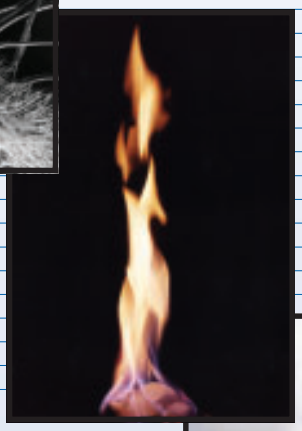
Interagency Coordination on Methane Hydrates R&D



Demonstrating the power of working together

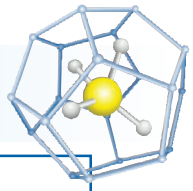
Over the last 20 years, scientists have changed their view of how natural gas occurs within the Earth. New discoveries are being made in the world's most remote regions, including the Arctic and the deep-water oceans, that could dramatically alter both the global balance of the world energy supply and our understanding of the way the Earth's crust, oceans, atmosphere, and climate interact. The cause of this excitement is naturally occurring *Methane Hydrates.*

The issues surrounding methane hydrates are broad and complex. In addition to their potential as a huge energy source, we now know that methane hydrates are a dynamic component of the natural environment. Deep-sea dives in the Gulf of Mexico (GOM) and elsewhere have shown that methane hydrates support unique communities of life seen nowhere else on Earth. In addition, methane hydrates form and dissociate rapidly in response to changing conditions. This continual equilibration to ongoing natural changes in the environment is requiring scientists to rethink current views on the global carbon cycle, the evolution of the sea floor, and global climate.

The multi-faceted issues associated with naturally occurring methane hydrates demand a coordinated approach to studying (1) the potential of this resource as a U.S. fossil energy source, and (2) the possible hazards of tapping the resource. The National Methane Hydrates Research and Development (R&D) Act of 2000 requires the development of a national methane hydrates R&D program that utilizes the talents of federal, private, and academic organizations.

This brochure covering interagency coordination on methane hydrates R&D describes a new type of federally funded, collaborative program in basic science and technology R&D. Our goal is to efficiently use all the resources at the Nation's disposal to maximize collaboration on hydrates R&D, avoid R&D duplication among member agencies, and ensure that no important questions are left unanswered.

Methane is actively dissociating from a hydrate mound on the Gulf of Mexico deep sea floor.



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The photos in this publication are provided by the participating agencies, Texas A&M University, C. Fisher, Penn. State University, and the Woods Hole Oceanographic Institution.

Abbreviations

CMRET	Center for Marine Resources and Environmental Technologies
DOC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
3-D	three dimensional
EEZ	exclusive economic zone
FE	(DOE Office of) Fossil Energy
FY	fiscal year
GHASTLI	gas hydrate and sediment test laboratory instrument
GOM	Gulf of Mexico
ICC	Interagency Coordination Committee
MBARI	Monterey Bay Aquarium Research Institute
MCS	multi-channel seismic (system)
MMS	(DOI) Minerals Management Service
NETL	(DOE) National Energy Technology Laboratory
NOAA	(DOC) National Oceanic and Atmospheric Administration
NRL	(DoD) Naval Research Laboratory
NSF	National Science Foundation
NURP	National Undersea Research Program
OCS	outer continental shelf
ODP	Ocean Drilling Program
OMM	Offshore Minerals Management (Program)
ONR	(DoD) Office of Naval Research
R&D	research and development
ROVs	remotely operated vehicles
SCNG	(DOE) Strategic Center for Natural Gas
USGS	U.S. Geological Survey

What Are Methane Hydrates?

The fossil fuels that have powered the world's economies (first coal, then oil and natural gas) for many centuries have been derived almost exclusively from *thermogenic* deposits. These deposits form when organic material is pressure-cooked at great depths within the Earth's crust over geologic time. In addition to thermogenic processes, natural gas is continually being produced in vast quantities at and near the Earth's surface through *biogenic* or *microbial* processes. Scientists assumed, however, that no natural process exists to collect and concentrate biogenic gas into viable economic deposits.

This view began to change in the 1970s. Tantalizing evidence from Siberia, the Black Sea, and the North Atlantic suggested that under certain conditions typical of deep oceans, water may naturally form hydrate cages that trap and concentrate biogenic methane—virtually as it is being produced. Then in 1982, scientists onboard the Glomar Challenger retrieved a 1-m (3.28-ft) thick sample of pure methane hydrates from the deep-water sediments offshore of Guatemala. This core became the impetus for the first national R&D program dedicated to hydrates. Over the next 10 years, the U.S. Department of Energy (DOE), the U.S. Geological Survey (USGS), Naval Research Laboratory (NRL), and many other organizations demonstrated that methane hydrates occur in staggeringly vast quantities all over the globe. By 1990, it was clear that the volume of energy stored in methane hydrate exceeded that of all the world's coal, oil, and conventional natural gas *combined.*

Methane hydrates are solid, naturally occurring compounds composed of methane (the main component of natural gas) trapped inside a rigid lattice of water molecules. Methane hydrates form naturally under conditions of high pressures and relatively low temperatures. Under these conditions, methane molecules are compressed into very tightly packed ice-crystal cages. Therefore, methane hydrates have high energy density at surface pressures. When dissociated at normal surface temperatures and pressures, a 0.028 m^3 (1 ft^3) block of solid methane hydrates could release up to 4.53 m^3 (160 ft^3) of methane.

Methane hydrates occur naturally in Arctic permafrost regions at depths greater than 200 m (656 ft). They also form at ocean depths of 500 m (1,640 ft) or more where temperatures hover near freezing and the weight of the overlying water produces high pressures. The high pressures and relatively low temperatures allow high concentrations of methane to accumulate in the ice.

Methane hydrates can form in rocks or sediments of any type, given suitable pressures, temperatures, and supplies of water and methane. Although methane hydrates commonly occur as disseminated grains, other forms are known. These include massive layers of pure hydrates up to 4-m (13-ft) thick, nodules that grow and displace surrounding sediments, veins filling small fractures, thin layers along bedding planes, and as a cement binding sedimentary grains together.

Worldwide Methane Hydrate Deposits

Federally Sponsored Methane Hydrates R&D

Soon after the Glomar Challenger ocean research vessel retrieved the first core sample containing methane hydrates from the sea floor, the DOE Office of Fossil Energy (FE) embarked on a 10-year, $8 million research program to learn more about methane hydrates. From 1982 to 1992, DOE collaborated with labs and academic institutions to build the foundation of basic knowledge about methane hydrates that guides our research today. During this time, DOE joined the USGS, Los Alamos National Laboratory, Texas A&M University, University of Alaska, University of Washington, and University of Pittsburgh, among others to

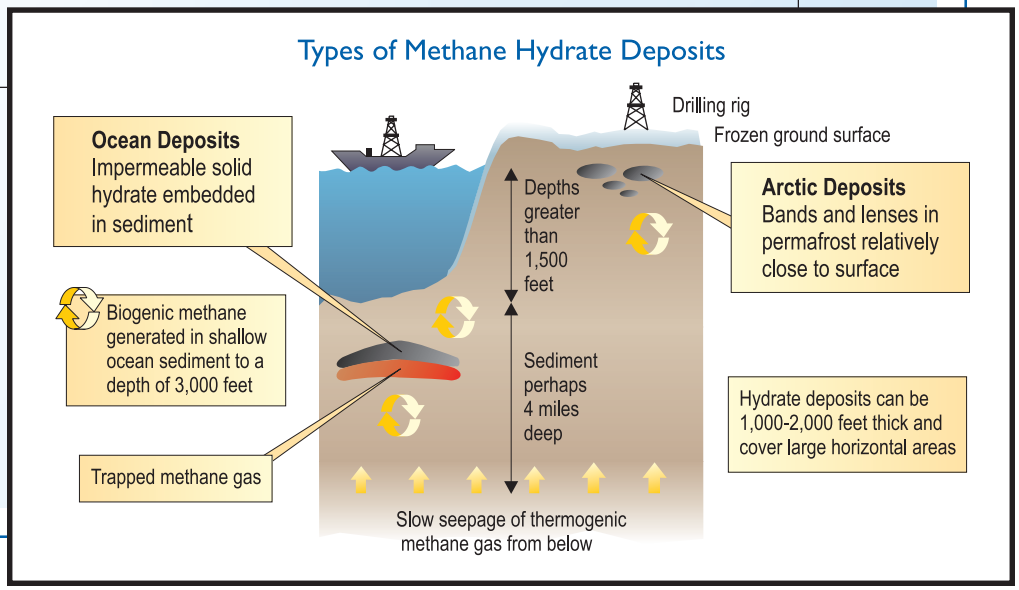
- Establish the existence of hydrates in the Kuparuk Field, Alaska;
- Complete studies of 15 offshore hydrate basins;
- Develop preliminary estimates of gas-in-place for hydrate deposits;
- Develop preliminary production models for depressurization and thermal production of gas from hydrates; and
- Build the gas hydrate and sediment test lab instrument (GHASTLI), a device that simulates deep-sea conditions to allow testing of hydrate-bearing sediments.

DOE continued somewhat smaller-scale research efforts throughout the early 1990s with USGS, NRL, universities, and laboratories. In 1991 and 1994, DOE sponsored the International Conference on Methane Hydrate R&D so hydrate researchers all over the world could share results and problems. In the mid-1990s, although DOE's funding was reduced, NRL and USGS continued the make significant discoveries. The National Oceanic and Atmospheric Administration (NOAA), Minerals Management Service (MMS), and National Science Foundation (NSF) were also involved in hydrate-related activities.

In the late 1990s, DOE began planning for a multi-agency, national, gas hydrates program. The goals for this second phase of research, identified in two workshops in 1998, focus on four areas:

1. Resource characterization,
2. Drilling safety and sea floor stability,
3. Global climate change, and
4. Methane production from hydrates.

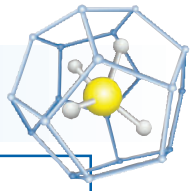
The program was further spurred in 1998 and 1999 by the startling success of international drilling programs in Canada and Japan that indicated the commercial exploitation of methane hydrates may occur much sooner than previously thought.



National Methane Hydrate R&D Act of 2000

Recognizing the importance of hydrate research and the need for coordinated effort, Congress and the President of the United States enacted Public Law 106-193, the *Methane Hydrate Research and Development Act of 2000*, in May 2000. The bill called for the Secretary of Energy to

- ***Commence*** a methane hydrate R&D program in consultation with the U.S. Departments of Commerce (DOC)—represented by NOAA, Defense (DoD)—represented by NRL, Interior (DOI)—represented by MMS and USGS, and NSF.
- ***Award*** grants, contracts, or cooperative agreements with institutions of higher education and industrial enterprises on a competitive, merit-based process to
  - *Conduct* basic and applied research to identify, explore, assess, and develop methane hydrates as a source of energy.
  - *Assist* in developing technologies required for efficient and environmentally sound development of methane hydrate resources.
  - *Undertake* research programs to provide safe means of transport and storage of methane produced from methane hydrates.
  - *Promote* education and training in methane-hydrate resource R&D.
  - *Conduct* basic and applied R&D to assess and mitigate the environmental impacts of hydrate degassing (including both natural degassing and degassing associated with commercial development).
  - *Develop* technologies to reduce the risks of drilling through methane hydrates.
  - *Conduct* exploratory drilling in support of the activities authorized by the Act.
- ***Establish*** an advisory panel, consisting of experts from industrial enterprises, institutions of higher education, and federal agencies. This group is charged with recommending research priorities for the program and for reporting to Congress after 2 years on the impact that hydrates have on global climate change.
- ***Receive*** updates on the progress of this research program from the National Research Council, and transmit a report to Congress containing the Council's recommendations for future methane hydrate R&D needs no later than September 30, 2004.



National Methane Hydrate R&D Program

The National Methane Hydrate R&D Act of 2000 ensured growing interest in and higher levels of federal funding for hydrates R&D. DOE funding for methane hydrates R&D grew from $3 million in fiscal year (FY) 2000 to over $9.5 million in 2001. Total government funding among all federal agencies reached $17 million in 2001. The National Methane Hydrate R&D Program, mandated by the Act, is now well under way. The planned research work, framed through discussions among the six member federal agencies and in consultation with advisory panels from industry and academia, will

- Better characterize the chemical and physical properties of hydrates;
- Provide needed technology for a more complete survey of hydrate distribution;
- Describe and devise means to mitigate the hazards that hydrates pose to ongoing deep-water oil and gas drilling and production;
- Improve our understanding of how hydrates interact with the natural environment, including any links to issues of seafloor stability and global climate;
- Visit, sample, characterize, and protect the unique biological communities dependent upon hydrate occurrences;
- Develop tools to improve the investigation of hydrates in both the lab and the field; and
- Appraise technologies for the safe and commercial production of methane from hydrates so that hydrates can be part of the solution for the Nation's long-term energy security.

The following sections describe hydrates research activities at each of these agencies.

The work is being coordinated by the Interagency Coordination Committee (ICC), consisting of representatives from the six government agencies mandated in the National Methane Hydrate R&D Act of 2000:

- DOE, through FE and represented by the Strategic Center for Natural Gas (SCNG) located at the National Energy Technology Laboratory (NETL);
- DOC, represented by NOAA;
- DoD, represented by NRL;
- DOI, represented by MMS and USGS; and
- NSF.

Participating Agency

DOE—Office of Fossil Energy, and National Energy Technology Laboratory

The Methane Hydrates Act of 2000 established DOE FE as the lead organization in the National Methane Hydrate R&D Program. DOE awards grants, contracts, and cooperative agreements on a competitive, merit-review basis to conduct basic and applied R&D to develop methane hydrates as a source of energy. FE ensures that the federal agencies involved in hydrates research communicate effectively with each other through the Interagency Coordination Committee (ICC). FE is also responsible for establishing and chairing the advisory committee for methane hydrate research. The advisory committee held its first meeting in May 2001.

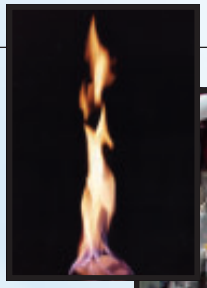
The primary mission of NETL is to ensure that U.S. fossil energy resources can meet increasing demands for affordable energy without compromising the quality of life for future generations of Americans. Within this context, NETL focuses on the development of advanced technologies related to fossil energy resources—coal, natural gas, and oil.

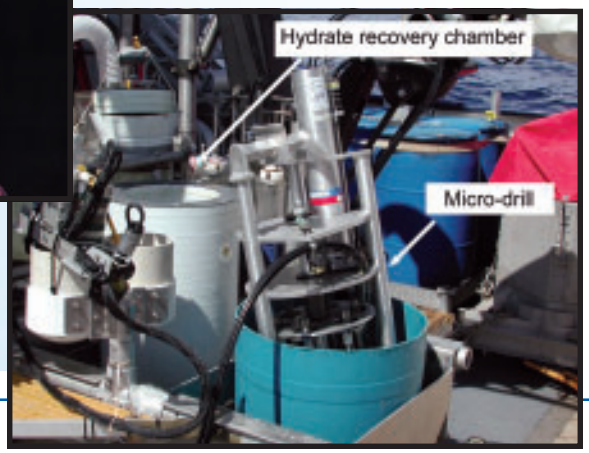
SCNG, located at NETL, coordinates methane hydrate R&D within DOE FE. SCNG emphasizes partnering with industrial, academic, and other governmental entities to create commercially viable technical solutions to energy and environmental problems.

FE normally requires the research participant to provide cost sharing for any project. In FY 2001, the average cost share provided by participants was in excess of 40 percent of the R&D value. To continue this cost-share goal, SCNG must receive input from industry and other stakeholders prior to issuing requests for proposals.

SCNG hosted a GOM methane hydrates R&D planning workshop in cooperation with Chevron Petroleum Technology Company in August 2000 to develop a plan to address GOM hydrate R&D needs. This effort focused on three key goals:

1. Ensuring the safety of deep-water oil and gas exploration and production operations that require drilling through or around overlying marine hydrate deposits.
2. Ensuring the long-term supply of natural gas by developing the technology base to allow commercial production of methane from domestic hydrate deposits by 2015.
3. Understanding the impact of methane hydrates on the global environment.





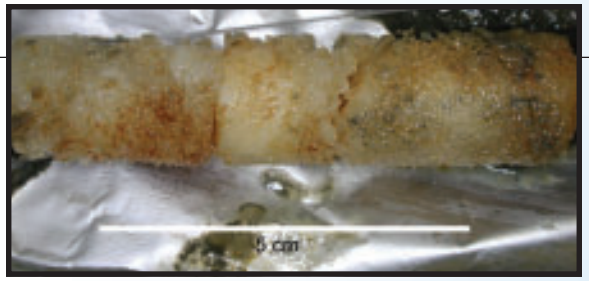
The prime near-term need is improved characterization of naturally occurring methane hydrates through an integrated and collaborative program of laboratory and field investigations. Laboratory work is focusing on both pure hydrates and hydrate-sediment mixtures to better define the parameters that control hydrate stability. These data will continue to be tested through field investigations of naturally occurring methane hydrates in a variety of settings.

New tools to investigate and analyze methane hydrates will be designed, developed, tested, and implemented. As new data are collected, the tools will be used to test and improve computer programs designed to model the behavior of methane hydrates in both the natural state and under induced environmental changes. These models will be critical in assessing the role of hydrates in sea-floor stability, global climate, and future energy supplies. In the near term, all the accumulated data will be provided through public databases.

In FY 2001, SCNG asked industry, academia, and other national labs to provide proposals for methane hydrate research. As a result, SCNG made six selections from the industry and academia solicitation and five selections from the national laboratory solicitation. Most of the work will be conducted in the GOM and on the North Slope of Alaska.

SCNG also has ongoing projects with the Center for Marine Resources and Environmental Technology (CMRET) at the University of Mississippi, University of Wyoming, University of Texas at Austin, and several national laboratories. Work continues with USGS on Arctic and offshore hydrate characterization and with NRL on radiocarbon dating and shallow water flows.

NETL is currently working on two in-house projects. The first is the establishment of the U.S. national methane hydrate R&D website as a mechanism for communication of ideas and data within the hydrates research community. The second project is the design and establishment of the NETL methane hydrate database. The database will include all available information on physical properties, well logs, and seismic data.



Discrete samples of gas hydrates (above) are collected from Gulf of Mexico seeps using a mini-drill and a gas hydrate recovery chamber deployed from the submersible Johnson Sea Link.

Selected NETL Hydrates Projects

- ***Joint Oceanographic Institutions, Washington, D.C.***—in-situ sampling and characterization of naturally occurring marine methane hydrates using the drilling vessel named the Joint Oceanographic Institutions for Deep Earth Sampling Resolution.
- ***Chevron Petroleum Technology Co., Houston, Texas***—characterizing natural gas hydrates in the deep water of the GOM; applications for safe exploration and production activities.
- ***Maurer Technology Inc., Houston, Texas***—methane hydrate production from Alaskan permafrost; what, when, where, why, and how?
- ***BP Exploration Inc., Anchorage, Alaska***—resource characterization and quantification of naturally occurring gas hydrates and associated free-gas accumulations in the Prudhoe Bay/Kuparuk River area on the North Slope of Alaska.

Participating Agency

DOC—National Oceanic and Atmospheric Administration

NOAA's mission is to

- Describe and predict changes in the Earth's environment, and
- Conserve and manage wisely the Nation's coastal and marine resources to ensure sustainable economic opportunities.

NOAA directs laboratories, research and monitoring organizations, and partnership programs to accomplish its mission. NOAA is particularly interested in the implications and interrelationships that methane hydrates have for energy, climate, and marine ecosystems.

The National Undersea Research Program (NURP) is the Nation's only federal scientific program that specializes in providing undersea assets to support marine exploration and environmental research. Under NURP, NOAA and civilian scientists have access to private and U.S. Navy submersibles and remotely operated vehicles (ROVs) for research to 6,000 m (19,685 ft). NURP is NOAA's contact for manned submersible and ROV charters and partially supports Alvin, a manned submersible capable of diving to 4,500 m (14,764 ft).

The NOAA Office of Ocean Exploration is the first step in a new approach to ocean resource management, improved marine science and education, and a new vision for ocean stewardship. This aggressive ocean exploration program will investigate the ocean's physical, chemical, and biological environments, processes, characteristics, and resources through (1) interdisciplinary expeditions to unknown, or poorly known, regions; and (2) novel experiments. Researchers will initially focus on the U.S. exclusive economic zone (322 km or 200 mi offshore) and continental margins, Arctic, southern oceans, and inland seas (Great Lakes). Methane hydrates occur in all these areas except the Great Lakes.

NURP has supported numerous GOM submersible cruises to study hydrates, their unique environments, and the ecosystems associated with them. Using technologies from the various NURP centers, scientists can study hydrate behavior and associated communities in situ. NURP's undersea technologies and expertise are important complements to the methane hydrates program at DOE.

New species of polychaete worm found living in gas hydrates during a NOAA/NURP-sponsored sub cruise in 1997 on the northern Gulf of Mexico continental slope at a depth of 549 m (1,800 ft).

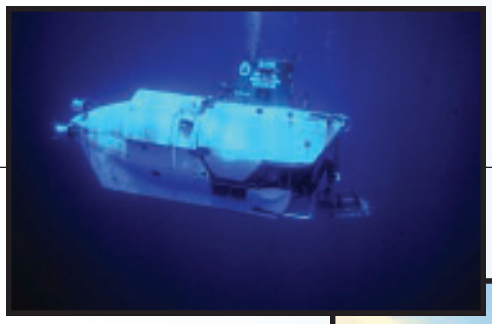
The knowledge gained from NURP studies has global applications, including carbon budgets, climate change models, sediment slope stability, and energy resource issues. Undersea vehicles used for these expeditions were funded by several agencies, including the NSF and Monterey Bay Aquarium Research Institute (MBARI).

In September and October 2001, NOAA's Office of Ocean Exploration and NURP participated in the Deep East expedition. The expedition explored three regions of the Atlantic Ocean from Maine to Georgia. During the expedition, researchers observed the formation of new gas hydrates in real time, recovered methane hydrates, studied the role of gas hydrates in continental slope stability, and examined live specimens retrieved from the deep-ocean floor.

During 2002, attempts will be made to quantify the methane discharge at the summit of Hydrate Ridge North (offshore Oregon and Washington). In addition, NOAA will be working with the Ocean Drilling Program (ODP) on a 2-month drilling leg to study this site, one of the most important scientific drilling sites in the world.

Selected NOAA Hydrates Projects

- The *Gas hydrate mounds: sites of metastable sea floor and high microbial productivity* study, supported by NURP, produced valuable information on the geology, bacterioplankton productivity, and geochemistry of these methane-hydrate sea-floor mounds.
- The NURP study *Geochemical consequences of gas hydrate formation in sediments of the Cascadia accretionary prism* focused on the conditions surrounding sites actively venting methane, as well as hydrate decomposition.
- Jointly sponsored submersible dives by NURP and MMS in the GOM resulted in the discovery of a new species of polychaete worm living in a hydrate bed.
- In 2000, Alvin was used to verify seismic records. In addition, several new shallow hydrate beds were discovered at sites across the GOM.



ALVIN Underwater

Ocean Research Vessel Atlantis

Participating Agency

DoD—Naval Research Laboratory

NRL is the U.S. Navy's laboratory for research in ocean and atmospheric sciences with special strengths in physical oceanography, marine geosciences, ocean acoustics, marine meteorology, and remote oceanic and atmospheric sensing. NRL focuses its research efforts on the Nation's strategic interests and needs in the post-Cold War world. The Navy focuses on defending American interests in the world's littoral regions, and NRL has the special knowledge and capabilities the Navy needs to operate in these waters.

As the Navy's corporate laboratory, NRL conducts a multidisciplinary program of advanced scientific and technological R&D directed toward maritime applications. Activities include the development of new and improved materials, techniques, equipment, and systems for oceanic, atmospheric, and space sciences. NRL's parent organization, the Office of Naval Research (ONR), coordinates, executes, and promotes the science and technology programs of the U.S. Navy and Marine Corps through universities, government laboratories, and nonprofit and for-profit organizations.

NRL brings over 10 years of experience and expertise to the study of marine hydrates. One significant contribution was the development of the deep-tow, high-resolution, multi-channel seismic (MCS) system, which provided site selection and drilling safety support for Japanese efforts to exploit methane hydrates in the Nankai Trough. NRL's accelerated gas-hydrates research-initiative program, funded by ONR, was a 5-year effort to understand the role of methane hydrates in the marine environment. NRL developed and used state-of-the-art analytical instrumentation to study methane hydrate formation and stability. NRL has also studied the processes related to hydrate generation and dissociation, and the impact of those processes on sediment properties.

NRL is involved in multidisciplinary investigation of the distribution and concentration of methane hydrates in the GOM and on the Cascadia Margin. It is conducting research into the dissociation and creation of methane hydrates, and is testing new technology to predict slope failure and shallow flow related to dissociation.

Scientists are analyzing a deep ocean core sample.

NRL is collaborating with USGS and industry in developing improved in-situ methane sensors, four-dimensional ocean bottom cables, and sea-floor deployable seismic sources, as well as techniques to minimize alteration of sediment/hydrate samples.

British Petroleum and the Energy Research Clearing House are working with NRL, with funding from DOE, to study shallow flow problems in the GOM using deep-tow seismic technology. NRL has established a collaborative program with Halliburton to use the methane in hydrates for in situ energy to support Navy and industrial interests. NRL has collaborated with the Japanese National Oil Corporation to conduct high-resolution MCS profiles in the Nankai Trough as a means to better locate drill sites and understand the distribution of methane hydrates in that region.

To showcase this research, review state of the art technologies, and identify research needs for gas hydrates, NRL, DOE, and the Hawaii Natural Energy Institute-University of Hawaii co-sponsored a conference in Hawaii in March 2001. The conference, "Fiery Ice from the Seas," was billed as "the first workshop of the International Committee on Methane Hydrates." The workshop promoted international R&D partnering, and was instrumental in starting a dialog on international cooperation on methane hydrates research.

With supplemental funding from DOE and ONR, NRL has a number of projects in the planning stages. Deep-tow MCS and side-scan sonar studies of the Blake Ridge collapse structure will be conducted in the summer of 2002. Additional seismic and geochemical studies of GOM hydrates, studies of hydrates in the Cascadia Margin, and carbon isotope studies to identify the source of hydrates also are planned.

Johnson Sealink Submersible Diving Vessel

Selected NRL Hydrates Projects

- ***NRL and USGS***—deep-tow MCS and side-scan sonar investigation in the Blake Ridge area; development of a broad-based study of methane hydrates in the GOM, including coordinated deep-tow MCS and deep-coring investigations.
- ***NRL, Geologic Survey of Canada, and University of Victoria***—integrated (deep-tow MCS, heat flow, core samples, fluid flux) investigation of methane hydrates in the complex region of the Cascadia Margin.
- ***NRL, Texas A&M University at Austin, Florida State University, Woods Hole Oceanographic Institute, University of California at San Diego, Massachusetts Institute of Technology, and University of North Carolina***—in situ sampling of methane hydrates and sediments; geochemistry related to methane hydrates and sediments; improved techniques for interpretation of deep-tow MCS data.

Participating Agency

DOI—Minerals Management Service

The mission of MMS is to

- Manage the mineral resources on the Nation's outer continental shelf (OCS) in an environmentally sound and safe manner; and
- Collect, verify, and distribute, in a timely fashion, mineral revenues generated from onshore and offshore federal and Indian lands.

MMS manages the Offshore Minerals Management (OMM) Program and the Minerals Revenue Management Program. OMM manages all phases of offshore mineral resources (natural gas, oil, and hard minerals such as sand and gravel) by

- Analyzing geologic, geophysical, and other geo-scientific data to support OCS program decisions;
- Assessing the likely effects of OCS activities on marine, coastal, cultural, and human environments; and
- Conducting research specific to issues associated with OCS mineral leasing and development.

MMS works closely with numerous public, private business, and government interests in developing workable solutions to multi-disciplinary problems. The agency maintains an interest in methane hydrates because of the large volume of natural gas they contain in offshore, deep-ocean environments. To facilitate coordination of research efforts on methane hydrates, MMS sponsored a gas hydrates session at a recent information transfer meeting.

MMS provided start-up funding and continues to fund the Center for Marine Resources and Environmental Technologies (CMRET). The Center was established to identify, design, and test equipment and techniques to study gas hydrates and marine minerals in the GOM.

MMS also maintains a technology assessment and research program that supports operational safety and pollution prevention research. Several projects related to gas hydrates as geohazards have been funded. The Resource Geoscience Division of the Geochemical and Environmental Research Group at Texas A&M University supports hydrates hazard research with MMS funding.

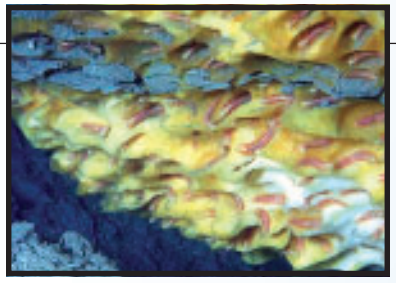
MMS is involved in a joint industry project to locate and characterize gas hydrates and improve understanding of the impacts of gas hydrates on drilling, pipelines, and sea-floor stability. This work included mapping gas hydrates across the GOM and analyzing the samples used for the mapping. A regional geophysical sea-floor-mapping project is being completed to assist in evaluating hydrates resources. This project is expected to enhance overall risk assessment, environmental protection, and resource evaluation. Collaborative Alvin dives in the summer of 2000 included researchers from DOE, NOAA, MMS, and academia.

MMS is particularly interested in protecting sensitive and unique chemosynthetic communities from deterioration as a result of oil and gas activities. These communities are often associated with outcrops of gas hydrates that may be identified remotely using three dimensional (3-D) seismic data. MMS has funded two large-scale studies on chemosynthetic communities that exist near GOM oil seeps and gas hydrate outcrops.

With the oil and gas industry moving into ultra deep water, a more detailed understanding of the location and extent of hydrates on the continental rise is necessary, especially locations in the GOM Mississippi Canyon and Atwater Block areas, where the potential for hydrate extraction is attractive. Submersible diving with Alvin would be ideal to identify hydrate outcrops and delineate subsurface distributions.

Selected MMS Hydrates Projects

- *MMS Benthic Research on Hydrates*—Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico; Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study; Summary of the Northern GOM Continental Slope Studies.
- *MMS Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study,* being conducted by Texas A&M University, used Alvin to investigate both chemosynthetic communities and hydrate outcrops.
- MMS analyzes seismic waveforms from sea-floor reflectors to determine if the waveforms can help distinguish hydrates from other hard reflectors such as authigenic carbonates.
- MMS has an ongoing study with Louisiana State University and the Coastal Marine Institute to improve the predictive capability of 3-D seismic surface-amplitude data used to identify chemosynthetic communities. The purpose is to better understand sediment instability issues.
- The CMRET at the University of Mississippi has initiated a project to study gas hydrate mounds and hydrocarbon vents in the GOM.



The so-called ice worm, Hesiocaeca methanicola, lives in the sediment that cover gas hydrate deposits and digs burrows that extend into the hydrate mass. They are thought to live by browsing bacteria, which are in turn supported by the abundant methane.

Participating Agency

DOI—U.S. Geological Survey

USGS is the sole DOI science agency. It is neither a regulatory nor a funding agency, and serves the Nation by providing reliable scientific information to

- Describe and understand the Earth;
- Minimize loss of life and property from natural disasters;
- Manage water, biological, energy, and mineral resources; and
- Enhance and protect our quality of life.

USGS is an objective, fact-finding agency that collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. It accomplishes its mission using in-house scientific expertise in partnership with other federal, academic, and industrial personnel.

USGS spends approximately $1.2 million per year on hydrates research in four major areas: natural hazards, resources, the environment, and information and data management. Much of the USGS work on methane hydrates has been done in cooperation with other agencies. The goals are to understand natural gas hydrates in relation to energy resources, sea-floor stability/drilling safety, and global carbon budget/climate effects. USGS seeks to identify gas hydrates by remote sensing, and to understand processes that control hydrates in nature through five study groups:

- ***Marine Geophysical Studies.*** This group concentrates on seismic reflection profile data collected at sea. Regional high-resolution seismic studies in the GOM are determining the acoustic character of the gas-hydrate stability zone, the potential distribution of gas hydrates, and the potential link between gas hydrates and slope stability. Regional maps of gas hydrate variability have been completed on the U.S. Atlantic continental margin. A depression of about 400 km (249 mi) has been studied in the Blake Ridge region offshore South Carolina (1) to consider its implications for sea-floor stability and drilling safety, (2) to determine the age of the sediments, and (3) to research methane flux.
- ***Well Logging and Arctic Geological Studies.*** Extensive work has been done in northern Alaska, northern Canada, and on

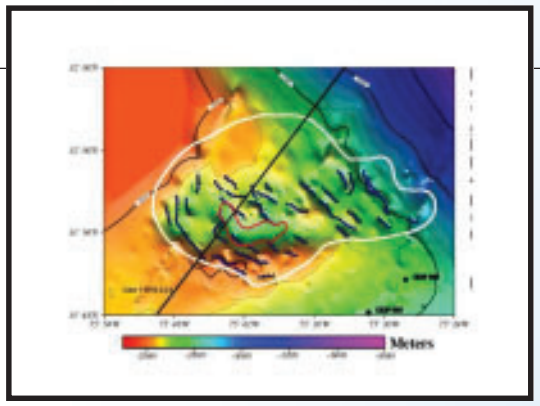
USGS
science for a changing world

The GHASTLI system simulates deep-sea conditions.

the Blake Ridge. USGS partnered with the Japan National Oil Corporation and the Geological Survey of Canada in drilling a Canadian Arctic well. Collaborative work is also planned with oil companies to assess the recoverability and potential production characteristics of onshore hydrates and free gas accumulations in the Prudhoe Bay-Kuparuk River area. Other joint studies will include the examination of downhole log data from offshore wells drilled under the ODP.

- ***Physical Properties Studies of Natural and Laboratory-Formed Gas Hydrate-Sediment Mixtures*** using GHASTLI, which tests cores containing sediment, water, water ice, and gas hydrates and their variations with gas hydrate content. The data can be used to predict in-situ behavior and relate predictions to remote sensing data and well logs. Lab-created gas hydrate-sediment mixtures have been analyzed, as have naturally occurring gas-hydrate-bearing cores obtained in cooperative studies with the ODP and with the Japan National Oil Corporation/Geological Survey of Canada.
- ***Petrophysics.*** This group provides information on sediment properties to better understand the effects hydrates have on sediment in-situ. This information helps bridge the gap between measurement of textures/properties of lab-synthesized and naturally occurring hydrate-sediment aggregates.
- ***Organic Geochemistry.*** A goal of this study group is to compare and contrast the gas composition of synthetic and naturally occurring gas hydrates. The purpose is to improve the interpretation of geophysical data on the extent and abundance of gas hydrates.

USGS is currently supporting gas hydrates studies in the GOM, Blake Ridge, and the Alaska and Canada Arctic, in part using DOE funding. These programs focus on remote sensing, processes controlling hydrates in nature, and measurement and testing of arctic deposits.



This bathymetric map shows the Blake Ridge region located on the continental shelf offshore South Carolina.

Selected USGS Hydrate Projects

- International collaboration between Japan, Germany, Canada, and DOE exists for a production test well in northern Canada.
- USGS has proposed projects to characterize the hydrate resource in Alaska.
- Cruises in the GOM in the summer of 2002 are planned to collect geophysical data and giant piston cores (50 m or 164 ft) at hydrate sites.
- USGS is preparing for the Mallik well production test this winter.
- Petrophysical studies with MBARI are under way on hydrates dissolution rates in the deep ocean. Further studies are planned.

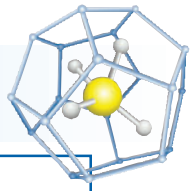
Participating Agency

National Science Foundation

NSF is an independent U.S. government agency responsible for promoting science and engineering through programs that invest over $3.3 billion per year in almost 20,000 research and education projects in science and engineering. NSF was established by the National Science Foundation Act of 1950 to promote the progress of science; advance national health, prosperity, and welfare; and secure our national defense. NSF partnerships—with academia, industry, and state and local governments—advance science, engineering, mathematics, and technology through nationwide research and education programs.

NSF funds research and education in most fields of science and engineering. It does this through grants to and cooperative agreements with more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations, and other research institutions throughout the United States. NSF accounts for about one-fourth of all federal support to academic institutions for basic research. The Foundation operates no laboratories itself, but does support national research centers, user facilities, certain oceanographic vessels, and Antarctic research stations. It also supports cooperative research between universities and industry and U.S. participation in international scientific efforts.

NSF interest in methane hydrates is coordinated through its ocean and climate research efforts. The ODP collects and logs geologic samples from the floor of deep ocean basins through rotary coring and hydraulic piston coring. Logs and samples of the cores are available to qualified scientists worldwide for research projects. Drilling operations are managed by Texas A&M University, and logging is managed by the Lamont-Doherty Earth Observatory at Columbia University. NSF is interested in investigating (1) potential drilling regions, especially by means of regional geophysical field studies; (2) the feasibility and initial development of downhole instruments and techniques; and (3) downhole geophysical and geochemical experiments.



Although NSF funds were not specifically earmarked for hydrates R&D, NSF selected almost $4 million in gas hydrates projects for support in FY 2001. NSF is a major supporter of ODP hydrates studies offshore Oregon and Vancouver. It contributed to the Deep East expedition, and has funded investigations of how changes in the composition of atmospheric gases affect climate. For example, paleo-climate studies involve measuring atmospheric gases trapped in ice cores. These studies show evidence that very rapid climate changes in the past were related to increased greenhouse gases and the amount of carbon in the atmosphere. Large quantities of carbon are trapped in methane hydrates; thus, it is important to investigate and model the effects of methane release into the atmosphere.

NSF's methane hydrate research is a collaborative effort involving several research institutions, such as the University of Texas Institute of Geophysics, Georgia Institute of Technology, Woods Hole Oceanographic Institute, University of Wyoming, and the University of Oregon.

The primary goal of research on extreme environments is to define microbial communities and processes in brine and gas hydrate environments, and to understand the interrelationship between the microbiota and the geochemistry of the system. Microbial communities that inhabit Earth's extreme environments provide a framework for studying the origin and evolution of life on Earth, and the potential for detecting life on other planets. It is vital that we understand all facets of the environment before any exploitation of methane hydrates can occur.

Selected NSF Hydrates Projects

- The *Life in Extreme Environments* project is jointly funded by NSF's Division of Biological Oceanography and the ODP. This project focuses on the microbiology and biogeochemistry of two "extreme" sea-floor environments. Cruises in 2002 will visit GOM brine pools and methane mounds.
- NSF and the German Ministry of Education are jointly funding geophysical research on hydrates offshore Peru.
- DOE and NSF funded a project to convert sound waves to shear waves, because shear waves are sensitive to gas hydrates.
- NSF funded a two-ship program to study gas hydrates at convergent plate margins.
- NSF is supporting a study to document methane leakage from the Arctic Shelf caused by gas hydrate decomposition related to a rise in the sea level.

The JOIDES Resolution is 143 m (470 ft) long and 21 m (70 ft) wide. The ship's derrick towers 26 m (202 ft) above the waterline. A computer-controlled dynamic positioning system, supported by 12 powerful thrusters and two main shafts, maintains the ship over a specific location while drilling into water depths up to 8,230 m (27,000 ft). A seven-story laboratory stack and other scientific facilities located fore and aft occupy 1,115 m^2 (12,000 ft^2).

Methane Hydrate Interagency Coordination Plan

Interest in naturally occurring methane hydrates is growing. Many nations, intrigued by the vast volumes of methane contained in hydrates and the promising results of recent well tests in Japan and Canada, are starting to think of hydrates as a future energy source. The widespread occurrence of methane hydrates indicates that the resource could dramatically alter the international balance of power with regard to energy supply as well as provide energy self-sufficiency to many nations now dependent on others.

The growing recognition that methane hydrates exist on a massive scale in nature presents public interest issues that require immediate and focused investigation:

- We need to find ways to mitigate the potential hazards that hydrates pose to ongoing deep-water oil and gas drilling and production, and
- We must better understand the role methane hydrates play in the natural environment.

Vast methane hydrate accumulations are continually absorbing and releasing methane gas as they equilibrate in response to natural changes in pressure, temperature, and geochemical regimes. This vast, dynamic, and previously unnoticed methane storehouse raises questions about our current understanding of the global carbon cycle, long-term climate, sea-floor stability, and other natural phenomena. A successful National Methane Hydrate R&D Program will answer many of these questions and will have enormous long-term public-interest benefits.

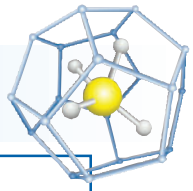
National Methane Hydrate R&D Program Goals

Primary Goals:

- Provide the knowledge and technology to ensure the safety of deep-water oil and gas operations.
- Fully realize the potential of methane hydrates to support our Nation's continued economic growth, energy security, and environmental protection.

Near-Term (by 2005):

- Conduct laboratory and field studies on methane hydrates to compile more complete data on the physical and chemical properties of hydrates and hydrate-bearing sediments.
- Provide databases on methane hydrate topics on a global website for use by the entire methane hydrate R&D community.
- Conduct initial investigations into the relationships among naturally occurring methane hydrates, the global carbon cycle, and climate; and report results to Congress.
- Provide improved assessments of the distribution and volume of methane hydrates.
- Provide practical means to avoid or mitigate the potential hazards of overlying hydrate deposits on conventional oil and gas production in the GOM.
- Develop improved seismic and other geophysical tools for hydrate identification and characterization.
- Develop pressure/temperature-controlled devices to collect and preserve samples in low-temperature, high-pressure environments.



Mid-Term (by 2010):

- Refine analytical tools to identify and characterize naturally occurring methane hydrates.
- Produce estimates of the recovery potential from methane hydrates.
- Develop and test engineering concepts for producing methane from hydrate deposits.

Long-Term (by 2015):

- Commercially produce methane from hydrates, providing a secure, long-term supply of domestic natural gas.
- Allow the continued safe production of oil and gas from deep-water deposits overlain by hydrates.
- Provide a comprehensive knowledge base and suite of analytical tools to support ongoing research into methane hydrates and their role in the global environment.
- Secure the United States as a global leader in the science of natural gas hydrates and the technology of hydrate production.

Federal Advisory Committee

Effective collaboration and coordination among agencies require that these agencies also work in partnership with industry and academia. The Methane Hydrate R&D Act of 2000 established the Federal Advisory Committee. This committee consists of experts outside the government, including industrial enterprises and institutions of higher learning. The Committee advises the Secretary of Energy through the Assistant Secretary for FE, and is charged with recommending research priorities for the program and for reporting to Congress on the impact that hydrates have on global climate change. In addition, this committee coordinates with member agencies by inviting ICC members to attend meetings. The first meeting of the Federal Advisory Committee occurred in May 2001.

Interagency Coordination Committee

Congress passed and the President signed the Methane Hydrate R&D Act of 2000. In response, the agencies named in the legislation formalized their collaboration on hydrates research with the creation of the ICC. The member agencies are (1) DOE through FE and NETL's SCNG, (2) DOC represented by NOAA, (3) DoD represented by NRL, (4 and 5) DOI represented by MMS and USGS, and (6) NSF.

The purpose of the ICC is to increase communication and sharing of information and resources among member agencies. The Committee responds to the Act and answers a need of the National Methane Hydrates Research Program. DOE is responsible for coordinating ICC activities. The ICC is required by law to meet every 120 days to review progress of the program and make recommendations on future activities. The overall purpose of these meetings is to avoid duplication of effort and to collaborate on hydrates R&D. Committee meetings encourage sharing of information on past, present, and future work by each agency.

Bringing together national groups with significant experience in hydrate R&D should stimulate the creation of new ideas as well as new ways to solve problems. Each agency has unique abilities, experiences, and resources that will be valuable in R&D coordination. This collaboration facilitates the sharing of resources, and thus, increases the efficiency and scope of the individual agency programs.

The ICC met for the first time in January 2001. The agencies exchanged information about ongoing hydrate R&D activities at that first meeting and determined that an interagency Technical Coordination Team would be beneficial to ensure the free flow of information among agencies.

Technical Coordination Team (TCT)

- TCT includes representatives from each of the six ICC member agencies.
- Team members possess highly technical methane hydrate knowledge and expertise.
- TCT provides input to shape methane hydrates R&D program.
- TCT reviews projects and identifies methods for collaboration.
- TCT enhances agency collaboration on hydrates R&D.

Methane Hydrate R&D Cooperative Projects and Workshops

The member agencies collaborate on specific R&D projects. One means of collaboration is the joint funding of programs for outside research. For example, in October 2000, NETL's SCNG, NOAA's NURP, and MMS conducted two GOM dives to collect hydrate samples. Scientists under the direction of Texas A&M University assessed outcroppings and retrieved samples from the GOM floor. The scientists traveled to the sea floor aboard the deep submergence vehicle Alvin. A first-of-its-kind special website was established at NOAA and NETL for this project. The website featured daily videos about the hydrate program, daily conversations with researchers on board the ship, and daily interactive question and answer sessions.

A DOE- and NSF-funded project with the Universities of Wyoming and Texas is another example of cooperative work. This project included a research cruise aboard the research vessel Ewing to acquire two related data sets: a 3-D MCS reflection image of the hydrate/gas system on the Blake Ridge; and two profiles of three-component, ocean-bottom seismometer data. These data will show whether shear wave velocity is a potential indicator for hydrates in sediments.

Another mechanism for cooperative R&D projects between agencies is the direct transfer of funds from funding agencies to performing agencies through interagency agreements such as those that exist between DOE and USGS, and DOE and NRL. For example, in FY 2000, DOE provided funding to USGS and MBARI to conduct a

piston coring study in the Blake Ridge area. The purpose of this effort was to define the origin and age of a collapse structure possibly related to naturally occurring gas hydrates. A better definition of this structure will aid in understanding of the known gas hydrates in the Blake Ridge area, with implications for both gas resource estimates and sea-floor safety and stability. A total of 33 piston cores and 14 gravity (trigger) cores were recovered during the 9-day cruise in July 2000. All together, 240 m (787 ft) of piston core samples were collected.

Effective interagency information exchange requires more than just meeting with the technical and management leads from these organizations. Each agency has programs with many participants. Therefore, the ICC plans to hold a jointly sponsored hydrate R&D review conference on a routine basis. The purpose of this conference is to establish open lines of communication between researchers to foster partnerships and joint projects. The conference will feature hydrate projects with industry, academia, national laboratories, government agencies, and nonprofit organizations. The first of these conferences will be held in 2002.

National Methane Hydrate R&D Website—www.netl.doe.gov/scng/hydrate

The ICC plans to make methane hydrates information available on a continuous basis via the internet. In November 2001, SCNG launched the U.S. National Methane Hydrate R&D website. The purpose is to stimulate worldwide cooperation in addressing the entire spectrum of issues surrounding this potentially enormous energy resource. The website is a repository of information dealing with methane hydrate issues. Major areas of information include resource characterization, methane production, global carbon cycle and climate change, and safety and sea-floor stability.

Featured website topics include

- Newsletter—covers the latest development in hydrate research,
- The National R&D Program—the role of U.S. Government in stimulating R&D,
- Interagency Coordination Plan—path to the future,
- Methane Hydrate Data Bank—technical information on worldwide resources, and
- Participants—the people and institutions exploring opportunities.

Although SCNG maintains the website, all the agencies involved in the hydrate program have input into the contents. The ICC is exploring all methods of possible communication and collaboration.

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