

AN INTERAGENCY FIVE-YEAR PLAN FOR METHANE HYDRATE RESEARCH AND DEVELOPMENT FY2007-FY2011



Prepared By

**The Technical Coordination Team
of the National Methane Hydrate R&D Program**

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An Interagency Five-Year Plan for Methane Hydrate Research and Development

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This document compliments an earlier *Interagency Roadmap for Methane Hydrate Research and Development (2006)*. The Roadmap can be found on the Office of Fossil Energy's website at http://www.fe.doe.gov/programs/oilgas/publications/methane_hydrates/mh_interagency_plan.pdf

1.0 Executive Summary

An Interagency Five-Year Plan for Methane Hydrate Research and Development is a joint effort of representatives of seven federal agencies: the U.S. Department of Energy (DOE), the U.S. Geological Survey (USGS), the Minerals Management Service (MMS), the Bureau of Land Management (BLM), the Naval Research Laboratory (NRL), the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). This document outlines near-term research priorities and a set of performance milestones designed to enable measurement of program progress relative to the goals of the Methane Hydrate Research and Development Act of 2000 (the MHR&D Act), as amended in Section 968 of Public Law 109-58, 30 USC 1902 (The Energy Policy Act of 2005). This 5-year plan is set within the context established by *An Interagency Roadmap for Methane Hydrate Research and Development* (2006) that set long-term (through 2025) goals for the program and described the overall nature, scale and progression of R&D activities necessary to meet those goals.

The Fiscal Year 2007 through 2011 R&D activities and milestones set forth in this document are designed to ensure that U.S. gas hydrate science moves forward at a pace necessary to meet the program's key long-range goals. In accordance with the MHR&D Act, the program's goals are wide ranging, with particular focus on demonstrating the technical and economic viability of methane recovery from gas hydrate deposits. The program will achieve this goal through the integrated development of the following: geologic and geochemical models of gas hydrate occurrence, validated exploration tools, numerical simulation capability, specially-tailored drilling and completion technologies, and applied reservoir engineering to maximize the efficiency and safety of production methods. Primary near term milestones to meeting this goal include 1) the establishment of the first of a series of long-term production testing programs on the North Slope of Alaska, and 2) the initiation of multi-well exploration and assessment studies within the Gulf of Mexico to test different models of gas hydrate occurrence and the ability of remote sensing technologies to accurately identify and characterize natural accumulations. In pursuing these goals, the program will aggressively seek out

opportunities to leverage, and collaborate with, all interested international R&D programs.

The program will also pursue its long-term goals to assess 1) the role of gas hydrate in global environmental systems such as carbon cycling, global climate, and sea-floor stability and 2) the potential for, and impacts of, degassing resulting from either ongoing “conventional” oil and gas exploration and production (E&P) activities or future gas hydrate production activities. Included in these possible impacts are land or seafloor surface subsidence, disturbance of permafrost, negative impacts on sensitive deepsea environments, and release of gaseous methane that may find its way into the atmosphere. The program recognizes that defining, and designing effective mitigations for, any potential environmental impacts is a true prerequisite to large-scale commercial production. Primary near term milestones in meeting these goals includes increased support for ocean-bottom observatories, support for new field and modeling studies to better determine the flux and fate of methane from marine and permafrost environments, and the leveraging of future resource-related field programs for monitoring the impact of drilling and production perturbations on natural gas hydrate systems.

The program will continue to emphasize sound management practices, including extensive interagency communication, public outreach, and the use of external merit-based peer review of potential and ongoing projects. The program will seek out opportunities to support, collaborate with, and leverage the data-collection opportunities provided by, international gas hydrate research and development programs. Finally, the program will place a strong emphasis on providing educational and training opportunities for future generations of energy scientists.

2.0 Background

2.1 Program Philosophy

The Department of Energy (DOE) will work with collaborating agencies, public and private research partners, and interested international entities to achieve the goals of the Methane Hydrate Research and Development Act (MHR&D Act) of 2005. These goals, and the general nature of R&D activities required to reach them, have been outlined in a preceding Interagency Roadmap for Methane Hydrate Research and Development (Technical Coordination Team, 2006).

To maintain progress towards reaching these goals, the program's highest priorities in the near term will be as follows: 1) to establish the first of a series of long-term production tests on the North Slope of Alaska that will enable the program to determine the response of natural accumulations of varying nature to a range of alternative potential production methods; and 2) to conduct the first of a series of multi-well drilling and evaluation expeditions within the Gulf of Mexico to assess both the scale and nature of the gas hydrate resource and the technologies for pre-drill prospect identification and characterization through remote sensing. These two priorities are designed in order to provide answers to the two following questions as quickly as possible: 1) is production from naturally-occurring gas hydrates economically feasible in certain settings? and 2) does gas hydrate occur in the abundance and nature sufficient to provide the meaningful longer-term resource potential?

In the near term, the DOE expects these two goals to be pursued primarily within the existing cooperative agreements with BP (focused on permafrost issues) and the Chevron JIP (focused on the Gulf of Mexico). These efforts will continue to be supported by focused activities that tap unique talents and equipment within the DOE National Laboratories and in collaborating federal agencies. Funding for these supporting efforts will be directed primarily to those organizations producing the highest impact studies as determined through regular scientific peer review.

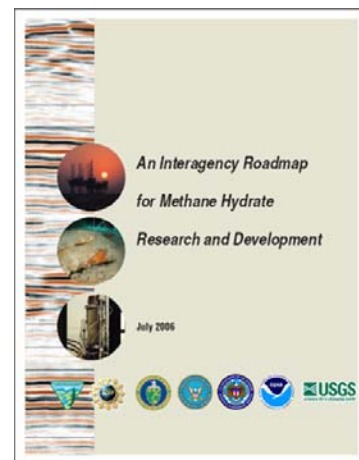
A second priority for the program in the near term will be to continue to advance our understanding of gas hydrate's role in the natural environment. In this regard, the program will refocus its efforts toward 1) supporting the most promising efforts to establish ocean-bottom observatories, 2) identifying and supporting promising new field and modeling studies to better determine the flux and fate of methane from marine and permafrost environments, and 3) leveraging opportunities within existing production-focused field efforts to monitor the impact of drilling and production perturbations on natural gas hydrate systems.

Both of these primary research priorities will be supported through ongoing studies within 11 additional existing cooperative agreements (CAs) selected during competitive solicitations offered in FY2005 and FY2006. The merits and contribution of these projects to the program's critical goals will be regularly evaluated through external merit reviews, the first of which to be held in the Fall of 2007. Regardless of available funding, the DOE will not continue projects that are deemed to be providing minimal benefits. The need for the addition of new projects will be determined through periodic public workshops designed to identify the key remaining R&D and data gaps. As was the case with all the existing CAs, all new projects will be selected through a competitive process incorporating external merit review and will contain internal decision points that can be used as opportunities to modify project scope to maximize impact, or to terminate projects that are deemed underperforming or no longer relevant.

This Five-Year Plan assumes that appropriations not significantly different from the authorizations of the MHR&D plan will be available over the near term. If future appropriations deviate significantly from these levels, this plan, as well as the program portfolio, will be re-evaluated. DOE would conduct this re-evaluation through consultation within the existing interagency working groups, and would also provide the gas hydrates research community and other interested stakeholders a full opportunity to provide input through open public meetings.

2.2 The Interagency Roadmap and the Interagency Five-Year Plan

R&D plans for the DOE-led interagency program are developed through discussion within two interagency working groups (see Appendix A) that include representatives of seven federal agencies concerned with naturally-occurring gas hydrates: the DOE, the U.S. Geological Survey (USGS), the Minerals Management Service (MMS), the Bureau of Land Management (BLM), the National Science Foundation (NSF), the Naval Research Laboratory (NRL), and the National Oceanic and Atmospheric Administration (NOAA). The Interagency Coordination Committee (ICC) consists of program managers and other high-level officials and is responsible for communication of the overall mission and focus of each agency. Coordination of events in the field and technical collaboration occurs within the Technical Coordination Team (TCT), consisting of field scientists and those responsible for program implementation.



*The 2006 Interagency Roadmap
(Technical Coordination Team)*

In 2006, the ICC asked the TCT to develop *An Interagency Roadmap for Methane Hydrate Research and Development* (the “Roadmap”). That document was designed to obtain and describe a general consensus within the collaborating federal agencies as to the general nature and progression of R&D activities through year 2025 that would be needed to achieve the stated goals of the Methane Hydrate Research and Development Act of 2000 (MHR&D Act; as modified and extended by the Energy Policy Act of 2005).

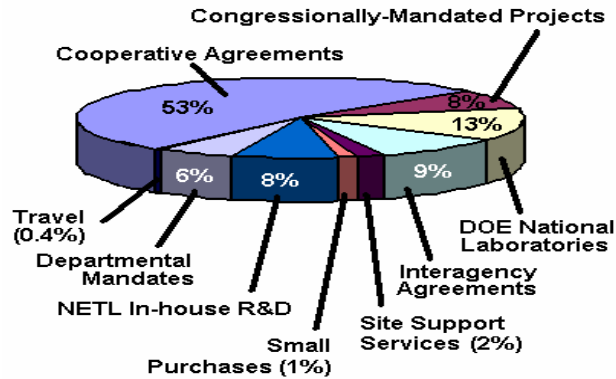
Like the earlier Roadmap, this “Interagency Five-year Plan” was developed by the members of the TCT at the request of the ICC. The purpose of this five-year plan is to detail the near-term R&D activities that are necessary to move the program efficiently toward the long-term goals laid out in the Roadmap. Together, these plans are designed to achieve three purposes: 1) align long-range and near term R&D activities within the collaborating agencies; 2) provide a document for communication of program goals and

areas of research emphasis to the broader national and international research community; and 3) provide information to the Methane Hydrates Federal Advisory Committee (FAC, see Appendix B) in support of an evaluation that the FAC is required to submit to Congress by August 2007 on the adequacy of the program’s five-year research plans.

2.3 Past Program Funding

This Interagency plan and in general, the overall “Interagency R&D effort” refers to the total federal effort related to goals of the MHR&D Act. A primary component of that effort is the R&D program accomplished using funding provided to the DOE. As directed by the MHR&D Act, the DOE actively collaborates with the other participating federal agencies to help assure that the DOE funded work takes full advantage of, and does not unnecessarily duplicate, work being accomplished within the other agencies using their own budget allocations. Over the past seven years, the level and ultimate allocation of DOE-directed funds for this program over the past seven years is shown below: the distribution of funding for 2006 is shown in the pie chart to the right.

2000:	\$2,900,000
2001:	\$9,900,000
2002:	\$9,800,000
2003:	\$9,400,000
2004:	\$9,000,000
2005:	\$9,400,000
2006:	\$11,880,000
2007:	\$12,000,000



The allocation of DOE’s FY2006 funding. The funding through cooperative agreements (competitively-awarded projects with industry and academia) totaled 53% of all funding. Non-competitive funding totaled 37% of all allocations, including congressional mandates (earmarks), funded Field Work Proposals with National Labs, agreements with other federal agencies (USGS, NRL, and NIST), and projects within NETL. Project support activities, such as travel, and funding for NETL (site-support) and DOE HQ (departmental mandates) support services accounted for the remaining 10% of all allocations.

2.4 Key Planning Assumptions

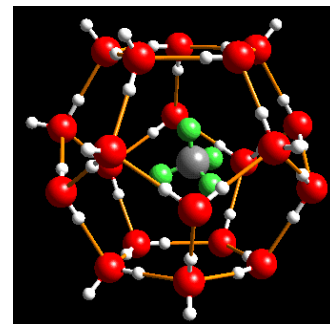
Using guidance from the ICC, the 2006 Interagency Roadmap was not limited by historical or anticipated funding levels. Instead, the goal was to describe what

progression of R&D activities would be needed to achieve the goals of the MHR&D Act. Similarly, the interagency Five-year Plan describes activities that would be pursued assuming funding consistent with the existing authorization (totaling \$150 million over the period FY2006 through FY2010). Also, this Five-year plan follows the Interagency Roadmap in preferring continued alignment of major field-based R&D activities with industry to the extent possible, but similarly realizes the necessity of considering options for direct coordination with state and federal agencies, as well as other nations, that offer opportunities to accelerate the achievement of critical milestones.

2.5 Program Drivers

Gas hydrate is an abundant natural form of clathrate, a unique chemical substance in which molecules of one material (e.g., water) form an open solid lattice that encloses, without chemical bonding, appropriately-sized molecules

of another material (e.g., methane and related gases). Surveys conducted around the world's coastal oceans demonstrate that methane is the dominant gas contained in gas hydrates. Research during the past two decades has revealed that gas hydrates exist both as a void-filling material within shallow sediments (both onshore in the Arctic and within deep-water continental margins) and as massive "mounds" (often in association with unique chemosynthetic biota) on the deep sea floor. Once thought to be relatively rare in nature, gas hydrates are now widely considered to store immense volumes of organic carbon, rivaling, if not exceeding, the amount remaining in all the world's oil, natural gas, and coal deposits combined. A major driver for the U.S. program, and for a number of growing economies worldwide that currently rely on foreign energy sources, is the desire to determine, and then realize, the energy supply potential of gas hydrates.



Model of methane hydrate's cage-like structure in which methane (green/gray molecules) are enclosed - without direct chemical bonding - in voids within a solid water lattice (red/white molecules) (Heriot-Watt U.)

In addition to being a potential energy resource, gas hydrates represent a highly dynamic and poorly-understood component of the natural environment. It is apparent now that this global methane reservoir is in constant flux, absorbing and releasing gas as it continually equilibrates to natural (and potentially man-made) perturbations in pressure, temperature and geochemical regimes. Understanding the behavior and implications of this previously unrecognized component of the natural environment on the carbon cycle, long-term climate, and seafloor stability is an additional critical component of the Interagency R&D program in methane hydrates.

2.6 The Federal Role

The federal government has a recognized role in addressing opportunities to catalyze long-range R&D with the potential to significantly promote the public good. To date, industry has clearly determined that R&D on the resource potential of gas hydrates is too high-risk or too long-term to justify investment. Instead, industry has elected to invest in gas hydrates R&D only to address issues that impact their core business – primarily safety concerns related to 1) secondary gas hydrate formation within pipelines and production equipment and 2) in strata that must be drilled through to reach deeper target horizons. In contrast, a growing number of foreign governments, lead by Japan and India, but also including Korea, China, and Malaysia, are conducting gas hydrates R&D at scales that match or exceed the level of the U.S. investment.

The benefits of a successful federal program to study the resource potential and environmental implications of naturally-occurring gas hydrates includes; 1) increased assurance of the long-term sustainability of natural gas supply, with enormous ramifications for the nation's economy and energy security, as well as the global balance of energy supply; 2) an improved understanding of our natural environment, providing significant benefits through more informed decision-making on a wide variety of issues including from ocean policy and global climate change; and 3) continuation of the nation's role as a leader in fundamental scientific research and in the development of the information and technology that would support a future gas hydrates industry.

2.7 Program Long-Range Goals

As described in the Roadmap, the long-term goals of the program are to develop a comprehensive knowledge base and suite of tools/technologies that will enable 1) safe and economic methane production from hydrates while minimizing environmental impacts and 2) full integration of gas hydrate science into our understanding of global environmental and climate processes.

The program's primary goal for the next five years is to determine whether gas hydrates have significant potential as a future energy resource by:

- conducting a long-term production testing program on the North Slope of Alaska (to begin by 2008); and
- initiate (by 2010) a large-scale, multi-well exploration and assessment program in the Gulf of Mexico in collaboration with industry and interested international partners that will result in a marine production test.

As described in the Roadmap, the program's goals for year 2015 are as follows:

- conduct additional sampling, analyses, and testing to assess the economic feasibility of Arctic gas hydrate development and production;
- demonstrate viable technologies to assess and mitigate the environmental risks related to unintended gas hydrate dissociation related to ongoing "conventional" oil and gas E&P activities; and
- document the risks and demonstrate viable mitigation strategies related to safe drilling in gas hydrate-bearing areas;

The goals for year 2025 are as follows:

- conduct the necessary demonstrate the technical recoverability and assess the economic recoverability of marine gas hydrates;

- document the potential for and impact of natural gas hydrate degassing on the environment, including carbon cycling and climate change; and
- assess the potential to further extend marine gas hydrate recoverability beyond the initial producible areas.

Chapter 4 of this report outlines the specific near-term (5-year) accomplishments that the interagency Technical Coordination Team feels are necessary to keep the program on the course to accomplishing these goals.

2.8 Interagency Collaboration

In implementing this Five-year R&D plan, the DOE will continue to foster a true spirit of interagency involvement in the R&D activities conducted under the authority of the MHR&D Act. Representatives of the DOE, USGS, MMS, NOAA, BLM, NSF, and NRL will continue to meet at least twice per year, through both the ICC and the TCT, to discuss research activities and priorities. DOE will also continue to pursue a number of recent initiatives to further interagency communication and improve program effectiveness, including the incorporation of technical experts from the collaborating agencies into program planning and evaluation (merit reviews), the selection of fellowship awardees, and review of new project proposals. Active scientific collaboration will also continue, including: 1) the co-funding of projects of mutual interest, including IODP and critical international ventures; 2) the communication and incorporation of research results into our respective programs; and 3) direct funding to fellow agencies to tap into unique capabilities.

2.9 International Collaboration

The participants in the DOE-led interagency effort understand the outstanding value and contributions that collaboration with international gas hydrate R&D efforts can provide to our national R&D program. In particular, the USGS and the NRL have done exceptional work in building U.S.-International scientific collaboration in gas hydrates. The DOE-led interagency program will continue to build on this foundation through support of cooperative efforts with foreign R&D programs and researchers when meaningful

opportunities arise. The agencies will also enable, to the extent possible and practical, opportunities for foreign parties to observe and participate in domestic gas hydrate programs. In the near-term, the USGS and the DOE will work to build on the great success of the recent exploration program conducted by the Indian government, and will encourage cooperative post-cruise studies that seek to integrate the findings of that expedition into the



Indian and U.S. Scientists collaborate aboard the Joides Resolution during NGHP (India) Expedition 01, summer 2006.

existing body of gas hydrate knowledge. In addition, international collaborations initiated by NRL and DOE with New Zealand and Chile are expected to continue, and new collaborations with additional countries will be explored. The agencies will similarly look to expand collaborative opportunities with Japan, and will continue to nurture ties built through cooperative ventures such as Mallik 2002 and an ongoing collaborative effort (with DOE, USGS, and others) to compare gas hydrate reservoir simulators. The program will also work to assure the success of the international database effort being conducted in association with CODATA.

The program will also look to expand its interaction and collaboration with leading international working groups such as the United Nations Framework Conventional on Climate Change, the Intergovernmental Panel on Climate Change and others. DOE will continue its interaction with international organizations such as the Asia Pacific Economic Cooperation Forum (APEC), and the North American Energy Working Group (NAEWG) that have, in the past, included gas hydrates within their areas of interest. To help accomplish these linkages, the TCT will plan to establish a sub-working group of interested individuals to pursue these opportunities.

2.10 External Scientific Oversight and Review

In both 2005 and 2006, the DOE actively incorporated external scientific oversight into its program management through merit reviews of selected ongoing projects, external review of proposals for new projects under DOE solicitations, and ongoing consultation with the interagency committees and the Federal Advisory Committee (see Appendix B). This input has been extremely valuable, and the program will continue to solicit and carefully consider this input. Notably, an external merit review of the full program portfolio is expected for the fall of 2007 and will be accomplished biannually thereafter.

2.11 Ensuring Information Availability

Critical to a collaborative effort such as the national methane hydrate R&D program is the efficient dissemination of information. The DOE will continue to ensure that its researchers and research partners share research results through publication in peer-reviewed journals and regular participation in professional conferences and planning workshops. To further encourage wider data availability, the DOE signed (in 2006) an Interagency Agreement with the Department of Commerce's National Institutes for Standards and Technology (NIST) to develop a searchable, web-based gas hydrates database in association with the international CODATA gas hydrates effort. Going forward, the DOE will work with its research partners to ensure that research findings are available through this international database. An additional avenue for information exchange will be the continued quarterly publication of the DOE's electronic newsletter, *Fire in the Ice*, as well as regular maintenance of the program's web sites including latest project status and downloadable copies of all federally-funded reports and products.



2.12 Public Outreach

Essential to the ultimate achievement of the resource-related goals of this program will be the acceptance and understanding of the public. Although initial gas hydrate-derived resources may come from established oil and gas production areas (Alaska, the Gulf of

Mexico), full realization of gas hydrate’s resource potential may mean tapping areas that currently lack an industry presence. Furthermore, gas hydrates have an uncertain association with past episodes of rapid climate change, raising concerns over the behavior of gas hydrate bearing sediments during potential methane extraction. Therefore, the program will actively search for ways to responsibly address these topics and to fully share the facts as they emerge on issues of rightful concern to the public. To improve the availability of information on gas hydrates to those outside the scientific community, the DOE will work with the collaborating agencies to 1) provide through its websites (and promote the existence of) information, graphics, videos, and other materials in a format designed for use by educators (K to 12) on gas hydrate-related issues; 2) conduct a series of public lectures, symposia, and/or prepared articles for the non-technical press on the findings and implications of gas hydrate science; and 3) explore other activities that expand the awareness and understanding of gas hydrate issues and potential.

2.13 Providing Educational and Training Opportunities for New Scientists

Over the past five years, universities have played a major role in the program, both in support to the program’s industry-led field projects, as well as in individual competitively-awarded R&D projects. The DOE and the collaborating agencies will continue to expand this commitment to providing educational and training opportunities to the next generation of energy scientists. Furthermore, in FY2007, the DOE established a formal, competitive, merit-based program in cooperation with the National Academy of Sciences that will recognize and provide full support to at least two “National Methane Hydrate R&D Program Fellows” per year at either the graduate or post-doctoral level.



Ms. Monica Heintz of U. California-Santa Barbara was selected as the initial NETL-NAS National Methane hydrate R&D Program Fellow

3.0 Overview of the State and Needs of Gas Hydrates R&D

Gas hydrate science is now clearly dominated by its major field expeditions, with critical and important contributions continuing to be made in the lab, in the design of new and improved exploration and laboratory analysis tools, and in numerical simulation. The following is a very brief outline of the current status of research in several critical areas.

3.1 Field Production Tests

Since the Mallik production experiment in 2002, there has been a broad consensus in the gas hydrate scientific community that a long-term field production test is the most critical need in advancing gas hydrate science as it relates to resource issues. The Japanese government, in association with the government of Canada, is currently preparing for an extended production test at Mallik over the next two winter seasons



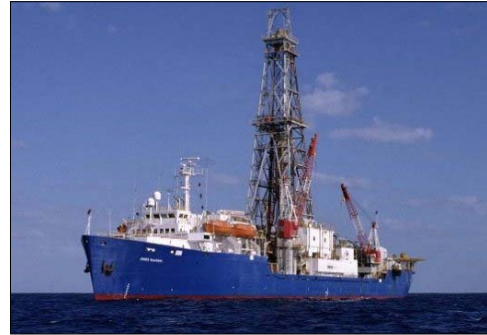
Mallik, Northwest Territories Canada, site of the Mallik 2002 Gas Hydrate Production Research Well Program

(2006/2007 and 2007/2008). Ongoing discussions with Japan will clarify the ability of the U.S. program to collaborate in this effort or to access its findings. In the U.S., a long-term and continuous production test is currently planned as part of the project with BP Exploration (Alaska), Inc, and should begin, with both BP and DOE approval, by FY2008. FY2009 is anticipated as the approximate date for an initial marine production test by the Indian government; extensive U.S. involvement (USGS and DOE) in that effort, when it occurs, is expected.

3.2 Major Field Programs

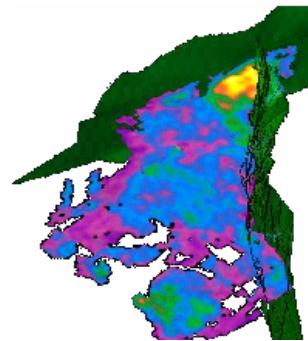
Although a number of comprehensive field studies have occurred in the past decade, the vast majority of potential global gas hydrate occurrences remain unsampled. In recent years, three seminal marine expeditions and two critical arctic field programs have occurred that will widely inform the near-term efforts of the program. The first marine

effort, in 2004, was the Integrated Ocean Drilling Program's (IODP) Expedition 311 (with major U.S. funding provided by NSF with contributions from the USGS and DOE) within the accretionary wedge offshore Vancouver Island. X311 (building on the ODPs earlier Leg 204 to "Hydrate Ridge") has greatly advanced the gas hydrate community's understanding of the primary controls on gas hydrate distribution in nature; including the importance of gas source, gas solubility, and the presence of suitable host lithologies and structures. The second expedition, conducted by the Chevron JIP in the Gulf of Mexico in 2005, probed drilling safety issues related to gas hydrate-bearing fine-grained sediments and provided the first ground-truthing of pre-drill estimates of gas hydrate occurrence from remote sensing data. The third, India's summer 2006 Expedition 01 (with major support by the USGS and additional contributions by DOE), collected an unprecedented volume of data and samples from a wide range of gas hydrate-bearing geologic environments.



The drillship Joides Resolution was the platform for ODP leg 204, IODP X311, and NGHP Expedition 01 (Ocean Drilling Ltd.)

In the Arctic, the 1998 and 2002 Mallik programs, accomplished the government of Japan through a broad international consortium, have provided an enormous wealth of data on the nature and behavior of gas-hydrate bearing sandstones. The DOE-USGS effort with BP Exploration (Alaska) at Milne Point early in 2007 has built significantly on the Mallik data, providing confirmation of exploration methods and extensive new data on gas hydrate reservoir petrophysics. A primary near-term goal of the program will be to fully integrate the findings of these expeditions into the existing body of knowledge to obtain a fuller view of the overall controls on hydrate occurrence in nature.



Seismic amplitude display of the fault-bounded "Mt. Elbert" gas hydrate prospect, Milne Pt. Alaska, (BPXA; USGS)

3.3 Exploration Tools

Currently, the most promising tool for remote detection and characterization of gas hydrate deposits, either in the permafrost or in the deep ocean, is the integration of acoustic data with existing (or newly acquired) well log data. In 2005 and 2006, BP, the USGS, and others demonstrated the ability to delineate and describe discrete accumulations of hydrate-bearing reservoir sandstones within the Milne Point region of the Alaska North Slope (ANS). The ability was confirmed with the successful drilling of the Mt. Elbert prospect in early 2007. In 2005, the Chevron Gulf of Mexico Joint Industry Project (JIP) demonstrated an ability to discern general trends of gas hydrate occurrence in the marine environment through advanced velocity analysis of existing 3-D seismic data. Currently, the JIP is working to determine its ability to delineate the extent of a known (observed in a borehole with a full log suite) gas hydrate-bearing sandstone through analysis of existing seismic data. Ongoing work with Stanford University and Rock Solid Images, Inc., is advancing the fundamental rock-physics models that are needed to reliably and consistently infer gas hydrate occurrence from acoustic data. A project with the University of Texas-Austin plans to build on the success of groups in Norway and elsewhere that demonstrate the ability of four-component ocean-bottom seismic data to improve remote sensing capabilities in gas hydrate detection and quantification. In addition to seismic data, DOE has recently awarded a contract to Baylor University to apply a promising electro-magnetic (EM) resistivity technology to deep water hydrate detection, and is also supporting EM work by other groups as part of the JIP activities. NRL, supported by DOE and ONRG, will continue working on preliminary gas hydrate site evaluations with a combination of seismic surveys, geochemical analyses of piston core porewaters, and heatflow probes. Going forward, the program will work to integrate these methods of detection into a full exploration system that integrates gas hydrate indicators derived from modeling of the relevant geologic, geochemical, and hydrologic systems.

3.4 Field Analysis Tools

Currently, the analyses of subsurface gas hydrate accumulations occur primarily through well logging and collection, handling, and analysis of conventional and pressure cores. Well logging technologies are currently well advanced, and based on the successes of Logging-while drilling (LWD) deployments in IODP Expedition 311, the Gulf of Mexico JIP, and India Expedition 01, future field projects will likely to make use of up-front LWD to efficiently screen sites and collect *in-situ* property data. Although LWD deployment is costly, its advantages over the difficult and time-consuming open-hole wireline logging are considerable. Among the technological improvements needed for more efficient LWD is a reliable sonic velocity tool. Conventional coring continues to rely heavily on technologies developed nearly two decades ago (IODP's Advanced Piston Coring (APC) and Extended Core Barrel (XCB) systems). Although these technologies work sufficiently well, recovery remains poor in non-cohesive sediments, and core quality degrades rapidly as formation stiffness increases. A major development from NGHP Expedition 01 is the significant increase in the reliability of pressure coring technologies. In particular, the HYACE Rotary Corer (HRC) performed very well and will likely be viewed by IODP and others as a reliable and fully-operational technology in certain geologic settings. Through the Chevron/DOE Gulf of Mexico JIP, the program will look to further extend the operational capabilities of pressure coring to include poorly-consolidated sands systems by developing a modified version of the Pressure Temperature Coring System (PTCS) first applied by the Japanese in the Nankai Trough with apparent great success.

With regard to sample analysis, recent work is showing that critical physical property measurements become unreliable with even minor sample disturbance. Therefore, tools for making measurements on pressure cores, including further development of Georgia Tech Integrated Pressure Testing Chamber (IPTC), will continue to be a program priority. Beyond pressure core analysis,



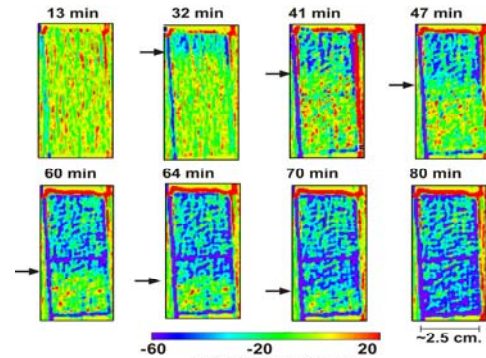
The IPTC is used to measure geophysical and mechanical properties of hydrate bearing cores under in situ pressures (Ga. Tech/Chevron JIP)

special emphasis within the JIP will be given to the development of tools that can be taken to the seafloor or downhole to measure gas hydrate-sediment characteristics *in situ*.

3.5 Laboratory Analyses

Gas hydrate research in the lab has made great advances, with several groups currently able to create samples and make meaningful property measurements. An external merit review of the ongoing activities in the National Labs (January 2006) provided several key recommendations that build upon the findings of an earlier workshop hosted by the USGS (August, 2005)

and were subsequently closely echoed in a recent workshop hosted by the Colorado School of Mines (September 2006). Implementation of recommendations for increased use of standards, incorporation of geomechanical issues, collection of measurements throughout samples (not simply on the surface), and focus on transient properties of gas hydrate-bearing porous media (rather than intrinsic properties of gas hydrate) will be a priority of the laboratory component of the program going forward. In addition, many laboratories continue to investigate the most appropriate gas hydrate-formation techniques. New methods will continue to be developed that more closely mimic both the process and the results obtained in specific natural settings, although it is recognized that the variety of natural processes and results is not yet fully known.



Progressive X-Ray CT Scans of hydrate dissociation in a porous media (LBNL)

3.6 Numerical Simulation

Numerical simulation will continue to be a critical component in the Interagency R&D program. Simulation capabilities will inform the selection, design, and analysis of results for both field and laboratory efforts. At present, several unique simulators exist, and the leading codes are participating in a comparison effort designed to reveal both their unique strengths and areas for further improvement. Completion of this effort, and the ultimate creation of a community-based, publicly-available code that contains the

scientific rigor and utility required for the evaluation of field gas hydrate occurrences, will be a major focus of the program.

4.0 Planned R&D Activities and Milestones by Long-Range Goal (2007-2011)

The following provides descriptions of the types of activities and areas of investigation planned for the next five years that are necessary to keep the program on track to achieve its long-term goals. In each section, proposed milestones are presented as a series of bulleted items with the initial date indicating the Fiscal Year in which the milestone is expected to be achieved. The parentheses that follow show the lead federal agencies addressing that issue.

4.1 Cross-cutting: Milestones Directly Supporting All Program Goals

Many activities within the program provide fundamental data or programmatic functions that will benefit the ultimate achievement of the program's primary R&D goals.

Key Cross-cutting Programmatic and Procedural Milestones

- 4.1.1 Ongoing:** Ensure that student researchers continue to have a meaningful role in the program's major projects and that funding policies enable universities and research institutions to attract and retain the best students (DOE, other agencies).
- 4.1.2 Quarterly:** Publication of the electronic newsletter, *Fire in the Ice* (DOE).
- 4.1.3 Quarterly:** Post up-to-date and comprehensive descriptions and of all DOE funded activities on the NETL methane hydrates website (DOE).
- 4.1.4 FY2007:** Establish clear objectives and activities for participation and collaboration with the Indian R&D program (USGS, DOE, and other agencies).
- 4.1.5 FY2007:** Establish a sub-group of interested scientists within the interagency working groups to focus on opportunities for effective programmatic outreach opportunities including lecture series, educational materials, and others (DOE, other agencies).

- 4.1.6 FY2007:** Award initial Methane Hydrate R&D Program fellowship via program established with the NAS. Make from 1 to 3 additional awards annually thereafter (DOE, with selection assistance from members of other agencies).
- 4.1.7 FY2007:** Hold first biannual external merit review of work funded through Cooperative Agreements and Interagency Agreements (DOE).
- 4.1.8 FY2008:** Develop clear objectives and activities for collaboration with Japan and other emerging Asian gas hydrate R&D programs (USGS, DOE, NRL, and other agencies).
- 4.1.9 FY2008:** Hold second biannual external merit review of work funded through National Laboratory field work proposals (DOE, with assistance for collaborating agencies).
- 4.1.10 FY2008:** Develop, and subsequently maintain and improve, internet-based informational content suitable for use by K-12 educators (DOE, other agencies).
- 4.1.11 FY2008 and FY2010:** If available funding permits, conduct a public workshop designed to identify existing R&D and data gaps to guide solicitation of new projects (DOE).
- 4.1.12 FY2008/Ongoing:** Draw representatives of 20 nations to the 6th International Workshop on Methane Hydrate Research and Development in Bergen, Norway. Provide ongoing support for the regular international methane hydrates meetings (DOE, NRL, others).

Key Cross-cutting Technical Milestones

- 4.1.13 Ongoing:** Maintain databases of gas hydrate relevant public data, and make those data available as feasible to collaborating agencies and other researchers (USGS, MMS, BLM).

- 4.1.14 Ongoing:** Continue to pursue opportunities to partner with industry on new data collection in wells of opportunity (USGS, MMS, BLM, DOE).
- 4.1.15 Ongoing:** Continue to work with DOI to access and utilize existing data in the Gulf of Mexico and elsewhere for the assessment of gas hydrate occurrence (USGS, MMS, DOE).
- 4.1.16 FY2007:** Quantify the impacts of depressurization of pressure core samples on sample integrity (USGS, DOE).
- 4.1.17 FY2007:** Finalize design and conduct field tests of new pressure coring tools (DOE (Chevron JIP)).
- 4.1.18 FY2007:** Support further testing and development of the Georgia Tech IPTC device through testing of pressure cores obtained during Indian Expedition 01 (DOE, (Chevron JIP)).
- 4.1.19 FY2007:** Document dramatic improvements in usability and run-time performance for Tough+Hydrate (DOE).
- 4.1.20 FY2007:** Integrate results of laboratory investigations into the basic relationships of intrinsic permeability, relative permeability, and capillarity within hydrate-bearing sandstones (DOE).
- 4.1.21 FY2007:** Create a gas hydrates mark-up language (GHML) to support development of global searchable hydrates database (DOE).
- 4.1.22 FY2007:** Identify appropriate locations with the Gulf of Mexico to assess the utility of 4-D OBS seismic in the detection and characterization of hydrate occurrence (DOE).
- 4.1.23 FY2007:** Establish an internet site housing the problems, solutions, and analyses of results from the international code comparison effort (DOE, USGS).

- 4.1.24 FY2008:** Pursue new opportunities for *in situ* measurement of gas hydrate/sediment physical and chemical properties (DOE, TBD).
- 4.1.25 FY2007:** Publish a dozen or more articles based on work conducted within Phase 1 of the Gulf of Mexico JIP within a peer reviewed journal (DOE, USGS, NRL, other agencies)
- 4.1.26 FY2008:** Publish improved rock-physics models for interpretation of hydrate occurrence from sediment acoustic responses that incorporates the latest available data (DOE).
- 4.1.27 FY2008:** Conduct field tests of the utility of electromagnetic (EM) resistivity surveys as a means of remote detection/quantification of hydrates deposits in deepwater marine environments (DOE).
- 4.1.28 FY2008:** Complete the initial phase of the international reservoir simulation code comparison study in collaboration with scientists from Japan and Canada with publication of the results of a field-scale problem based on the data acquired on the Alaska North Slope (DOE, USGS).
- 4.1.29 FY2008:** Demonstrate the ability to collect and conduct sophisticated geophysical and mechanical measurements on pressure cores in marine sandstones bearing hydrates (DOE (Chevron JIP)).
- 4.1.30 FY2008:** Complete modeling studies of well-bore stability issues related to production/dissociation from unconsolidated gas hydrate-bearing sandstones (DOE).
- 4.1.31 FY2008:** Create a data query portal and search engine that can be access data from a wide range of international gas hydrate databases (DOE).
- 4.1.32 FY2009:** Create a comprehensive internet-based database of gas hydrates information (DOE, other agencies).

4.1.33 FY2009: Integrate experimental results of the impacts of geomechanical deformation of gas hydrate reservoir hydraulic properties into existing gas hydrate numerical simulation capabilities (DOE).

4.1.34 FY2011: Develop geologically-based mathematical models for the distribution of gas hydrate within marine gas hydrate systems based on integrated pore scale models of gas migration, sediment failure, and hydrate formation (DOE).

4.2 Safe Drilling in Gas-Hydrate-Bearing Areas

The following are critical near-term milestones that contribute to the program's effort to provide the information and technology necessary to assure safe drilling of oil and gas wells in gas-hydrate bearing areas.

4.2.1 FY2008: Provide updated well-bore stability model (DOE (Chevron JIP)).

4.2.2 FY2008: Complete experimental work to determine geomechanical properties of end-member marine gas-hydrate-bearing sediments (DOE).

4.2.3 FY2009: Complete predictive studies of gas hydrate bearing sediment stability under mechanical and thermal loading (DOE).

4.2.4 FY2009/2010: Publish Gulf of Mexico JIP final project report that integrates drilling safety findings related to both low-gas-hydrate saturation shale reservoirs and high-gas-hydrate saturation sandstone reservoirs (DOE (Chevron JIP)).

4.2.5 FY2010: Demonstrate effective marine gas hydrate prediction, detection and quantification technologies (DOE, USGS, MMS, NRL).

4.3 Production Potential of Gas Hydrates

The following are critical milestones specific to the program's effort to realize a comprehensive assessment of gas hydrate production potential on the Alaska North Slope, in the Gulf of Mexico, and in the remaining U.S. Outer Continental Shelf.

- 4.3.1 FY2007:** Collect data from well log, core, and borehole-scale reservoir performance tests from several gas hydrate-bearing horizons at the Mt. Elbert prospect, Milne Point, Alaska to provide insight into pre-well seismic evaluation of gas hydrate occurrence and critical reservoir properties (DOE, USGS, (BPXA)).
- 4.3.2 FY2007:** Complete geochemical, geological, and geophysical studies to determine the presence and potential production history of gas hydrates at the Barrow and Walakpa gas fields in partnership with the North Slope Borough in order to determine the area's suitability for further field evaluation or potential test drilling (DOE, USGS).
- 4.3.3 FY2007/2008:** Conduct a drilling and logging program (and potentially a limited flow testing program as well) over several high-priority sites in the Gulf of Mexico that have evidence of high-saturation gas hydrate accumulations within sandstone reservoirs. Use data to better characterize gas hydrate reservoirs and ground-truth pre-well predictions of reservoir extent and nature (DOE, USGS, MMS (Chevron JIP)).
- 4.3.4 FY2008:** Incorporate results of the DOI's initial assessment (methane in-place as well as technically-recoverable) of gas hydrate resources on the North Slope of Alaska and on the U.S. Outer Continental Shelf (U.S. Department of Interior into program planning and priorities and adjust the nature of the targets for field investigation as appropriate (USGS, MMS, BLM), DOE).
- 4.3.5 FY2008:** Initiate a program of regional resource assessment and characterization in the Gulf of Mexico that incorporates extensive advanced

geophysical analysis with geochemical data and geological modeling for reservoir occurrence following the model set by the ongoing MMS assessment (DOE).

- 4.3.6 FY2008/FY2009:** Initiate an initial production test program on the ANS that couples investigation of production technologies with monitoring of environmental impacts such as gas release, permafrost affect, and land subsidence. The currently preferred location for the test is the confirmed hydrate accumulations in the western portion of the Prudhoe Bay unit (DOE, USGS, BLM (State of Alaska DNR and/or interested industry partners)).
- 4.3.7 FY2008:** Complete integrated bench-scale studies and numerical simulation of the potential feasibility of CO₂ injection and resultant CO₂/CH₄ exchange as a means of coupling CO₂ sequestration with effective methane production while enhancing reservoir stability (DOE).
- 4.3.8 FY2008/FY2009/FY2010:** Conduct incremental analyses of the potential economics of future gas hydrate production on the North Slope of Alaska that incorporates data as provided by work in Alaska and elsewhere (DOE).
- 4.3.9 FY2009:** Solicit and select additional laboratory and modeling efforts to test and refine the most promising production technologies and address specific reservoir engineering and environmental issues identified in the initial field production tests (DOE).
- 4.3.10 FY2009:** Initiate a second gas hydrate evaluation project on the ANS, potentially in an area outside the Eileen accumulation. Location, well design, and ultimate production test method to be influenced by progress within the Prudhoe region and will be intended to provide a second location of differing geological conditions to test emerging gas production and environmental monitoring technologies (DOE, USGS, BLM).
- 4.3.11 FY2009:** Establish the ability to conduct meaningful production simulations within a laboratory setting that includes natural heterogeneities

and fully distributed temperature and other pertinent data in order to provide a controlled setting to cost-effectively screen new ideas or investigate phenomena of interest (DOE).

4.3.12 FY2009: Complete controlled experimentation and modeling to isolate the impact of variations in reservoir lithology, pore geometry, and other factors on gas hydrate destabilization due to various drivers (heat, pressure drop, chemical inhibition) (DOE).

4.3.13 FY2010: Initiate/continue Gulf of Mexico exploration program and initiate project/program designed to lead to production testing and environmental monitoring activities in the Gulf of Mexico (DOE, USGS, MMS).

4.3.14 FY2010: Calibrate and improve existing reservoir simulation codes using long-term production test results generated in the initial production testing operations both in the Arctic, and potential in deep marine environments (DOE, USGS and linkages to international R&D programs).

4.3.15 FY2010: Depending upon the findings of the DOI gas hydrate resource assessment and the progress of domestic and international field programs, evaluate the appropriateness of initiating a program to assess potential hydrate accumulations with resource potential along the Atlantic and/or Pacific coasts (DOE, USGS, MMS).

4.3.16 FY2010/2011: Conduct initial analyses of the economic potential of marine gas hydrate production incorporating data obtained from international collaborations and the program's work in the Gulf of Mexico (DOE).

4.3.17 FY2011: Present final interpreted results of initial ANS long-term production tests and associated environmental monitoring activities, and plans for further testing/evaluation of ANS gas hydrate resource potential (DOE, USGS, BLM).

4.3.18 FY2011: Incorporate the findings of additional exploratory drilling and testing into Outer Continental Shelf resource assessments (USGS, MMS, DOE, BLM, NRL).

4.4 Assessing the Potential for, and Impacts of, Gas Hydrate Degassing

The following are critical milestones related to the program's efforts to document the role of gas hydrate in the natural environment (including carbon cycling, global climate, and large-scale instabilities of the continental margins) and to understand the potential impacts of methane release and sea-floor/permafrost instability related to gas hydrate dissociation due to either human activity or natural phenomena.

4.4.1 Ongoing: Continue to pursue means to integrate gas hydrate-related data into leading oceanic and global climate modeling efforts (DOE, NOAA, NRL).

4.4.2 Ongoing: Seek opportunities to collaborate in the development of local, regional, and global sea-floor process monitoring stations through existing projects (such as with CMRET) and potential new collaborations with OOI/ORION, Canadian (the Neptune Program) and/or European efforts (DOE, NOAA, NRL, other agencies).

4.4.3 FY2007: Work with NOAA to develop an advance solicitation that will access the global climate modeling community and provide additional time for proposal response and review (DOE, NOAA).

4.4.4 FY2008: Work with the Chevron JIP to establish clear objectives and activities that will provide relevant information on the effects and implications of drilling and other non-natural disturbances on methane hydrate stability (DOE, other agencies (Chevron JIP)).

4.4.5 FY2008: Complete analysis of rates of methanogenesis in deep marine environments and incorporate that data into global carbon cycling models (DOE).

- 4.4.6 FY2008:** Initiate capability for 4-D geophysical monitoring at the Mississippi Canyon 118 site through acoustic, electric resistivity and other means (DOE, MMS, NOAA).
- 4.4.7 FY2008:** Conduct collaborative North America west coast sub dives for research on surface methane hydrate deposits (NOAA, NRL).
- 4.4.8 FY2008:** Publish a review and synthesis of recent surveys of geophysical and geochemical indicators of gas hydrate occurrence in different coastal regions, including the Cascadia Margin, Texas-Louisiana Shelf, Mid-Chilean Margin, Blake Ridge and Hikurangi Margin off Northeastern New Zealand (NRL).
- 4.4.9 FY2008:** Complete studies of historical variation in carbon inputs and potential methane flux rates through analysis of sea-floor sediments in a variety of global settings (DOE).
- 4.4.10 FY2008:** Initiate geochemical and biogeochemical evaluation of methane cycling related to methane hydrate deposits and global warming in the Arctic Ocean through the Pacific Energy and Climate Change Program (NRL).
- 4.4.11 FY2008:** Complete geochemical studies of sediments from the Bering Sea for evidence of past rapid natural gas hydrate dissociation and any correlation to interpreted periods of global climate change (DOE).
- 4.4.12 FY2009:** Complete installation of sea-floor monitoring station in Gulf of Mexico Mississippi Canyon Block 118 (MMS, NOAA, DOE).
- 4.4.13 FY2009:** Expand national and international collaboration for coastal hydrate exploration and global warming prediction in the Arctic Ocean through the PECCP (NRL).
- 4.4.14 FY2009:** Complete the coupling of geomechanical and pore scale fluid pressure/flow modeling to describe the dynamic interactions of gas and water subjacent to marine hydrate systems (DOE).

4.4.15 FY2009: Incorporate into second round of Gulf of Mexico field studies efforts to monitor the effects of drilling and testing on gas hydrate stability, sediment physical properties, and released gas and water migration (DOE other agencies).

4.4.16 FY2010: Complete analyses of the nature and effectiveness of the ocean column microbes in controlling the flux of methane from the seafloor to the atmosphere (DOE).

5.0 Concluding Remarks

This document presents an overview of the near-term (FY2007 through 2011) research priorities and milestones for the DOE-led interagency program in natural methane hydrates. This plan, taken together with the earlier long-range *Interagency Roadmap*, will be the subject of a report to Congress from the methane hydrate Federal Advisory Committee by August, 2007. Subsequently, this plan will be revisited annually to reflect the continuing progress of the program.

Appendix A: The Interagency Coordination Committee and Technical Coordination Team

Interagency Coordination Committee:

- Jim Slutz, Chairman, DOE/Office of Fossil Energy
- Edith Allison, DOE/Office of Fossil Energy
- Nick Douglas, DOI/Bureau of Land Management
- Bilal Haq, National Science Foundation
- Bob LaBelle, DOI/Minerals Management Service
- Brenda Pierce, DOI/United States Geological Survey
- Bakhta Rath, DOD/Naval Research Laboratory
- Richard Spinrad, DOC/National Oceanic and Atmospheric Administration

Technical Coordination Team:

- Ray Boswell, Chairman, DOE/National Energy Technology Laboratory
- Roger Amato, DOI/Minerals Management Service
- Rick Coffin, DOD/Naval Research Laboratory
- Tim Collett, DOI/U.S. Geological Survey
- George Dellagiarino, DOI/Minerals Management Service
- Bob Fisk, DOI/Bureau of Land Management
- Matt Frye, DOI/Minerals Management Service
- Joe Gettrust, DOD/Naval Research Laboratory
- Bilal Haq, National Science Foundation
- Deborah Hutchinson, DOI/U.S. Geological Survey
- Beth Maclean, DOI/Bureau of Land Management
- Tamara Neukam, DOI/Bureau of Land Management
- Kimberly Puglise, DOC/National Oceanic and Atmospheric Administration
- Kelly Rose, DOE/National Energy Technology Laboratory

Appendix B: The Federal Advisory Committee

Installed in May, 2006

- Chair: E. Dendy Sloan, Colorado School of Mines
- Peter Brewer, Monterey Bay Aquarium Research Institute
- Richard Charter, National OCS Coalition
- Nader Dutta, Schlumberger
- Art Johnson, Hydrate Energy International
- Emrys Jones, Chevron
- Miriam Kastner, Scripps Institute of Oceanography
- Devinder Mahajan, Brookhaven National Laboratory
- Steve Masutani, University of Hawaii
- Robert Swenson, Alaska Department of Natural Resources
- Jean Whelan, Woods Hole Oceanographic Institute
- Scott Wilson, Ryder Scott Petroleum Engineers
- Robert Woolsey, University of Mississippi
- Kim Juenger, World Energy Systems, Inc.

Appendix C: Current Program Portfolio

Department of Energy:

Research Projects Started FY2001

- ***BP Exploration (Alaska)*** with research partners U. Alaska-Fairbanks, U. Arizona, U.S. Geological Survey, Interpretation Services Inc., APA Petroleum Consultants, and the Ryder-Scott Company. Phases 1 and 2 utilized proprietary 3-seismic data provide by BP as well as existing well log data/interpretations provide by the USGS to conduct geologic, geophysical, and numerical/economic modeling in the Milne Pt. unit of the greater Prudhoe Bay region. The project established the existence of 14 separate mappable hydrate prospects and selected one (“Mt. Elbert”) as the target of Phase 3 field activities. A well to be drilled, logged, cored, and tested in 2QFY07 will provide information relative to BP/DOE’s joint decision on progression into a subsequent long-term production test phase.
- ***Chevron Gulf of Mexico Joint Industry Project*** with research partners ConocoPhillips, U.S. Geological Survey, Minerals Management Service, Total, Schlumberger, Rice U., Georgia Institute of Technology, Reliance Industries, JOGMEC, and Scripps Oceanographic Institute. Phases 1 and 2 resulted in the 2005 drilling, logging, coring of two sites in the Gulf of Mexico to investigate safety aspects of hydrates in fine-grained sediments. Phase 3 (currently in planning) will pursue improved pressure coring tools, evaluate locations for gas hydrates within coarse-grained (sand) sediments, conduct initial drilling and LWD evaluation of those sites (4Q2007) and conduct follow-on drilling and coring operations (FY2008/2009).

Jointly-funded Projects

- ***University of Mississippi/Center for Marine Research and Environmental Technology*** led a large research group in continuing to develop and install a sea-floor monitoring station in Mississippi Canyon Block 118. This is a congressionally-directed program that is jointly funded by the MMS and NOAA.

Research Projects Awarded in FY2005

- ***Stanford University*** is investigating fundamental rock-physics models for improved evaluation of the seismic response of hydrate-bearing strata.
- ***Battelle Memorial Institute and U. Alaska-Fairbanks*** are conducting reservoir simulation (using STOMP) and bench-scale experimentation to determine the feasibility of CO₂ injection as a means of enhance reservoir stability, methane production, and CO₂ sequestration.
- ***University of Texas-Austin*** is utilizing an existing four-component ocean-bottom seismic dataset in the Green Canyon area (Gulf of Mexico) to determine the value and methodologies for improved hydrate characterization from advanced seismic.
- ***Woods Hole Oceanographic Institute*** is utilizing pre-existing cores from the Bering Sea to probe the links between sediment geochemical signatures, massive episodes of past methane release, and known global climatic events.

- **Texas A&M University, U. California-Berkeley, and Lawrence Berkeley National Lab** are conducting integrated reservoir simulation, numerical simulation, and lab-scale experimentation to probe the nature and implications of the geomechanical response of hydrate-bearing sediments under changing conditions (both natural and induced).

Research Projects Awarded in FY2006

- **Baylor U.** will develop and field test equipment and procedures for conducting direct current resistivity profiling for hydrate detection in deep-water settings.
- **The North Slope Borough** will conduct new gas sampling and utilize existing geologic, geophysical and production data to probe the occurrence and potential production contribution of methane hydrates within the Barrow and Walakpa fields of the Alaska North Slope.
- **Rice University** will conduct a coordinated multi-disciplinary study of marine methane hydrate issues, including geochemical profiling, geological process modeling, geomechanical investigations, and geophysical modeling.
- **The University of Texas-Austin** will conduct theoretical modeling of gas-water-sediment interactions both below and within the hydrate stability zone to provide prediction of sediment stability, fracturing, and hydrate and free gas occurrence.
- **Georgia Institute of Technology and Oak Ridge National Lab** will conduct multi-scale experiments on hydrate-sediment interactions to gain insight into the response of various systems to a range of possible production mechanisms.
- **Rock Solid Images** will investigate existing seismic/well log data sets to generate new cumulative seismic attributes that are predictive of hydrate occurrence.

FY2006 Projects with the DOE National Labs

- **Lawrence Berkeley National Lab** pursued the further development and calibration of ToughFX/HYDRATE and conducted focus laboratory experiments on hydrates in porous media.
- **Pacific Northwest National Lab** continued development of IR-based technologies for field applications, participated in the NGHP Expedition 01, and worked to develop and validate resonant ultrasound spectrometry as a novel investigative tool for hydrate research in the lab.
- **Oak Ridge National Lab** began an effort to instrument the 72-liter sea-floor process simulator and develop/implement procedures for conducting lab simulations of well-based production from hydrate reservoirs.
- **Idaho National Lab** with partners Monterey Bay Aquarium Research Institute, Oregon State University, and Rice University are establishing realistic rates for marine methane production and incorporating those data into existing global carbon cycle models.
- **The National Energy Technology Lab** continued to direct an international comparison of existing hydrate reservoir simulators, conducted molecular modeling studies, and continued

development of a practical tool for accurate and non-destructive thermal property measurement.

- **Brookhaven National Lab** continued development of the FISH unit for the investigation of the dynamics of methane hydrate within well-characterized fine-grained sediments.

FY2006 Interagency Agreements

- **The U.S. Geological Survey** provided ongoing technical expertise and recommendations for the programs major field projects (BP, Chevron JIP), and conducted experimental laboratory studies of the effects of short-term depressurization on cores (with LBNL) using elastic and thermal properties measured on gas-hydrate-sediment mixtures.
- **The National Institute for Standards and Technology** initiated an effort to produce a database of methane hydrate information that would be searchable through the World Wide Web.
- **The Naval Research Lab** conducted geophysical and geochemical surveys to provide new information on the relationships between geophysical response, hydrate occurrence, microbiology and active methane flux offshore New Zealand.

Other Initiatives

- **Queens College** and the Colorado School of Mines produced a Gas Hydrates Mark-up Language and associate software to produce a framework for a searchable internet-based hydrates database.
- **NETL and the National Academy of Sciences** established a fellowship program to support promising graduate students in furthering their academic careers.

Acronyms Used

ANS	Alaska North Slope
APC	Advanced Piston Core (IODP)
APEC	Asia-Pacific Economic Cooperation Forum
BLM	Bureau of Land Management
BPXA	British Petroleum Exploration (Alaska)
CA	Cooperative (Research and Development) Agreement
CMRET	Center for Marine Resources and Environmental Technology (U. Miss.)
CODATA	Committee for Data for Science and Technology
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DNR	Division of Natural Resources (Alaska)
EM	Electro-magnetic
E&P	Exploration and Production
EPACT	Energy Policy Act (2005)
FAC	Federal Advisory Committee
FPC	Fugro Piston Core
FY	Fiscal Year
GHML	Gas Hydrate Markup Language
GOM	Gulf of Mexico
HRC	HYACE Rotary Core

ICC	Interagency Coordination Committee
INL	Idaho National Laboratory
IODP	Integrated Ocean Drilling Program
JIP	Joint Industry Project
LBNL	Lawrence Berkeley National Laboratory
LWD	Logging-while-drilling
MBARI	Monterey Bay Aquarium Research Institute
MHR&D	Methane Hydrate Research and Development
MMS	Minerals Management Service
NAS	National Academy of Sciences
NETL	National Energy Technology Laboratory
NGHP	National Gas Hydrate Program (India)
NIST	National Institute for Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Laboratory
NSF	National Science Foundation
ODP	Ocean Drilling Program
ONRG	Office of Naval Research (Global)
ORNL	Oak Ridge National Laboratory
PNNL	Pacific Northwest National Laboratory
R&D	Research and Development
TCT	Technical Coordination Team
USGS	United States Geological Survey
XCB	Extended Core Barrel (IODP)