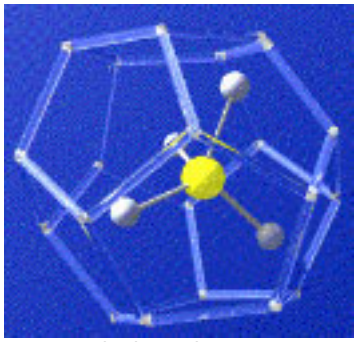
USGS Gas Hydrates

SUMMARY:

Gas hydrate is a crystalline solid formed of water and gas. It looks and acts much like ice, but it contains huge amounts of methane; it is known to occur on every continent; and it exists in huge quantities in marine sediments in a layer several hundred meters thick directly below the sea floor and in association with permafrost in the Arctic. It is not stable at normal sea-level pressures and temperatures, which is the primary reason that it is a challenge to study. It is important for three reasons: (1) It may contain a major energy resource; (2) It may be a significant hazard because it alters sea floor sediment stability, influencing collapse and landsliding; and (3) The hydrate reservoir may have strong influence on the environment and climate, because methane is a significant greenhouse gas. In the late 1990's, major interest developed in gas hydrate research and, in 2000, Congress passed the Methane Hydrate Research and Development Act of 2000, instituting a national gas hydrate research program. The Department of Energy is named as lead agency and Department of Interior, specifically the USGS, is named as one of four other cooperating agencies. The program as defined in the law will be managed by the Fossil Energy Program in DOE. The Coastal and Marine Geology and Energy Resources Programs in USGS have worked closely with the Fossil Energy group to assist them to plan the research program. DOe has supported our research generously over many years, especially for field programs, and we expect that this mutually valuable cooperation will continue as the research program continues. This project seeks to understand the occurrences of and geological processes that control methane hydrate in the natural environment. This includes topics such as identifying and quantifying gas hydrate from remote sensing techniques, determining its concentration into possibly extractable accumulations, studying how it changes the strength of sediments and generates overpressures, understanding processes of seafloor mobilization, and determining processes that sequester methane in the sediments and allow its transfer into the oceans and the atmosphere. Collaborations with academia and industry further explore the role of bacteria in methanogenesis in sediments and the hazards posed by gas hydrate for the offshore drilling industry.



hydrates image

INVESTIGATORS:

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DESCRIPTION:

There are four strategic objectives and four parallel long-term science goals for this project, which are more fully described in the USGS Gas Hydrates 5-year plan. (1) Strategic Goal 1: Contribute to Understanding the Energy Resource Potential of Onshore and Offshore Gas Hydrates Long-term Science Goal 1: Construct quantitative source-migration-reservoir models of the hydrate system for specific and general cases. (2) Strategic Goal 2: Assess the Role of Gas Hydrates in Sea-floor Stability Long-term Science Goal 2: Develop predictive capability for how gas hydrates interact with natural and man-made phenomena to affect sea-floor properties. (3) Strategic Goal 3: Assess the Role of Gas Hydrates in Global Climate Change Long-term Science Goal 3: Assess hydrates as a potential and/or significant source of green-house gas emissions? (4) Strategic Goal 4: Expedite Project and Information Management for USGS Gas Hydrates Research Long-term Science Goal 4: Maintain research flexibility and relevance in order to continue cutting-edge research in a viable and well-funded project. These objectives, broad in scope but focused in purpose, will set priorities for hydrates research through 2009 and position USGS to play a leadership role in the increasingly popular and competetive field of hydrates research. They will also ensure that USGS hydrate research evolves from description and characterization of hydrates to understanding and modeling the dynamic and highly interactive Earth processes that control their behavior.

START DATE OF PROJECT:

October 1, 1999

END DATE OF PROJECT:

September 30, 2008

TOPIC:

Domestic Resource Studies, Primary Energy Resources

APPROACH:

The USGS Gas Hydrates (GH) Project functions under a 5-year plan (FY 2005-2009) that defines strategic goals and objectives. This workplan represents the implementation of these objectives, which are identified in tasks and subtasks. An external scientific panel that reviewed scientific activities at the USG-WH commented about the GH project "...the project planning and develpment process embodied in this effort can serve as a model that should be applied towards other projects within the program." (Report, 1 June, 2005). We propose a strategy of multiple technical groups that have overlapping and mutually supporting interests. These groups work jointly on science tasks. Each technical group has a unique expertise essential to the geologic study of GH: (1) Field Geophysical studies that link geologic framework to natural GHoccurrence, include collection/interpretation of seismic data, GoMex and North Slope of AK, and eventually from other field areas. This work is performed at the seismic processing center in Den (3D) and at the smaller seismic processing centers (2D) in MP and WH. (2) Well logging studies link field studies and lab analyses to drilling results (North Slope of AK, GoMex, and Arctic) in cooperation with industry drilling. Further cooperative studies are anticipated with offshore holes drilled by the IODP. (3) Laboratory studies of physical properties of GH/sediment mixtures and pure GH are essential for understanding drilling results and developing parameters to constrain numerical models of GH behavior. These studies are carried out at the WH GHASTLI system, where natural and synthetic GH/sediment mixtures are studied, and at the MP petrophysics lab, where properties of pure GH are studied. Additional experiments are performed to investigate dynamic and pore-scale properties (e.g., dissociation rates, cage occupancy). (4) Geochemical analysis to determine the gases present and quantities of gas in natural samples will be carried out in the organic geochemistry laboratory at MP. Samples are analyzed from preserved samples that come from field and drilling programs that USGS participates in, and that are provided from other national and international research programs. (5) Numerical modelling is carried out in conjunction with field, laboratory, and theoretical studies to help develop a predictive capability for GH behavior. Field studies utilize seismic inversions and velocity calibrations to quantify GH volume in a regional setting. Models at outcrop scale (e.g., soil models) and at regional scales (e.g., basin models) help constrain drilling, chemical, and fluid flux observations. Models of pore-scale behavior (e.g., rock constitutive properties) help constrain laboratory observations. The level of expertise for these modeling skills varies amongst the centers. (6) Cooperative collaborations with federal and state entities, industry, and academia are utilized for maximizing scientific results from field, lab, and theoretical experiments. Examples of these cooperatives include geophysics (Ga. Tech, NRL); bottom photography (WHOI), well logging (industry), lab expts (NRL, Ga. Tech), geochemistry (MBARI), isotope analyses (Univ. Victoria), modelling (LBNL). FUTURE WORK The GH project anticipates similar levels of effort through the duration of the five year plan. We intend for OE to be augmented by reimbursable monies, especially to cover USGS leadership and participation in future field programs (phase 2 drilling GoMex JIP; phase 2 drilling by BP, NS of AK; and a possible new production test well, Mallik). The addition of a new hire (modeling) part way through FY2006 will serve to integrate USGS lab and field efforts, and help set priorities for synthesizing data and defining critical experiments.

IMPACT/RESULTS:

3 aspects of natural gas hydrate (GH) have justified its study (Sloan et al., 1999): 1. Energy: GH#s contributions to world energy depends on the availability, producibility, and cost of extracting methane from the hydrate phase. Yet the overall size and producibility at any one site are still rudimentary. Few dedicated surveys to identify GH deposits have been conducted, better methods to identify them need to be developed, particularly to identify zones of high concentrations. Our understanding of processes that control GH accumulation/extraction is primitive. 2. Seafloor Stability: Substantial direct observational evidence exists for major seafloor collapses, submarine slides, and drilling hazards that may be linked to the presence of GH. GH processes influence seafloor and well-bore stability by causing substantial changes in the physical properties of shallow sediments. 3. Global Change: The global GH reservoir may affect climate because of the greenhouse gas properties of methane. Changes in pressure/temperature can release methane from GH, e.g., by ocean warming. Understanding how GH is mobilized and migrates is critical for evaluating the role of GH in earth history and in global change. The first three strategic objectives and long-term science goals of the GH project parallel these three impacts. The US Department of Energy GH Program emphasizes the first and second of these impacts. Research into any of the impacts is likely to also reap benefits for the other two. OUTCOMES: Five areas show how USGS GH research has made an impact beyond project goals: * USGS plays a key role in rendering scientific judgment to national-level panels and committees: USGS scientists - have testified in hearings/briefings to Congress; are members of the DOE Interagency Federal Coordinating Committee; were invited speakers at 2 out of 3 public meetings of the NAS/NRC Review of DOE Activities under the MHR and D Act of 2000; were invited speakers at a DOS workshop on the foreign policy implications of GH. * USGS GH research has influenced decisions by management to assess GH natural resources and hazards: USGS scientists - advise MMS in developing new methodologies for assessing energy production potential of marine GH; are developing updated assessments of GH on the North Slope of AK with BLM and AK; are invited advisors to the AK GH study (BP) to identify hydrate deposits for drilling; are invited scientific advisors to the GH JIP (Chevron) to understand GH in Gulf of Mex as a hazard; were asked to lead the logging science for GH drilling of ODP, two Mallik drilling programs, and for the Chevron JIP, Gulf of Mex. * USGS research has had a profound effect on the direction of GH science: USGS lab measurements - are critical inputs that allow improvements to Production Gas Models; are regularly incorporated into models of logging properties and of offshore sediment stability. USGS GH papers are published in and cited extensively in prominent peer-reviewed journals. USGS scientists contribute to NSF and DOE proposal reviews. Foreign scientists/managers regularly visit the WH, MP, and Denver labs to learn how to develop critical expertise (e.g., Japan, India, Korea, China, Indonesia, Russia, Germany). * USGS GH research has resulted in considerable cost-savings for the GH project: USGS received natural samples of GH-bearing material from drilling programs without having to support acquisition costs (e.g., ODP, Mallik, Gulf of Mex). These samples help maintain USGS leadership in GH research which leads to

low-cost or no-cost collaborations with academic and international partners. * USGS is regularly consulted by the media about GH: USGS scientists respond to 5 -10 inquiries/year from newspapers, magazines, talk radio, and documentary film makers. USGS scientists also respond to questions from the public that arise from email about materials that are on the web.