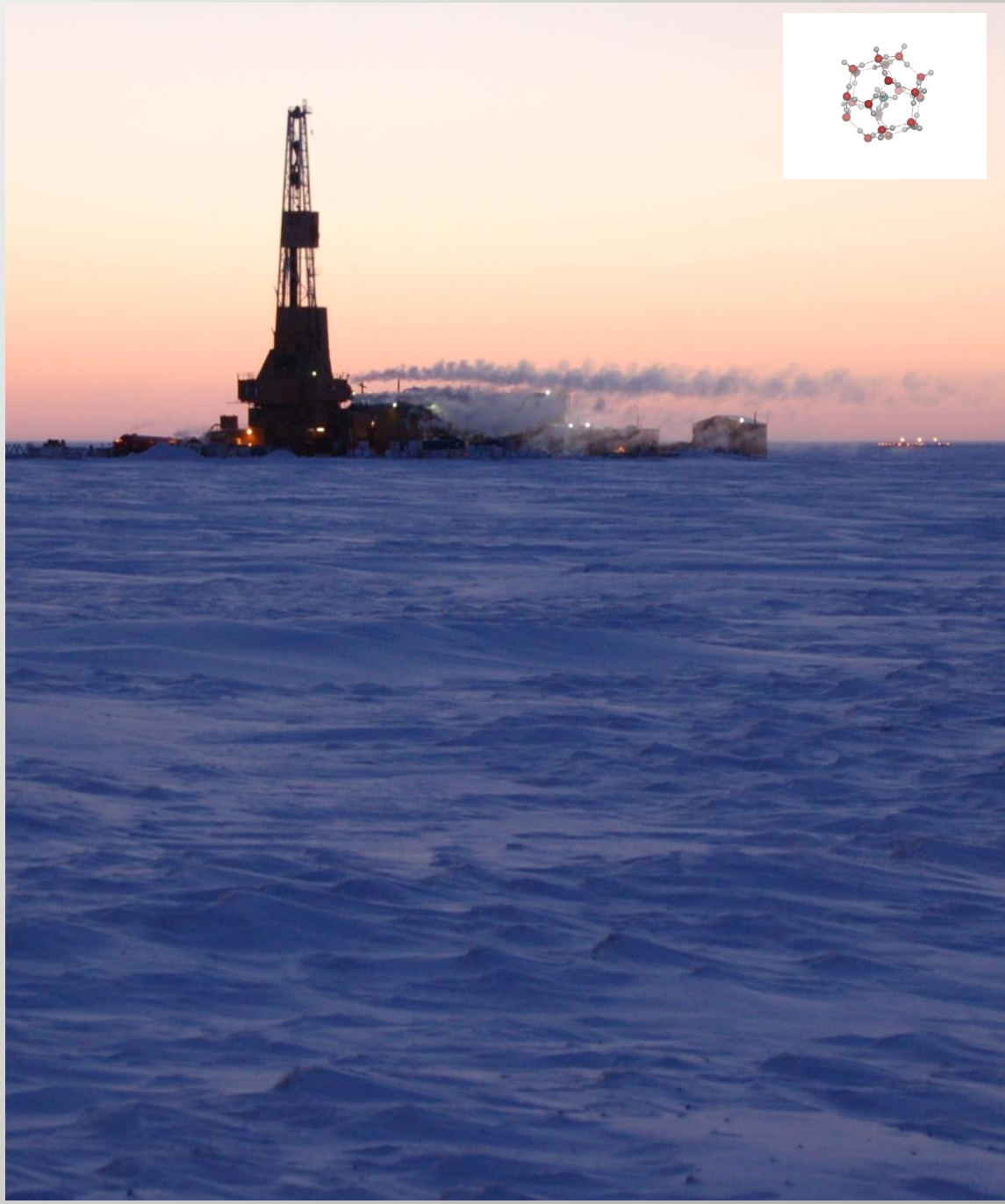
DOE'S NATURAL GAS HYDRATES PROGRAM

Rick Baker, DOE/NETL

Methane Hydrate
Federal Advisory Committee

May 7, 2015



Mt Elbert Test Site, ANS, 2007

Gas Hydrate R&D Issues

Status of first-order science/technology questions

Energy Resource Potential

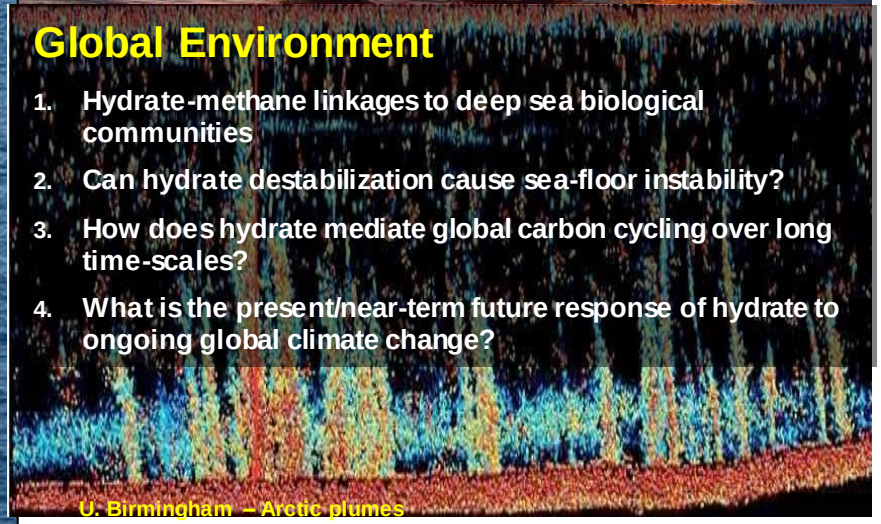
1. What types of deposits are the feasible targets, and what are the volumes?
2. How can they be found?
3. Can they be produced at viable rates?
4. What are the environmental impacts and how can they best be minimized?

Geohazards

1. Spontaneous formation in production/well intervention equipment.
2. Surficial hydrate hazards to sea-floor structures.
3. "Conventional" well drilling/production in areas of gas hydrate.

Global Environment

1. Hydrate-methane linkages to deep sea biological communities
2. Can hydrate destabilization cause sea-floor instability?
3. How does hydrate mediate global carbon cycling over long time-scales?
4. What is the present/near-term future response of hydrate to ongoing global climate change?



U. Birmingham – Arctic plumes

Status of International R&D

India
- Ongoing large-scale exploration program
- Collaboration with Japan (Chikyu)
- Approval for next program (field test)

Japan
- Analyzing 2013 results
- Planning 2016 and 2018 marine tests
- Would like intermediate AK-test

S. Korea
- Deferred 2015 production test plans
- Determining next steps

China
- Analyzing 2014 program results
- Various programs (onshore/offshore/gov/ind)
- Limited external collab (Fugro)

New Zealand
- Drilling and coring programs planned

Canada
- Terminated dedicated program

European Union
- New program announced; Germany at center
- Black Sea targets

R/V Chikyu

Vietnam/S. Africa
- Planning new program

Brazil
- Initiating program in Petrobras

Norway
- "Center of excellence" established at Tromso
- Statoil has de-emphasized its internal hydrate program

Taiwan/Colombia/Mexico/Uruguay/Turkey/Iran
- Uncertain status

U.S. National Program Approach

Public Domain

Interagency & International

Merit-based & Transparent

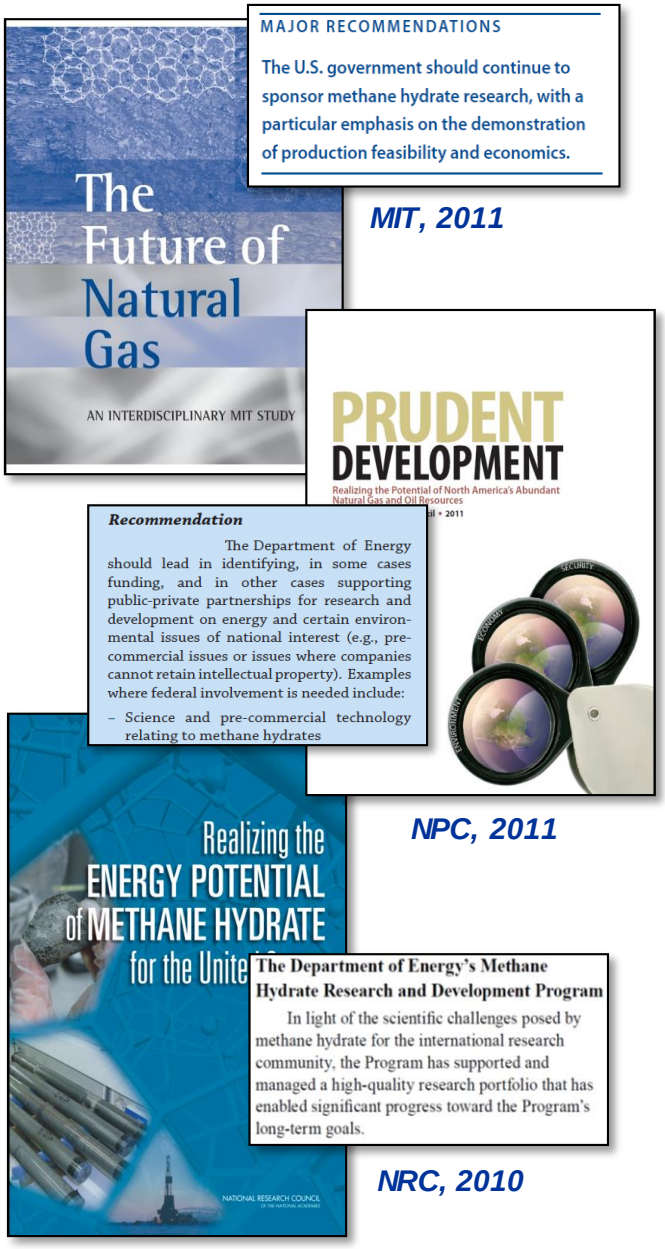
Gas Hydrate in Nature

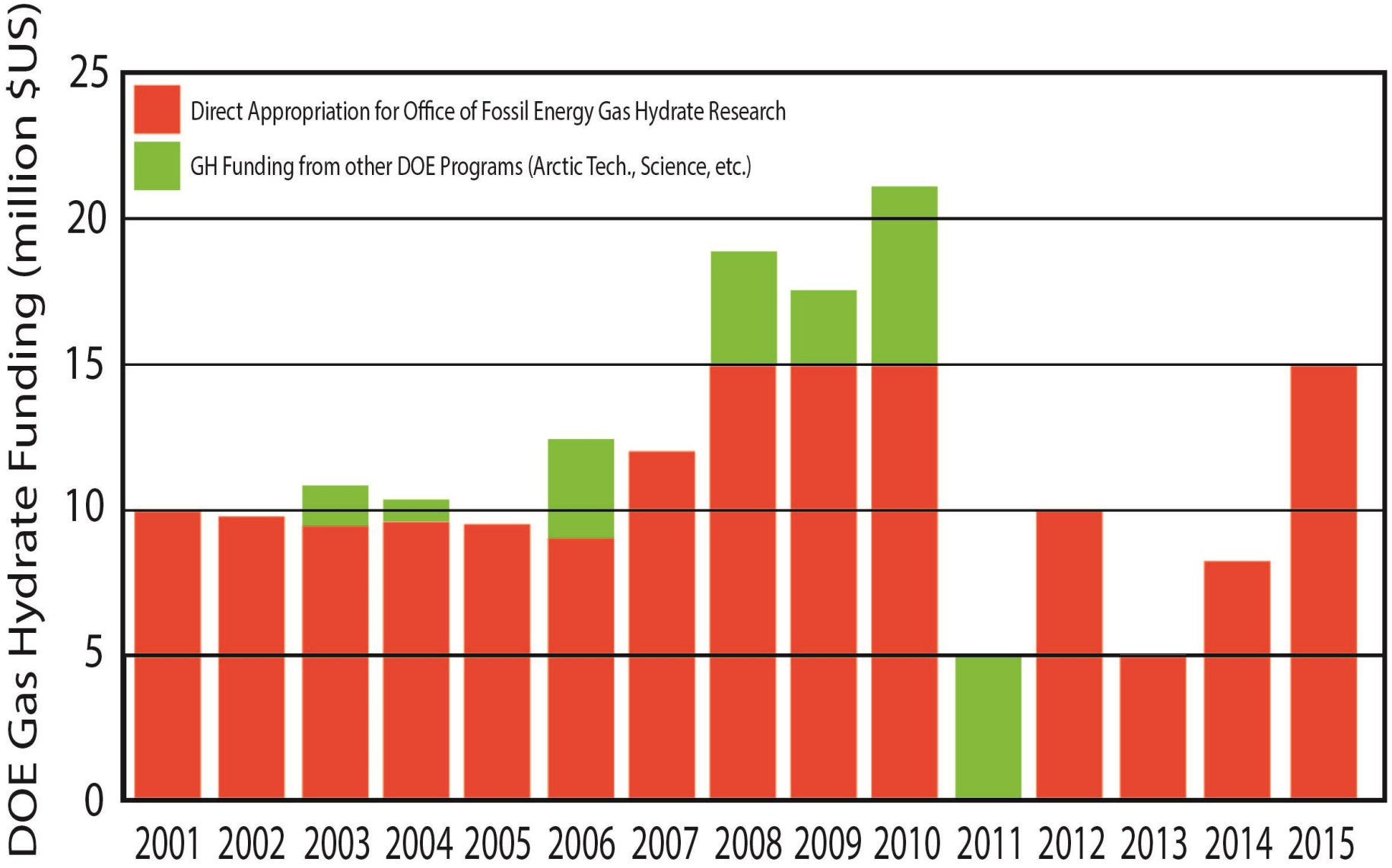
Science and Technology

Emphasis on Research *in the Field*

Outreach & Education

- **The federal role in gas hydrate science and technology development is widely accepted**
  - tangible, wide-ranging, public benefits.
  - consensus that DOE has managed the effort well n
- **The primary goals and next steps are clear and the groundwork well laid**
  - monitored production tests (Alaska first, then marine)
  - sampling/analysis of marine occurrences
  - resource confirmation in other US OCS areas
  - refinement/field calibration of exploration technologies
  - integration of GH science into climate change models
- **Lab and modeling work needed as support <u>but the answers will come from the field</u>**
  - the work to be done is <u>complex and costly</u>
  - industry/int'l perspectives change rapidly. Most of the industry is increasingly disinclined to lead further projects
  - Significant international interest




DOE Gas Hydrate Funding (million $US)
25
20
15
10
5
0
Direct Appropriation for Office of Fossil Energy Gas Hydrate Research
GH Funding from other DOE Programs (Arctic Tech., Science, etc.)
2001
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2003
2004
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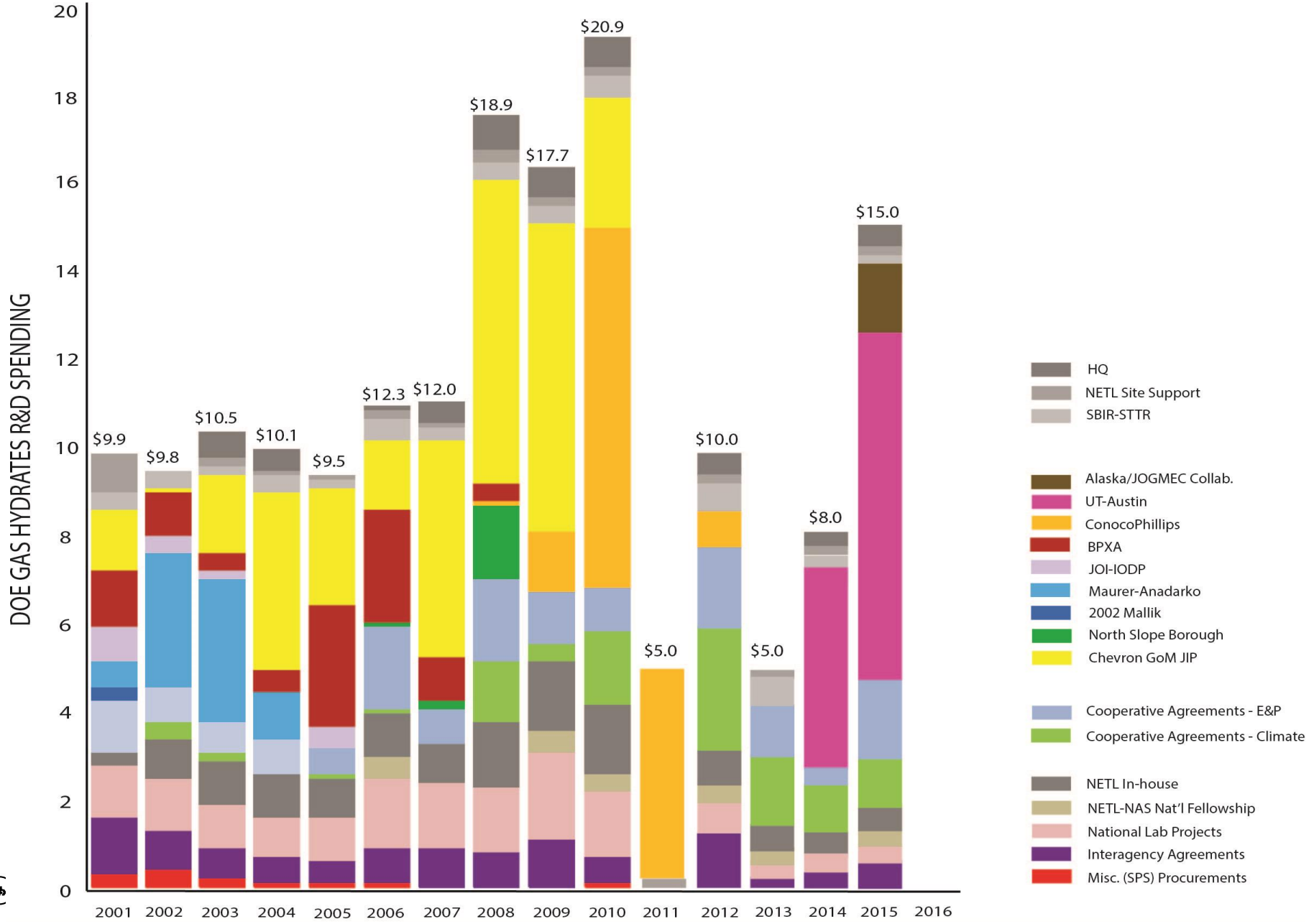
2014
2015


DOE GAS HYDRATES R&D SPENDING
20
18
16
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$9.5
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$12.0
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2016
HQ
NETL Site Support
SBIR-STTR
Alaska/JOGMEC Collab.
UT-Austin
ConocoPhillips
BPXA
JOI-IODP
Maurer-Anadarko
2002 Mallik
North Slope Borough
Chevron GoM JIP
Cooperative Agreements - E&P
Cooperative Agreements - Climate
NETL In-house
NETL-NAS Nat'l Fellowship
National Lab Projects
Interagency Agreements
Misc. (SPS) Procurements

Results of FY2014 Hydrate Program FOA

FOA Topic Areas:

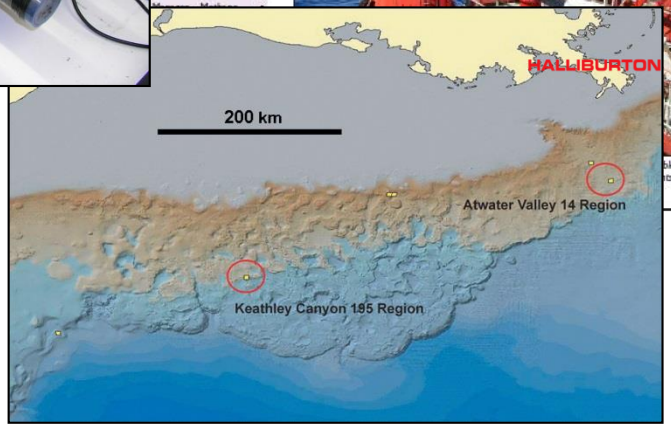
- **Area 1:** Extended Duration Testing of Arctic Gas Hydrate
  - conduct scientific field tests in Alaska to further our understanding of the long-term response of gas hydrate occurrences to controlled destabilization via depressurization and other complimentary approaches.
  - 3 initial applications received (1 disqualified, 1 withdrawn (JOGMEC), other not recommended for selection).
  - No direct responses from industry.
  - Alternative approaches for research in this area being pursued

- **Area 2:** Field Programs for Marine Hydrate Characterization
  - better characterize naturally-occurring gas hydrate deposits via multi-site deepwater marine drilling, logging, and/or sampling programs.
  - 5 applications received / reviewed
  - 1 application selected for award (UTA)

Marine Resource Characterization

Began with focus on Gulf of Mexico drilling hazards, JIP Leg I (2005)

- First hydrate drilling and sampling in the Gulf of Mexico
- First measurement of physical properties of core while retained under natural pressures
- Addressed prime issue associated with most common occurrence (in muds) – drilling safety
- Confirmed ability to safely drill low-saturation, deep-water, gas hydrates
- Program transitioned to resource evaluation



Chevron NETL USGS BOEM JOGMEC Schlumberger TOTAL ConocoPhillips Reliance Statoil

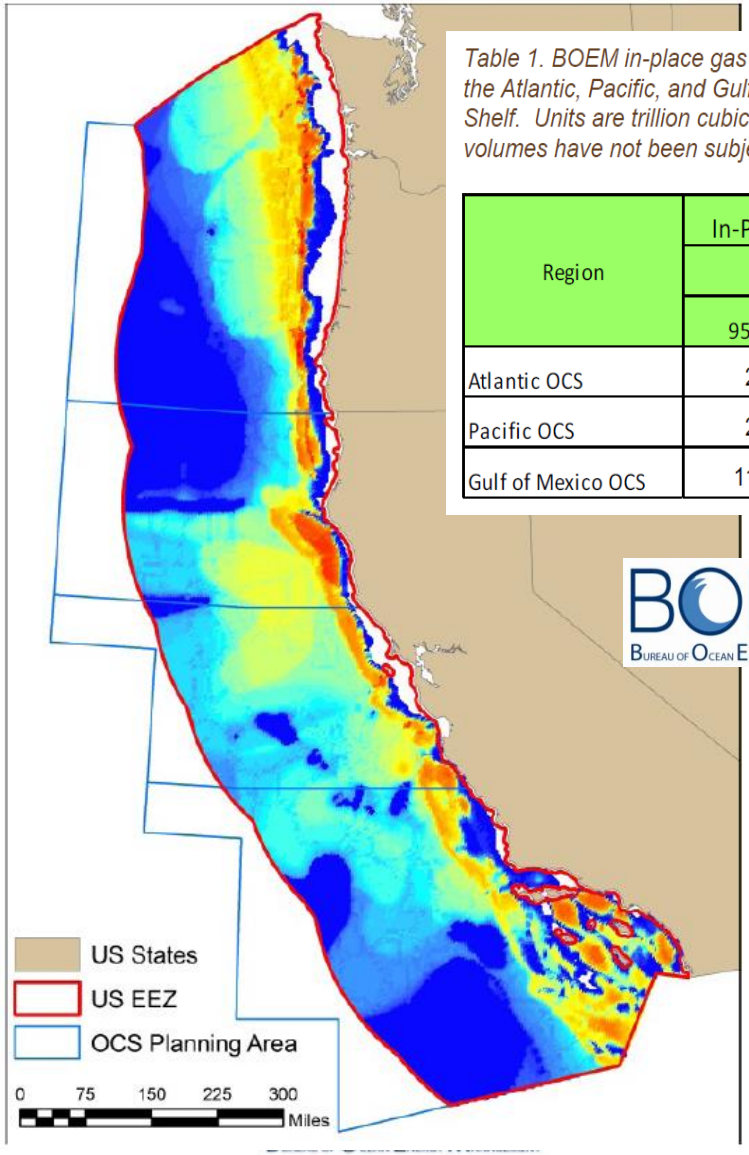
US Marine Gas Hydrates

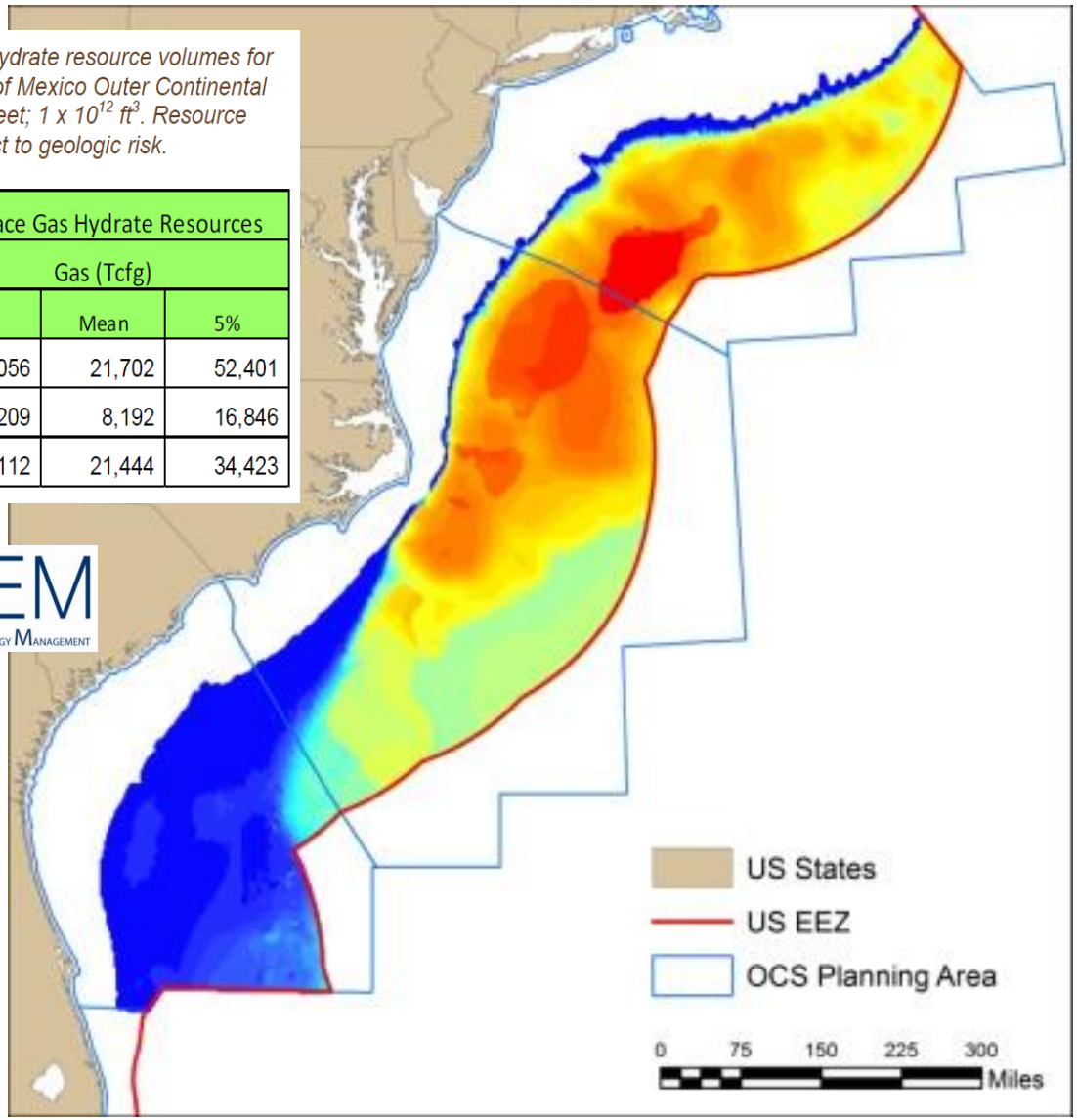
Substantial Resources Estimated

Table 1. BOEM in-place gas hydrate resource volumes for the Atlantic, Pacific, and Gulf of Mexico Outer Continental Shelf. Units are trillion cubic feet; 1 x 10^{12} ft^3. Resource volumes have not been subject to geologic risk.

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

BOEM
Bureau of Ocean Energy Management

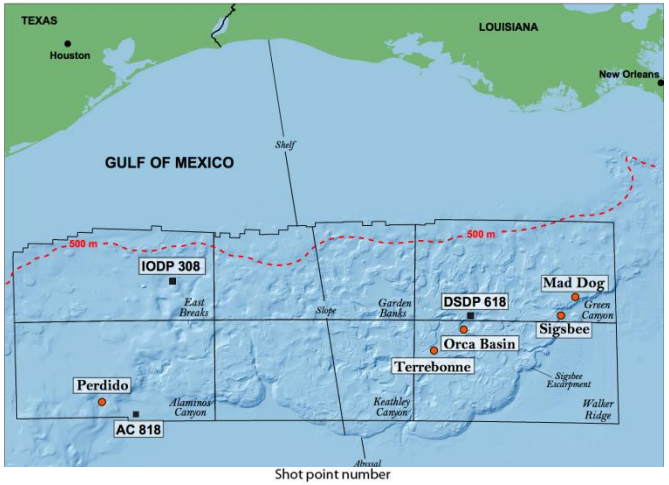


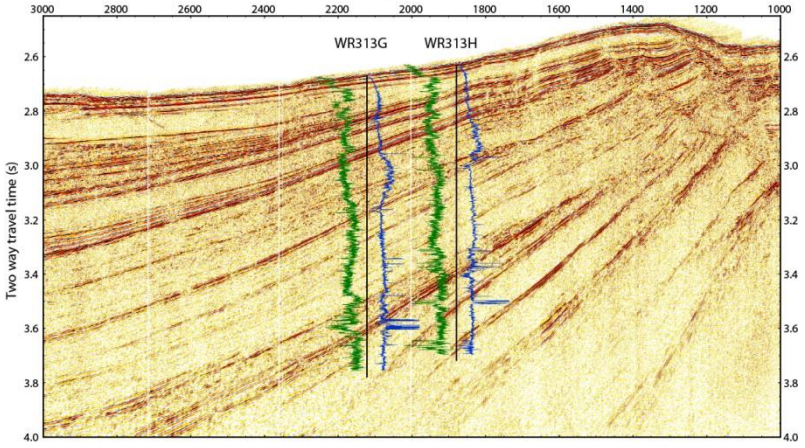


New GOM Project Awarded with U. Texas

Sampling and Exploration

- **"Deepwater Methane Hydrate Characterization and Scientific Assessment"**
- **Budget:** $64M (DOE- $41M, Cost Share - $23M)
- **Partners:** US Geological Survey, Ohio State University, Lamont Doherty Earth Observatory, Consortium for Ocean Leadership
- **Replaces the Chevron-led JIP which ended May, 2014**
- **Key components of the project**
  - Conduct evaluation of potential field sites in the Gulf of Mexico (known and prospective)
  - Plan to access scientific research Vessel (Joides Resolution) through the IODP CPP process.
  - Pursue final development and testing of pressure coring tools and pressure-core analysis devices
  - Conduct logging, coring programs





UT-Austin: Gulf of Mexico Drilling Program Status

- **"CPP" proposal submitted to IODP Apr. 1 2015**
  - initial response expected mid-July; revision by Sept 1.
- **FY15/16 activities (Phase 2)**
  - Continued evaluation and characterization of potential expedition sites
  - Development / refinement of operational, logistical and science plans
  - Initiation of permitting activities
  - Readiness of pressure coring and core analysis tools must be confirmed
  - Phase 2 costs ~$8.5M (~ $7.1M DOE)
- **FY17+ (Phase 3) activities: drilling/coring at GoM sites**
  - new exploration at high-potential sites
  - sample acquisition at sites discovered by JIP Leg (2009)
  - ~$30 million needed (as project contribution to the expedition).
  - Large IODP "contribution" to the project (50% of standard IODP ship costs = ~$6 million)…

IODP Proposal Cover Sheet

GOM^2 ("GOM Squared")

3 - Cpp a

Title	Genesis of Methane Hydrate in Coarse-Grained Systems: Northern Gulf of Mexico Slope
Proponents	P. Flemings, T. Collett, F. Colwell, A. Cook, D. Divins, D. Goldberg, G. Guerin, A. Malinverno, D. Sawyer, E. Solomon, D. Sawyer,
Keywords	Methane Hydrates, Gulf of Mexico
Area	Gulf of Mexico

Contact Information

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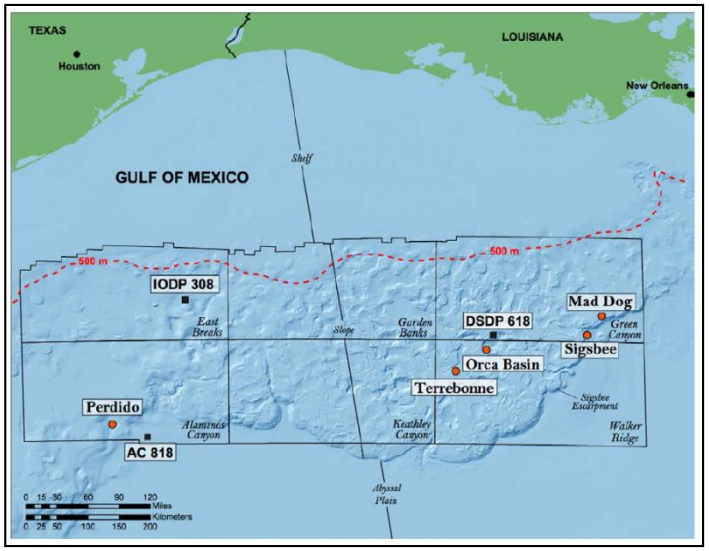
E-mail:	pflemings@jsg.utexas.edu		



UT-Austin: Status of Coring and Analysis Tools

- **DOE pressure coring system (originally developed under Chevron JIP) transferred to the UT project**
  - Service van with pressure coring tools at Aumann and Associates undergoing lab testing of recent fixes / upgrades to the tool. Lab testing nearing completion, successful to date.
  - Land Testing of system planned for Schlumberger Cameron site (Q1 FY2016)
  - Sea Test of system planned for ~3Q FY2016
  - very similar tools being deployed on NGHP-02.
- **DOE core analysis tools (PCCT)**
  - Original tools completed under Chevron JIP by GT
  - Used / tested in collaboration with Japanese hydrate program in 2013.
  - Temporarily assigned to another DOE / GT research effort
  - Current tools being transferred to USGS in FY15 for continued use / upgrade.
  - New versions of the tools (and / or complementary tools) being considered (NETL?, UT?. Other?)
  - Focus on assuring tool readiness and accessibility for UT project Phase 3

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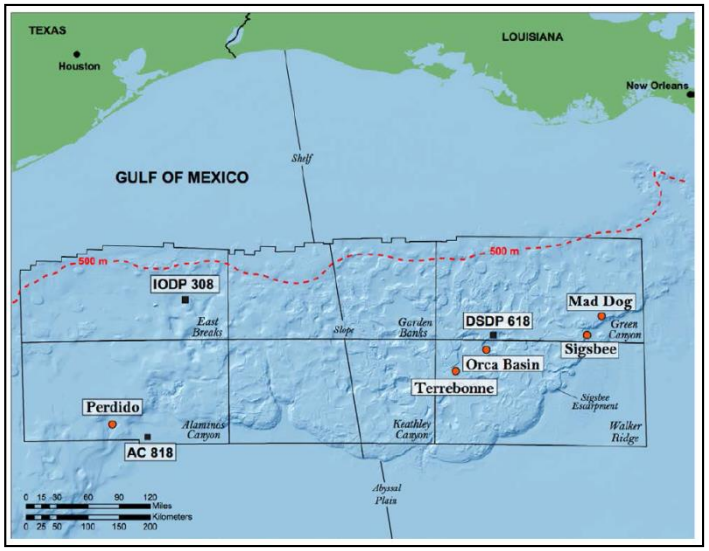


Arctic Gas Hydrate Update

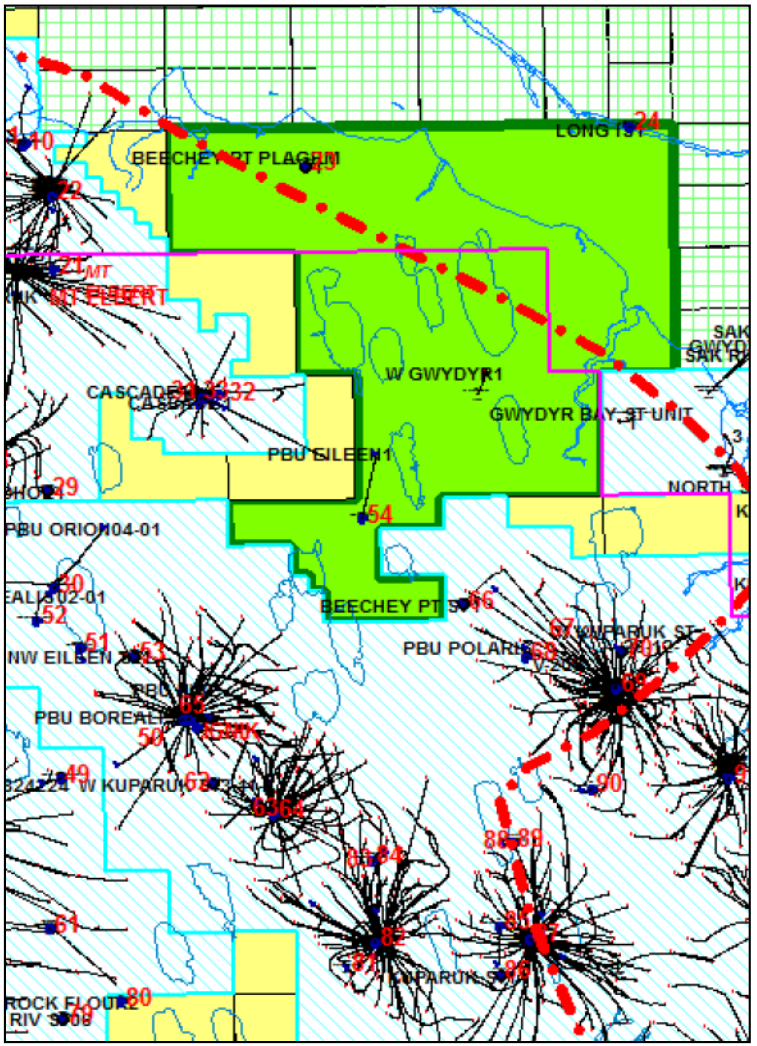
- **Long-Term Scientific Gas Hydrate Production Test remains a prime goal**
  - Also a long-standing goal of the Japanese Program and of the State of Alaska
  - Alaska is the only place on Earth where such a test can feasibly occur
  - DOE and METI (Japan) signed an SOI in 2008 (renewed indefinitely in 2011)
- **Collaboration with Industry (2001-2012)**
  - DOE FOAs generated Projects with BP and ConocoPhillips that leveraged data and facilities within the Prudhoe Bay field
  - 2011/12: industry perspectives change and further opportunities within the leased areas are (temporarily) no longer viable
- **State of Alaska offers a solution**
  - 2013: DOE and SOA sign an MOU. SOA sets aside unleased lands *that can only be accessed through collaboration with the US Gov.*
  - 2014: DOE FOA gets no workable response due to loss of operating partner
  - 2014: JOGMEC/NETL sign an MoU to enable progress on testing

Alaska Testing Program Status

Goal: Long-term test of hydrate producibility

- **Plan A: Conduct test in PBU**
  - requires access to site
  - efforts with Bp and CP lead to focused field programs of a temporary nature.
  - 2010 long-term test proposal derailed
  - subsequently, PBU operators have been unsupportive
  - continued engagement

- **Plan B: Conduct test on unleased land**
  - AK DNR MoU: set-aside leases until their value as test sites can be determined
  - JOGMEC / NETL MoU – partnership on AK
  - G&G evaluation ongoing (JOGMEC, USGS, DOE)
  - cost/logistics/operational/regulatory/NEPA evaluations ongoing.
  - end of July determination expected



Alaska Testing Program Review

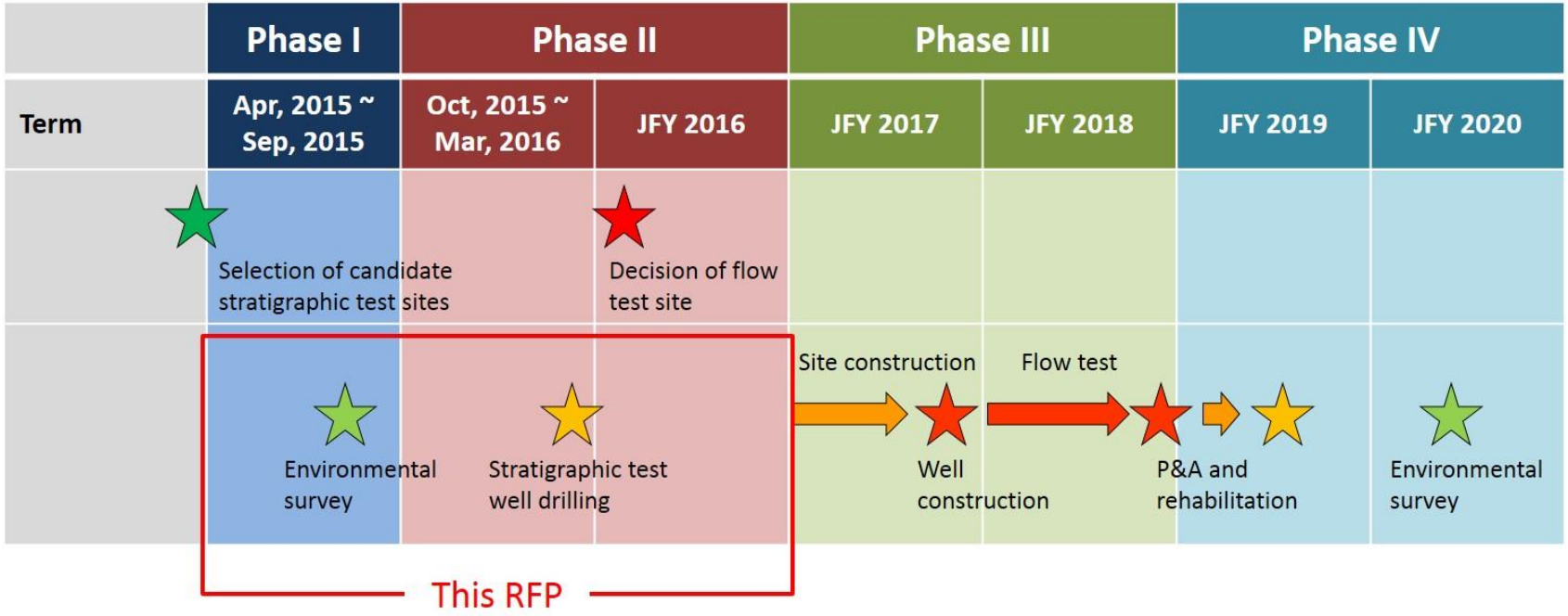
Non-Budgetary Issues

- **Geologic/Geophysical Review: Are viable sites present?**
  - Japan review meeting – review ongoing; sites as compelling as those known to exist in the producing units is unlikely.

- **Is a test logistically feasible at the sites?**
  - High costs? Roads, Pads, Operations (water disposal, etc.)… Year-round operations?
  - This is subject of the work recently initiated by PRA (separate JOGMEC and (pending) NETL agreements). Findings TBD.

- **Will an operator be needed? Will an operator be found?**
  - PRA could "operate" -- IF someone indemnifies them…. SOA knows that it may need to clarify or adjust the liability issues for an operation (R&D) of this type, if it can.
  - Remains unclear; ongoing discussions with AK DNR; meeting with ExxonMobil
  - General view has been that a plan is needed to engage operators (in lieu of strong top-down direction).

JOGMEC's Alaska Plan



RFP has two phases; Strat tests (2 or 3 sites) are in second Phase.

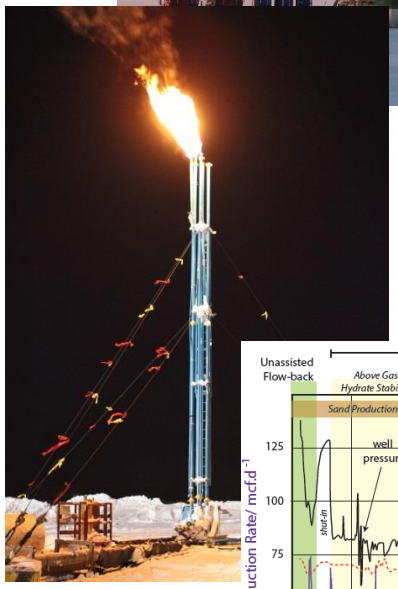
Second RFP (JOGMEC or DOE) could support Phase III/IV. Or Phases II, III, and IV….

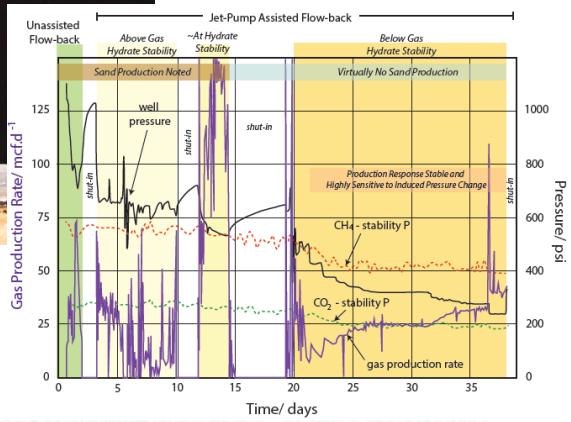
DOE is prepared to co-fund the studies within the JOGMEC SOW with the selected company.

Arctic Program - Results

Evaluation of CoP Iġnik Sikumi Data

- **Test conducted during 2011 / 2012**
  - Conducted from ice pad adjacent to PBU L-Pad
  - Huff-N- Puff type test from single vertical well
  - 14 days CO_2/N_2 injection, 1.5 days flow back above CH_4 hydrate stability, ~30 day pump assisted flow back below pure CH_4 hydrate stability pressure
  - First field test of GH response to injection of CO_2/N_2
  - Longest duration test (to date) of GH response to depressurization
- **Initial Interpretation of results from field trial documented in ICGH papers and summarized in FITI article (primary findings)**
  - N_2-CO_2-CH_4 exchange possible in natural GH reservoir
  - Reservoir free H_2O can limit success of pure CO_2 injection, but injection of carefully designed gas mixture can be effective
  - Wells require careful planning for rapid blockage remediation during any stops in operation
  - Solids production can be managed through standard engineering controls
  - Reservoir heat exchange during depressurization more favorable than expected (allow more aggressive pressure reduction?)
  - Field confirmation that GH destabilization is strongly self limiting





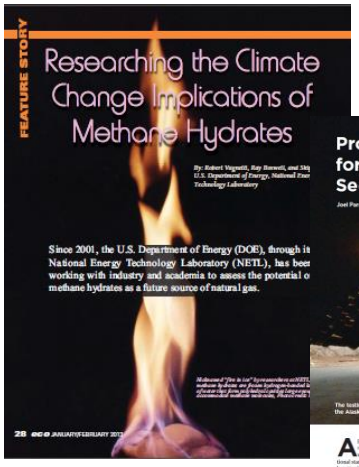
Other Items of Note

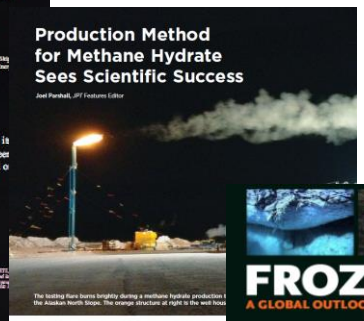
- **Global Environment**
  - Ongoing projects within the portfolio continue to investigate methane flux in climate sensitive areas and potential links to, and impacts on GH (sample of recent and forthcoming field activity)
    - Oregon State – samples collected at Svalbard margin (Norway) in October 2014, additional collection planned for summer 2015 as part of the effort to assess the response of GH to environmental changes in that region
    - U Washington – Completed sampling of the Cascadia Margin(off the coast of Washington) in November 2014 as part of investigation of the effects of contemporary bottom-water warming on GH stability in that area
    - Scripps – CSEM data collected in summer 2014, additional data to be collected in summer 2015 as part of investigation seeking to determine the extent of remaining offshore permafrost and potential GH stability conditions on the shallow-water U.S. Beaufort inner shelf.
    - Southern Methodist University / USGS – plan to collect data off the Atlantic cost in FY2015 and offshore AK in FY2016 to characterize the state of the upper boundary of pressures and temperatures where GH are in a stable form on the US continental slope
- **Outreach**
  - United Nations Environment Program released a new report (supported in part by DOE) "Frozen Heat, A Global Outlook and Methane Gas Hydrates
    - Comprehensive review of GH science and technology and discussion of potential GH role in the environment and global energy mix
    - Intended for policy makers, general public and other stakeholders
    - Developed with strong contribution from GH scientific community
    - Consists of 1) executive summary, 2) Volume 1 - review of GH in nature and 3) Volume 2 – potential significance of GH as an energy resource
  - Other outreach efforts continue

Outreach


MARINE AND PETROLEUM GEOLOGY
Thematic Set on
Guest Editors
Timothy S. Collett
Ray Boswell
Guest Editors
Ray Boswell
Tim Collett
Brion Anderson
Guest Editors
Carolyn Ruppel
Ray Boswell
Emrys Jones

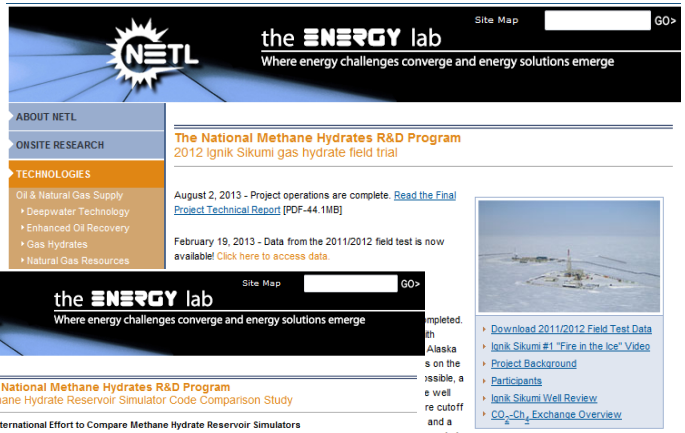

the ENERGY lab
Fire in the Ice
Vol. 9, Iss. 3
Methane Hydrate Newsletter
NETL
Joint Industry Project Leg II Discovers Rich Gas Hydrate Accumulations in Sand Reservoirs in the Gulf of Mexico
Ray Boswell, Tim Collett, Dan McConnell, Matt Frye, Bill Shedd, Stefan Mrozewski,
the ENERGY lab
Fire in the Ice
2013 Vol. 13, Issue 2
Methane Hydrate Newsletter
NETL
JAPAN COMPLETES FIRST OFFSHORE METHANE HYDRATE PRODUCTION TEST—METHANE SUCCESSFULLY PRODUCED FROM DEEPWATER HYDRATE LAYERS
CONTENTS
Japan Completes First Offshore Production Test 1
To prove the applicability of depressurization as a feasible method for producing methane from hydrates in deepwater sediments, Japan Oil, Gas, and Metals National Corporation (JOGMEC) conducted the first offshore methane hydrate production test off the coast of Honshu Island this past March, with funding from the Ministry of Economic Trade and


FEATURE STORY
Researching the Climate Change Implications of Methane Hydrates
Since 2001, the U.S. Department of Energy (DOE), through it
National Energy Technology Laboratory (NETL), has bee
working with industry and academia to assess the potential o
methane hydrates as a future source of natural gas.


Production Method for Methane Hydrate Sees Scientific Success
Joel Parshall, JPT Features Editor


FROZEN HEAT
A GLOBAL OUTLOOK ON METHANE GAS HYDRATES
UNEP
GRID


OFFSHORE
TECHNOLOGY CONFERENCE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Where energy challenges converge and energy solutions emerge
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Oil & Natural Gas Supply
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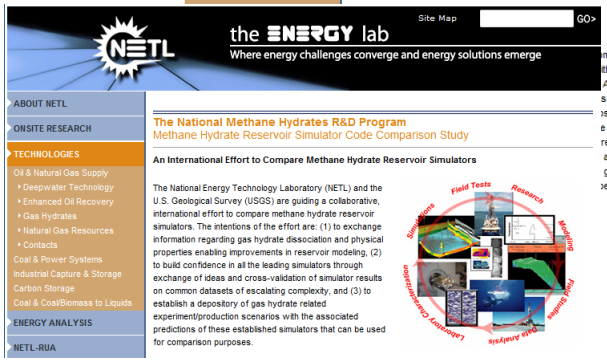
Enhanced Oil Recovery
Gas Hydrates
Natural Gas Resources
The National Methane Hydrates R&D Program
2012 Ignik Sikumi gas hydrate field trial
August 2, 2013 - Project operations are complete. Read the Final Project Technical Report [PDF-44.1MB]
February 19, 2013 - Data from the 2011/2012 field test is now available! Click here to access data.
Download 2011/2012 Field Test Data
Ignik Sikumi #1 "Fire in the Ice" Video
Project Background
Participants
Ignik Sikumi Well Review
CO2-CH4 Exchange Overview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ENERGY ANALYSIS
NETL-RUA
The National Methane Hydrates R&D Program
Methane Hydrate Reservoir Simulator Code Comparison Study
An International Effort to Compare Methane Hydrate Reservoir Simulators
The National Energy Technology Laboratory (NETL) and the U.S. Geological Survey (USGS) are guiding a collaborative, international effort to compare methane hydrate reservoir simulators. The intentions of the effort are: (1) to exchange information regarding gas hydrate dissociation and physical properties enabling improvements in reservoir modeling, (2) to build confidence in all the leading simulators through exchange of ideas and cross-validation of simulator results on common datasets of escalating complexity, and (3) to establish a depository of gas hydrate related experiment/production scenarios with the associated predictions of these established simulators that can be used for comparison purposes.
Field Tests
Research
Modeling
Field Studies
Laboratory Characterization
Basic Analysis
Simulations

Summary

Current State of the Gas Hydrate R&D Program

- **US Marine gas hydrate exploration**
  - Chevron project ended in March, 2014. Prospects for further industry support for marine programs are dim.
  - DOE gauging/developing interest in Academic and Service companies via CAs with COL and Fugro.
  - COL in, collaboration with R&D community, developed content informing goals in a "scientific drilling" context
  - DOE solicited research for marine hydrate field exploration and characterization and selected a proposal led by U. Texas (Flemings) with COL, Ohio State, LDEO late in FY2014.
  - New project with UT-Austin designed to advance marine resource evaluation. Field programs target opportunities to access the JR via CPP process and are nominally set for FY17 or 18.
  - Initial site evaluation and science planning complete and included in submission of IODP CPP proposal (decision anticipated by early September 2015)
  - JIP Sites provide opportunities for further scientific evaluation via sampling and analysis and new sites hold significant potential (including proximity to existing infrastructure)
  - Finalizing and testing pressure coring and core analysis devices is a critical path element

Summary (continued)

Current State of the Gas Hydrate R&D Program

- **US Arctic testing programs**
  - The dynamics of working with Industry are constantly shifting.
  - No recent interest from industry in the support of activities on the ANS.
  - Actively working with Japan and the State of Alaska to evaluate potential of proximal-to-PBU acreage made available by SOA for long term testing. Many challenges.
  - JOGMEC initiated contract with PRA to provide engineering support / logistical evaluation of potential ANS sites in set-aside lands including planning for potential Stratigraphic test wells at up to 3 locations in winter season of 2016 or 2017
  - DOE support for these and complementary PRA activities is in the works.
  - ConocoPhillips/JOGMEC exchange test data evaluation underway. Initial findings reported at ICGH
  - Exchange technology as a possible component of future production systems, but the foundation of future tests remains depressurization.
- **Efforts related to GH-GCC linkages continue to progress and collect critical field and laboratory data**
- **Program science and technology development efforts (related to exploration and potential production) continue through support of various numerical simulation and laboratory analyses**
- **Critical efforts of outreach and international collaboration continue**