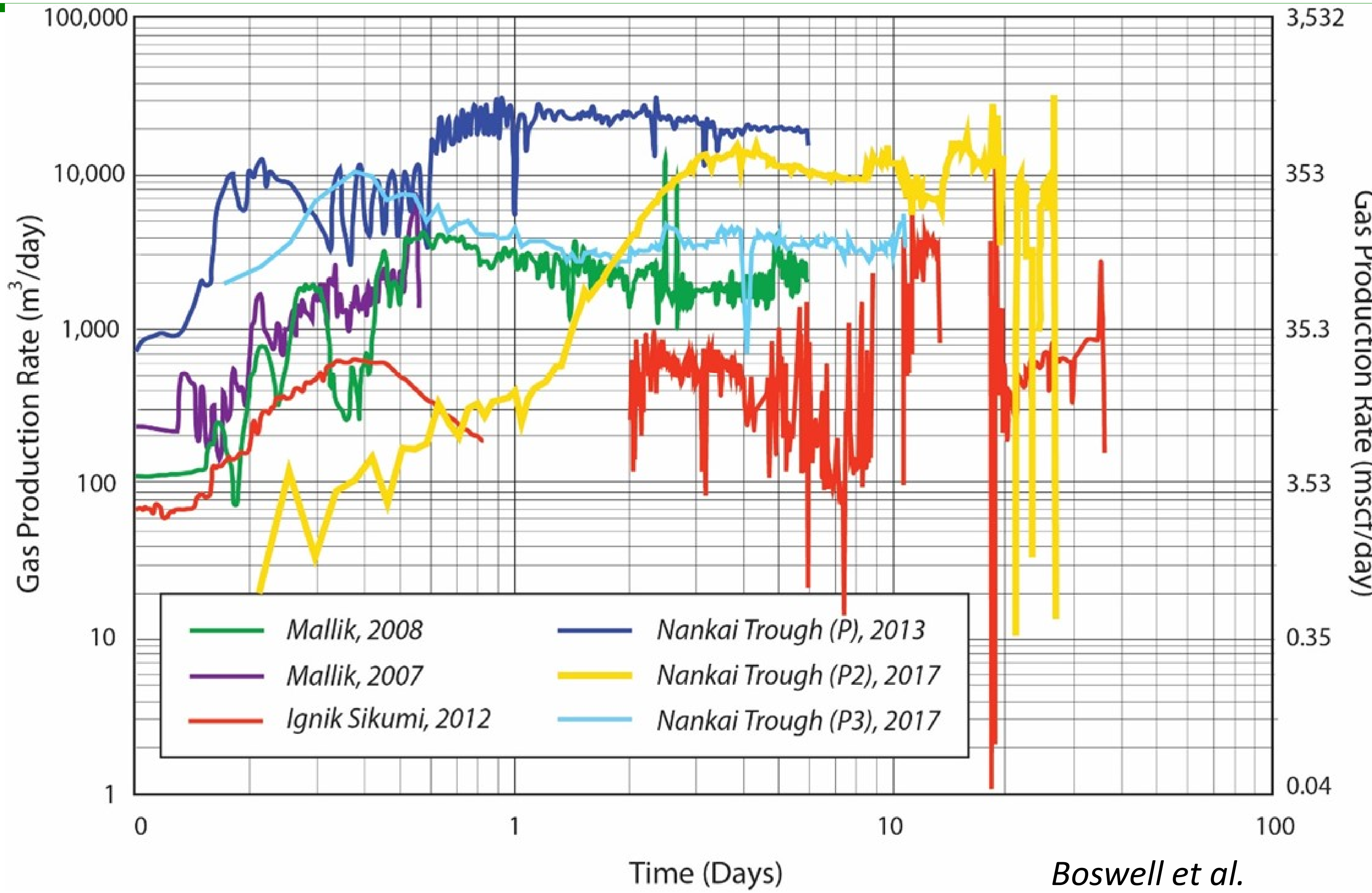
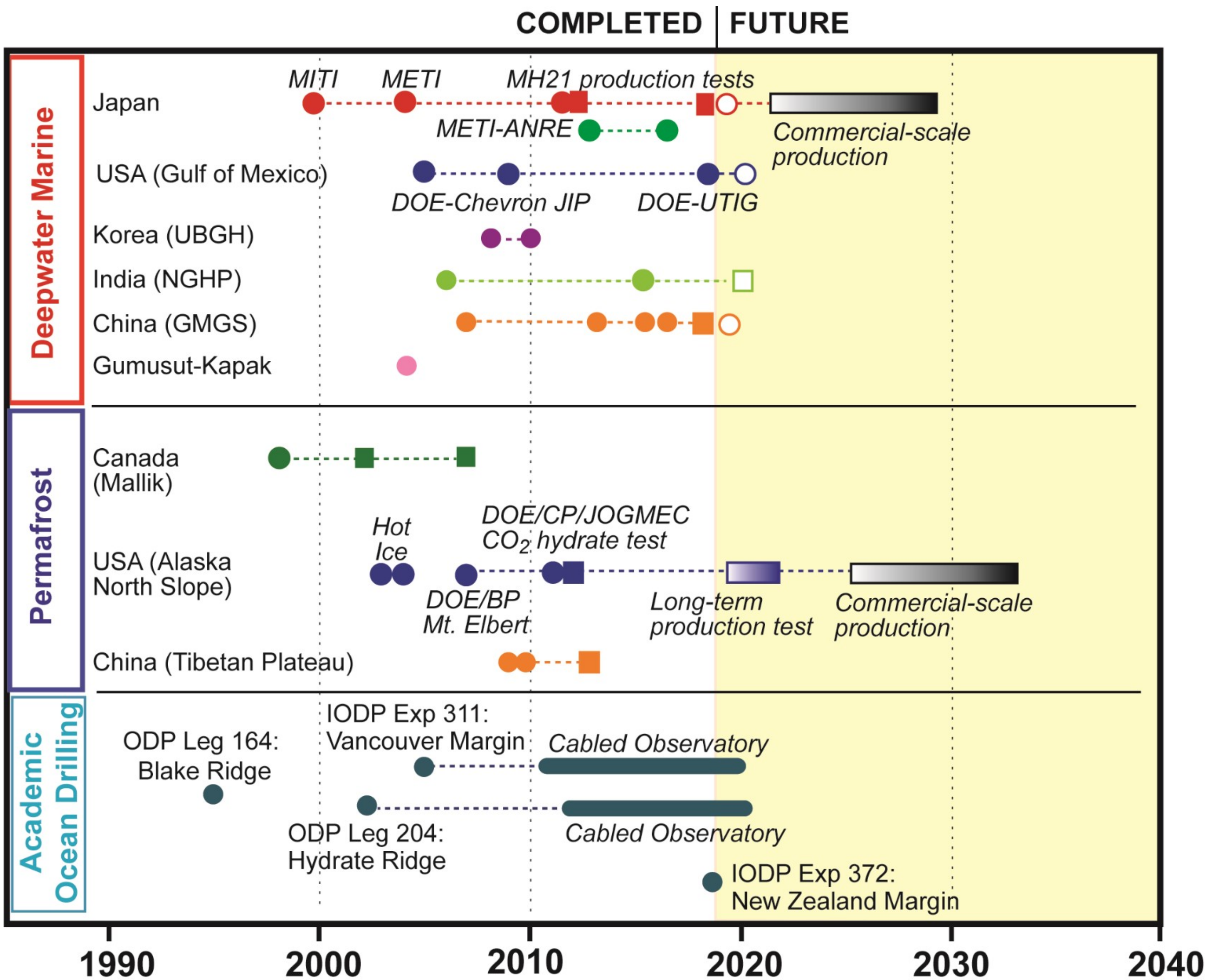


Boswell et al.

GH - Scientific & Industry Drilling



Source: Presentation by Dr. Tim Collett, USGS, 2019

INDIAN NATIONAL GAS HYDRATE PROGRAMME

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Members & Associations

- Gas hydrate research and exploratory activities in India are being steered by the Ministry of Petroleum & Natural Gas under National Gas Hydrate Program (NGHP) with Technical participation from Directorate General of Hydrocarbons (DGH),
- Members from E&P Companies & National Research Institutes i.e. ONGC, GAIL, OIL, IOCL, NGRI, NIO, NIOT, IITs
- Association with International Experts from USGS, USBM, USDOE, JOGMEC
- Objective: To discover highly saturated gas hydrate occurrences in sand reservoirs that could be the target of a future potential energy resource in a cost effective and safe manner

GAS HYDRATE R&D- INDIAN CONTEXT

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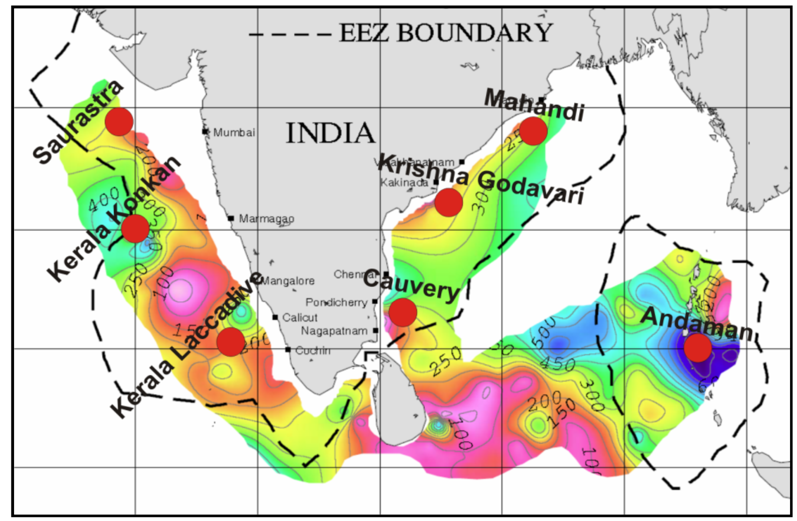
1997	• NGHP formulated to explore potential of Gas Hydrate
2000	• GoI restructured NGHP • DG, DGH Technical coordinator of NGHP
2006-2007	• **Expedition-I: Exploration-Presence of GH in Indian Offshore - Krishna Godavari, Mahanadi and Andaman** • Wireline logging, LWD, Coring • *Reservoir type- fine to medium sediments and white volcanic ash* • Total Prognosticated Gas Hydrate Volume: 1894 TCM
2012	• USGS assessed Gas Hydrates resources - 933 TCF
2015	• **Expedition-II: Exploration- Presence of Gas hydrate bearing sand reservoir systems in KG basin** • CHIKYU, Japan- Wireline logging, LWD, Coring, VSP & MDT

Potential Regions (Zone of Stability)



Expedition-III : Pilot Production Testing

Various studies are under progress

MAJOR OUTCOME: NGHP-01

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- 39 holes at 21 sites
  - water depth: 906 to 2674.2 m.
- Total of 494 cores containing 2,847.01 meters of sediment collected & studied.
- Gas hydrates occur in grayish green fine to medium sediments and white volcanic ash as pore-filling hydrate, while visible gas hydrates developed in black fine sediments (Site NGHP 1-10).
- The structures of the gas hydrates in the studied samples are all Structure I, with methane as the dominant guest.
- Established Physical Presence in Krishna Godavari, Mahanadi and Andaman can not be exploitable due to technical issues.
- Studies carried out under collaborations with expert agencies like USDOE, USGS & US BOEM to identify the hydrate bearing sand reservoirs:
  - To identify areas having free gas below hydrates
  - Identification of locations for Expedition –02
- National Gas Hydrate Program Expedition 02 was conducted in 2015

Location drilled during :NGHP-Expedition-02

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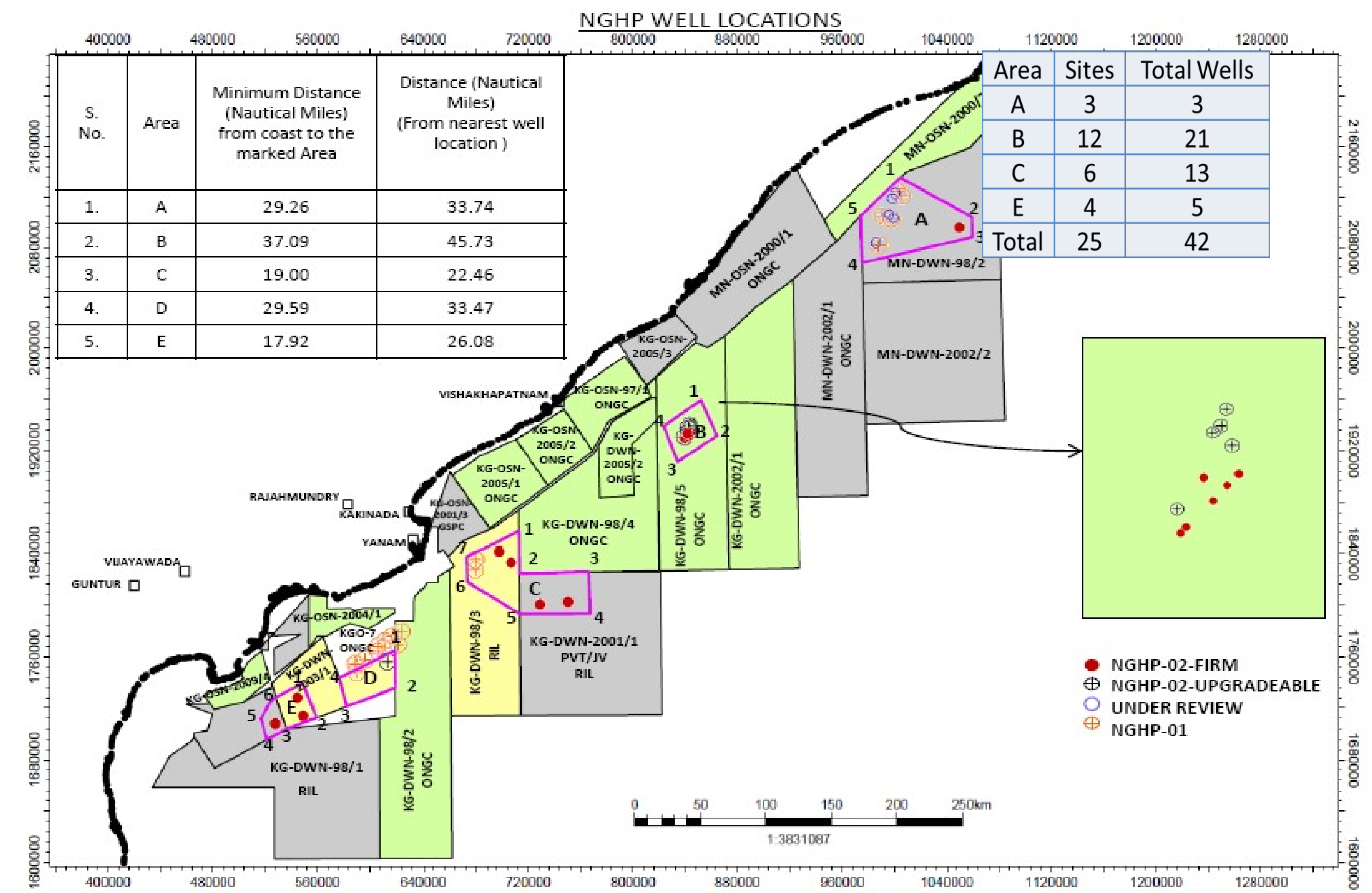

S. No.	Area	Minimum Distance (Nautical Miles) from coast to the marked Area	Distance (Nautical Miles) (From nearest well location)
1.	A	29.26	33.74
2.	B	37.09	45.73
3.	C	19.00	22.46
4.	D	29.59	33.47
5.	E	17.92	26.08

Area	Sites	Total Wells
A	3	3
B	12	21
C	6	13
E	4	5
Total	25	42

Major Out come:NGHP-Expedition-02

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- Identified two distinct gas hydrate accumulations.
- One is approximately 20 to 100m thick, layer-type unit developed in sand-rich facies at depths of about 400 meters below sea floor, and the other accumulation is a fracture-type unit of variable thickness at shallow levels.
- Areas 'B' & 'C' have shown presence of sand depositional systems within Gas Hydrate Stability Zone.
- Area A, which is in the Mahanadi deep water basin, has several sand zones having limited gas hydrate saturations.

WAY FORWARD

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Phased approached for Gas Hydrate Pilot Production testing.

- Phase 1:
  - Includes studies/researches pertaining to production test, reservoir simulation, flow modelling, sand ingress, risk & environmental impact assessment, obtaining statutory clearances, engineering design, finalization of rig and other services tender.
  - strong technical capacity for sustained project support by way of providing staffing requirements and Continued development of domestic R&D capabilities through domestic and international partnerships for India.
  - Various studies with the support of industry and academic research institutions to develop production technology
    - ✓ Require field level trial for validation of complex process involved in producing gas hydrate

Way Forward

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- **Phase 2:**
  - Characterization of geological and engineering conditions of the testing sites. This will include LWD and coring operations associated with identified sites.
  - Gas Hydrate resource estimation
  - Develop and refine geo mechanical and production models
  - Refined GH resource assessments, evolving from in-place (resource) to technical recoverable and reserve estimates
  - Planning of production testing with integration of geological model and engineering solutions.

Way Forward

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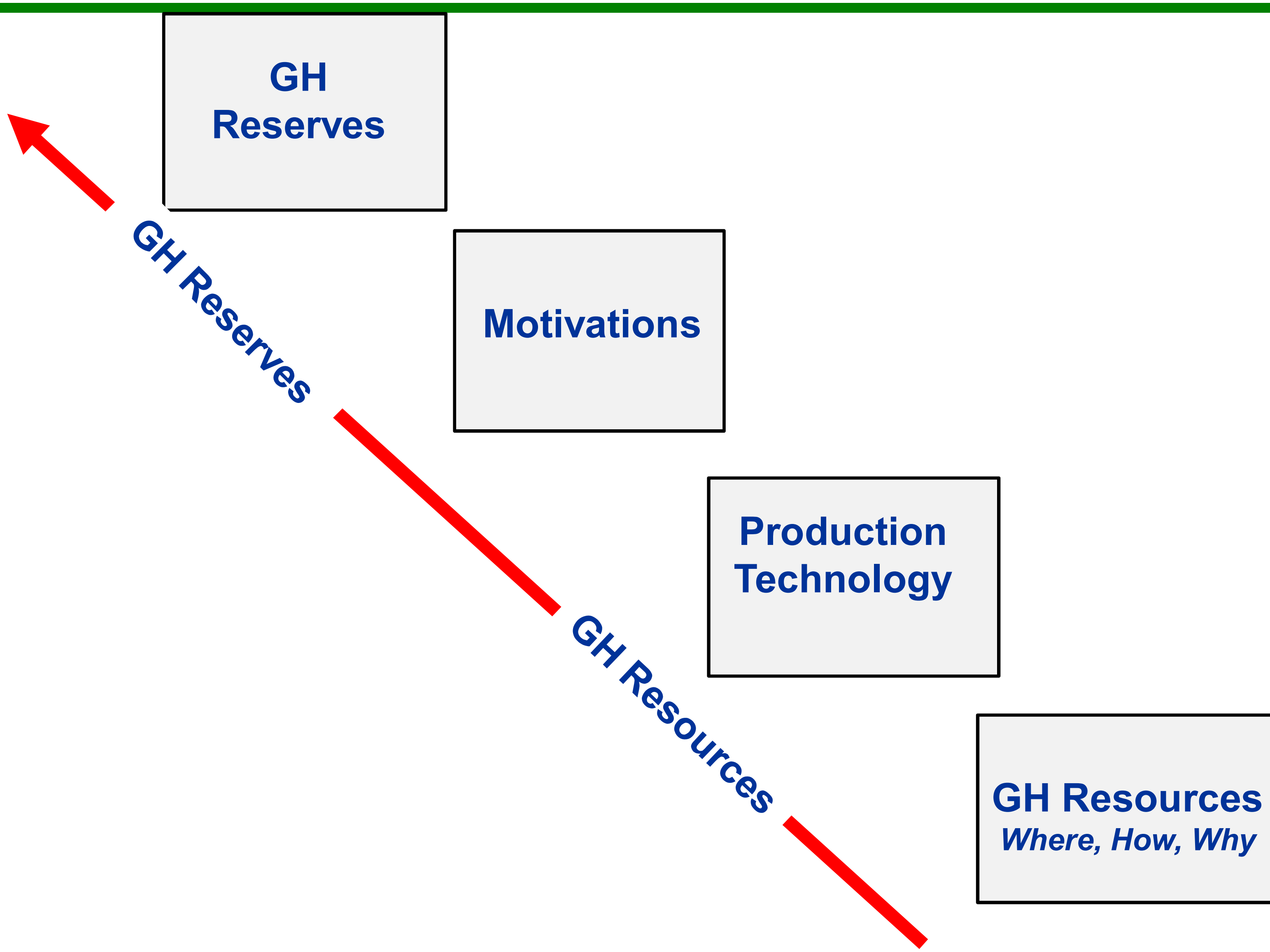

Way Forward

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•Develop and perform laboratory measurements to calibrate and interpret field data

•Develop and deploy new and improved field characterization tools to address the critical GH science/engineering requirements

•Further develop and refine GH prospecting techniques

- **Phase 3 :**
  - Design system for Reservoir Response monitoring
  - Design system for monitoring production response
  - subsea devices for the met-ocean condition of the test location
  - Flow assurance & design of artificial lift system/subsea devices
  - Pilot production testing phase; ~30-90 day long depressurization test.

GAS HYDRATE- CHALLENGES

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- Effective dissociation of gas from gas hydrates.
- Sustenance of continuous gas production
- Sand Ingress : Optimal drawdown and effective sand control measures.
- Problem of liquid loading/ Controlling large drawdown – Water handling.
- Design of suitable ESP for depressurization induced gas production.
- Hydrate reformation issue – critical flow rate/ use heating elements.
- Down-hole separation of gas and water
- Production drop due to reservoir cooling
- Physical response of gas hydrate reservoirs during dissociation is not known. -in-situ dissociation process to be understood
- Disaster management
- Cost considerations

THANK YOU