Oil & Natural Gas Technology

DOE Award No.: DE-FC26-01NT41330

Final Integrated Project Report
Report #41330R28

Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities

Principal Investigator:
Jimmy Bent
Chevron Energy Technology Company
1500 Louisiana Street
Houston, Texas 77005

Prepared for:
United States Department of Energy
National Energy Technology Laboratory

June 2014

Office of Fossil Energy

DISCLAIMER

"This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favouring by the United States Government or any agency thereof. The views and opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

ABSTRACT

In 2000 Chevron began a project to learn how to characterize the natural gas hydrate deposits in the deep water portion of the Gulf of Mexico (GOM). Chevron is an active explorer and operator in the Gulf of Mexico and is aware that natural gas hydrates need to be understood to operate safely in deep water. In August 2000 Chevron worked closely with the National Energy Technology Laboratory (NETL) of the United States Department of Energy (DOE) and held a workshop in Houston, Texas to define issues concerning the characterization of natural gas hydrate deposits. Specifically, the workshop was meant to clearly show where research, the development of new technologies, and new information sources would be of benefit to the DOE and to the oil and gas industry in defining issues and solving gas hydrate problems in deep water.

Following this workshop, Chevron formed a Joint Industry Project (JIP) in 2001 to write a proposal to conduct research concerning natural gas hydrate deposits in the deep water portion of the Gulf of Mexico. That proposal was selected for award by the DOE, and Chevron was awarded a cooperative agreement for research based on the proposal (DOE Award: DE-FC26-01NT41330). The title of the project is "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities".

Since 2001 the JIP has engaged in a multiyear effort to develop technology and collect data to assist in the characterization of gas hydrates in the deep water Gulf of Mexico. Other JIP members include ConocoPhillips, Schlumberger, Halliburton, Japan Oil Gas and Metals National Corporation, U.S. BOEM, Total, Reliance Industries Ltd., Korean National Oil Company, and Statoil.

During the project's first phase (Phase I), the JIP performed technical investigations into the occurrence, nature, and implications of gas hydrate in the Gulf of Mexico. Results included the development of seismic modelling and interpretation methods to identify and characterize hydrate deposits in deep water environments, a series of laboratory investigations to determine the impact of gas hydrate occurrence on sediment physical properties, identification of geohazards and well bore stability issues, and development of drilling and coring methods through hydrate intervals. Several workshops and conferences were held to share the results and to plan the subsequent phases of the project.

In next phase (Phase II) the JIP completed the project's first offshore drilling expedition in 2005 (Leg I) consisting of drilling, logging, and coring operations in fine-grained sediments at five locations in two GOM areas (Atwater Valley 13/14 and Keathley Canyon 151). The program collected an outstanding suite of well-logs and borehole seismic through the hydrate stability zone and collected over 200 meters

of core. Leg I demonstrated the viability of pre-drill techniques and technologies used for hydrate identification and characterization, and it demonstrated the ability to safely drill and operate in areas of hydrate occurrence.

Following on the success of Phase II the project moved to Phase III, which included a second offshore drilling expedition (Leg II). During this expedition extensive Logging While Drilling (LWD) data were acquired from additional GOM locations in order to further evaluate hydrate drilling hazards, to provide information on gas hydrate resource potential, and to develop plans for a third offshore expedition (Leg III) that focused on hydrate coring. Planning for Leg II began in 2005 with the evaluation of numerous sites prospective for the occurrence of gas hydrate at high saturations. Three sites were ultimately selected, and the Leg II drilling program was completed in 2009. Given program budgets, Leg II focused on LWD collection to confirm gas hydrate occurrence – with coring deferred to a later Leg. The Leg II operation obtained extensive LWD data from seven drilling locations at three GOM areas (Green Canyon 955, Walker Ridge 313 and Alaminos Canyon 21).

The scientific and operational objectives of the Leg II expedition were achieved, and the program was executed on budget and without any safety incidents. The logging program used an advanced set of LWD tools that obtained multi-azimuth images of the hydrate bearing sediments. Logs were successfully acquired at all locations. The string of tools provided shear and compressional wave slowness, resistivity, porosity, density, and gamma ray. The pre-cruise hydrate estimates were in agreement with the LWD data obtained in six of the seven wells drilled. High concentrations of hydrates were found in the sand bodies in four wells. The expedition proved that the methods employed by the JIP to locate and predict hydrates were accurate. As in Leg I, pre-drill seismic analysis was used to develop pseudo well logs (for Walker Ridge 313 and Green Canyon 955 drilling locations) which were compared to the actual field logs obtained during drilling. The predictions from this data proved to be accurate based on comparison to the actual results. Leg II successfully demonstrated the occurrence of gas hydrates at medium to high saturations in reservoir-quality sands in the GOM. The hydrate deposits were found in close accordance with pre-drill predictions, demonstrating the validity of the hydrate exploration and appraisal tools and techniques used in finding, delineating, and characterizing targeted accumulations.

Encouraged with Leg II results, the JIP planned to continue the drilling and coring program in a follow-up Phase (Phase IIIB) to obtain pressurized cores and to characterize hydrates at as close to in-situ conditions as possible. The plan for Phase IIIB included a Leg III offshore expedition to twin some of the previous wells drilled in order to collect extensive continuous pressure cores, wireline logs, wireline pressure profiles and fluid samples from gas hydrate bearing sand horizons. These pressure cores would be cut with a customized core barrel to retain in-situ pressure during the acquisition, retrieval, and transportation operation. Early versions of pressure coring tools were developed by industry prior to Phase III, but the JIP placed a focus on further development and testing of a pressure coring system in Phase III. Extensive work on the pressure coring system ramped-up in 2010 when Aumann & Associates (AAI) proposed the development of a High Pressure Temperature Corer (HPTC) for the JIP. A design and manufacturing contract for HPTC was awarded to AAI by the JIP in 2011. Following field testing of a related AAI prototype Pressure Coring System in Japan in July 2012, the design of the JIP system was changed to a Hybrid Pressure Core System (Hybrid PCS) and AAI was awarded a contract to design and manufacture the Hybrid PCS. Early in November 2013, the Hybrid PCS was tested for functionality at an onshore test at the Catoosa Test Facility in Hallett, Oklahoma. Several performance issues were observed during the Catoosa test. A technical review was subsequently conducted and the root causes of performance issues were identified. AAI has since upgraded the Hybrid PCS to rectify the performance issues observed at Catoosa, but the revised system has not undergone field-based testing.

In addition to further development of pressure coring tools, work was also conducted in Phase III to further develop the measurement systems that could be used to analyse the pressure cores under in-situ pressure conditions. This work was conducted by two collaborating research teams of scientists over many years: the USGS and the Georgia Institute of Technology. These teams have successfully developed the Instrumented Pressure Test Cell (IPTC) and the Pressure Core Characterization Tool (PCCT) systems. These systems have the capability to perform a number of analyses of hydrate core properties under in-situ pressure conditions. Early designs were tested in 2005 during the Leg I expedition. More recent field testing of the systems has been successful on pressured cores collected offshore Japan in January 2013.

Phase III also included the planning of a Leg III drilling expedition to collect hydrate pressure cores in offshore GOM. Preliminary planning work was completed by several project science teams in early 2010. However, after the Macondo well incident in GOM in 2010, a team of Chevron scientists and the Chevron Deepwater Drilling Operations Group completed a detailed assessment of drilling plans, well designs, and safety considerations. It was determined by this group that GOM deep water drilling operations by Chevron would require the use of a sixth generation deep water drillship. Largely because of the cost for this type of drilling program the Leg III expedition was not pursued in this project.

The project was concluded in May 2014. Final delivery of equipment and reports was completed by the end of the 90 day close-out period, which concluded in August 2014.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In 2001 Chevron formed a Joint Industry Project (JIP) group to conduct research concerning natural gas hydrate deposits in the deep water portion of the Gulf of Mexico (GOM). Chevron generated a research proposal which was submitted to DOE in April 2001 under a competitive DOE funding opportunity announcement (FOA). That application was selected for award by DOE under the FOA and Chevron was awarded a cooperative agreement for research based on the proposal. The title of the project is "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities". The project was funded and started in October 2001. At the project completion in May of 2014 total project funding was approximately $50MM ($35MM from the DOE and $15MM from the JIP). Over a period of 12 years the project completed a wide scope of hydrate scientific research, technology development, and technology testing / application. The project included drilling, logging, coring, acquisition and analysis of hydrate data and samples, development of analytical methods, and construction, testing and delivery of coring equipment and tools. The project included 10 JIP member companies and 20 subcontractors, including Universities, Oil and Gas Industry Service companies, Suppliers, Manufacturers, and Government Agencies. Data obtained by the project enabled over 180 technical reports / publications and over 120 technical presentations at industry forums. Thirty five University or College students contributed directly to the project and received educational funding. The project was concluded in May 2014. This report is the high level summary of the entire project.

Background

The project was set up to develop technology and collect data to assist in the characterization of gas hydrates in the deep water GOM. The efforts undertaken in Phases I and II of the project reflected industry's desire to more fully understand the safety issues related to conventional oil and gas operations in areas prone to hydrate occurrence. These goals necessitated the utilization of advanced seismic processing and interpretation methods, the collection of samples to validate assumptions that drive seismic interpretations, the determination of hydrate impacts on wellbore stability, and the development of field sampling methods.

The focus of activities under Phase III of the project was on the characterization of concentrated, reservoir-relevant, gas hydrate occurrence in coarse-grained intervals. This work helped to quantify the seismic and geologic hydrate prediction methods that were developed in project, while also providing valuable insight into the behaviour of concentrated hydrate occurrence. This activity also helped to advance a major program goal to assess the hazard and energy resource implications of marine gas hydrates.

Impacts

Results from this project have several key impacts:

- Increased the understanding of risks and appropriate operational procedures for conducting traditional oil/gas activities in areas of gas hydrate occurrence.
- Provided advanced techniques and technologies used to analyse and interpret gas hydrates in field and laboratory settings.
- Contributed to the scientific understanding of the role of gas hydrate in the global climate.
- Characterized gas hydrate occurrence in the deep water GOM.
- Served as a vital step in determining the commercial viability of offshore gas hydrate accumulations.

Key Accomplishments in Phases I and II:

- Completed an extensive array of laboratory studies on the physical and mechanical properties of fine-grained, hydrate-bearing sediments.
- Developed and applied seismic interpretation methods to identify and characterize hydrate deposits.
- Identified and characterized geohazards associated with drilling through hydrates during development of deeper conventional hydrocarbon resources.
- In May 2005, conducted the first dedicated hydrate drilling, logging, and coring expedition in the GOM (Leg I). Results include:
  - Drilled five wells at two distinct GOM locations (AV13/14, KC151)
  - Collected an outstanding suite of well-logs and borehole seismic through the hydrate stability zone.
  - Collected over 200 meters of core and conducted the first deployment of pressure core analyses devices.
  - Identified a 60 meter thick interval with hydrate saturation.
  - Demonstrated the viability of pre-drill techniques and technologies used for hydrate identification and characterization.
  - Demonstrated the ability to safely drill / operate in areas of typical GOM gas hydrate occurrence.
- Developed and field tested new tools to enable ship-based handling and analyses of field samples from marine hydrate expeditions.
- Furthered the development of pressure core capabilities by supporting the analysis of pressure cores taken during the Indian government's summer 2006 expedition.
- Conducted a series of workshops to set the criteria for selection and recommend possible sites for future Leg II and Leg III drilling expeditions in GOM.

Key Accomplishments in Phase III:

- Completed the design and construction of a new pressure coring tool and updated the pressure core analysis and transfer system.
- Completed the design and construction of enhanced pressure core manipulation and testing devices and several pressure core sub-sample analysis tools including the Instrumented Pressure Test Cell (IPTC) and Pressure Core Characterization Tool (PCCT).
- Completed modifications and testing of the IPTC and PCCT.
- In collaboration with federal partners, completed a detailed site evaluation and selection for the Leg II drilling and logging expedition, which resulted in defining drilling targets within GOM lease blocks AC818, WR313, GC955, AC21/65, EB990/992, and GC781/825.
- Successfully completed the Leg II drilling and logging expedition program. Results included:
    - Drilled and logged seven wells.
    - Demonstrated the occurrence of gas hydrates at high saturations in reservoir quality sands in four of the wells.
    - Found hydrate deposits in close accordance with pre-drill predictions in six of the seven wells, demonstrating the validity of the hydrate exploration and appraisal tools and techniques.
    - Logging featured the use of an advanced suite of logging-while-drilling tools that provided unprecedented 3D images of the hydrate-bearing sediments.
    - Wells drilled at WR313 represent the deepest gas hydrate research wells drilled in the world to date.
    - Discovered some of the most promising marine hydrate accumulations in the world.
- Public release of initial Leg II scientific results via the NETL website in March 2010.
- Completed modifications to the design of the Hybrid Pressure Coring System (PCS). A total of fifteen modification improvements over the previous design were incorporated into the design. The design improvements are based on knowledge derived from data gathered from the JOGMEC pressure coring operation offshore Japan in 2012.
- Field tests of the Instrumented Pressure Test Cell (IPTC) and Pressure Core Characterization Tool (PCCT) core analysis systems were successfully conducted (in collaboration with the Japanese Hydrate Program) in Japan in January 2013 through analyses of core collected during 2012.
- Presented project activity, status, and results to date at the 7th International Conference on Gas Hydrates in Edinburgh, Scotland.
- Completed the initial selection of a Leg III offshore expedition science staff and the definition of scientific targets and objectives.
- After the Macondo well incident in the GOM, Chevron completed a Leg III operational and drilling safety assessment. This evaluation mandated a Leg III operational plan with very specific safety

requirements and the use of a sixth generation offshore drill ship. The operational plan and the estimated cost of the Leg III program resulted in a decision to eliminate plans for the Leg III expedition from this project.

- Aumann & Associates Incorporated (AAI) completed the construction of the Hybrid PCS. Factory acceptance tests were conducted in September 2013 at AAI's facility in Salt Lake City.
- Chevron engineers developed the plan and executed some portions of the drilling/coring functionality test of the Hybrid PCS at the Catoosa Test Facility in Hallett, Oklahoma. Issues with the system necessitated further analysis and changes to the system.
- Completed root cause analysis for issues discovered during the drilling / coring functionality testing of the Hybrid PCS at Catoosa.
- Completed modifications to the Hybrid PCS based on the issues found during drilling / coring functionality testing at Catoosa.
- Completed final project reporting and delivery of coring tools and associated equipment to the DOE.

1. INTRODUCTION

In 2000 Chevron began to frame a project to characterize the natural gas hydrate deposits in the deep water Gulf of Mexico (GOM). Chevron is an active explorer and operator in the Gulf of Mexico and was aware that natural gas hydrates needed to be better understood in order to operate safely in deep water. In August 2000 Chevron worked with the National Energy Technology Laboratory (NETL) of the United States Department of Energy (DOE) to conduct a workshop in Houston, Texas that identified and discussed the key issues concerning the characterization of natural gas hydrate deposits. Specifically, the workshop was meant to show where research, the development of new technologies, and new data collection and analysis would be beneficial to the DOE and to the oil and gas industry in defining issues and solving natural gas hydrate problems in deep water.

In 2001 Chevron formed a Joint Industry Project (JIP) group to write a proposal and to conduct research concerning natural gas hydrate deposits in the deep water GOM. Chevron generated a research proposal which was submitted to the DOE in April 2001 under a competitive DOE funding opportunity announcement (FOA). That application was selected for an award by the DOE under the FOA, and Chevron was awarded a cooperative agreement for research based on the proposal. The title of the project is "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities". The project was funded in October 2001, and in December 2001 additional workshops were held to identify the project sub-teams and to develop the high level project phases and tasks (Figure 1). A high level, illustrative summary of the overall project objectives is available on the DOE-NETL Methane Hydrates Web Site. This summary is titled "Gulf of Mexico Joint Industry Project" [1].

Since 2001, the JIP has engaged in a multiyear effort to develop technology and collect data to assist in the characterization of gas hydrates in the deep water GOM. The JIP members include ConocoPhillips, Schlumberger, Halliburton, Japan Oil Gas and Metals National Corporation (JOGMEC), U.S. Bureau of Ocean Energy Management (BOEM), Total, Reliance Industries Ltd., Korean National Oil Company (KNOC), and Statoil. Since its initiation the JIP project work has continued over three main phases:

<u>Phase I:</u> During the first phase, the JIP performed technical investigations into the occurrence, nature, and implications of natural gas hydrates in the GOM. Planning for an offshore expedition to collect hydrate data was also conducted. During the period March - May 2002 a series of technical workshops were held to define the detailed project scope, key tasks, work plan, and schedule. The project governance and technical teams responsible for completing the work were also established [2,3]. These workshops included:

- Data Collection Workshop – March 2002
- Drilling, Coring and Core Analysis Workshop – May 2002
- Modeling, Measurement and Sensors Workshop – May 2002

The results of these project planning workshops are described in the Topical Report 41330R03 [4]. Subsequent workshops were held to identify the project subcontractors and to initiate plans for drilling site selection and drilling operations.

Phase II: During the second phase, the JIP completed the first offshore expedition in 2005. This Leg I expedition consisted of drilling, logging and coring operations in fine-grained sediments at five drilling locations in two GOM areas (Atwater Valley 13/14 and Keathley Canyon 151). The expedition collected an excellent suite of well-logs and borehole seismic through the hydrate stability zone. Over 200 meters of core was recovered and a 60 meter thick, gas-hydrate-bearing interval was identified. The data obtained from Phase I and Phase II activities, including the Leg I offshore expedition, demonstrated the potential for gas hydrate characterization using industry-standard seismic data, and it demonstrated the ability to safely drill and operate in areas where modest to low saturations of gas hydrate might occur in the fine-grained sediments that typify the GOM.

Phase III: The third phase was contingent upon success with the first two project phases. It was determined to hold continued value and was therefore included in the project. Phase III was established as two distinct sub-phases:

- Phase IIIA – Activities under this sub-phase included a second offshore expedition (Leg II) to obtain extensive Logging While Drilling (LWD) data from additional locations in the GOM with a focus on areas anticipated to have higher saturation hydrate occurrence in coarse grained sediments. Planning began in 2005 and the Leg II expedition was completed in 2009. The Leg II expedition obtained extensive LWD data from seven drilling locations at three GOM areas (Green Canyon 955, Walker Ridge 313 and Alaminos Canyon 21). Leg II successfully demonstrated the occurrence of gas hydrates at medium to high saturations in reservoir-quality sands in the GOM. The hydrate deposits were found in close accordance with pre-drill predictions, demonstrating the validity of the hydrate exploration and appraisal tools and techniques used in finding, delineating, and characterizing targeted accumulations. Also in this phase, systems for handling and analyzing pressured cores were further developed.

- Phase IIIB - The Phase IIIB activities included the technology development of pressure coring equipment suitable for characterizing and evaluating hydrates at *in-situ* conditions in the GOM. Design alternatives for a functioning pressure coring device were developed, and a prototype pressure coring tool was built and tested. The systems for handling and analyzing pressured cores were continued to be refined. These systems were successfully tested on pressured, hydrate-containing cores obtained by JOGMEC (a JIP member) in 2012 during an expedition offshore Japan. A preliminary planning study for a potential marine pressure coring acquisition expedition in the GOM (Leg III) was also competed in order to determine the drilling requirements and cost.

Throughout all project phases regular project reporting included Semi-Annual Reports and Topical Reports. These reports are listed in Table 1 and are all available on the DOE-NETL Methane Hydrates Website. This Final Project Report is intended to provide a summary level description of the key activities undertaken during the project (all Phases I-III), and it includes a high level description of the methods used, the types of data that resulted, and critical insights and conclusions resulting from the project. References to specific project reports (such as Semi-Annual Reports or Topical Reports) and associated scientific reports that utilize JIP data (such as scientific publications) are provided for full technical detail. A comprehensive listing of all professional publications, technical papers and presentations are provided in Appendix A. The listing of all students funded under the project by the Recipient, all subcontractors as a result of project activities, and the members of the JIP are provided in the Acknowledgement section.

Figure 1: Project Phases and Key Activities

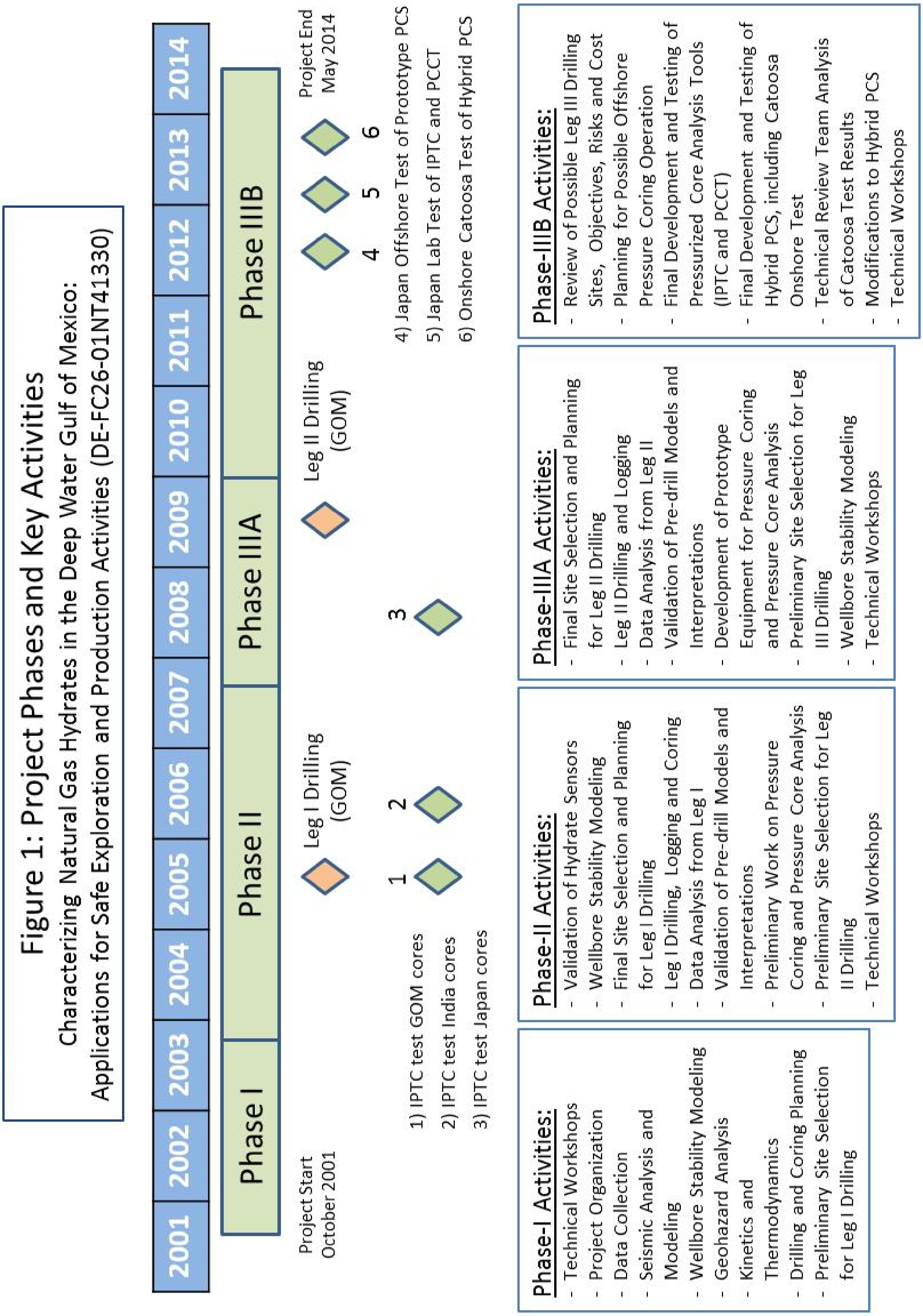

Table-1: Listing of Semi-Annual and Topical Reports.

Report #	Report Type	Start Date	End Date	Phase	Topics Included in the Report
41330R01	Semi-Annual Report	Oct-01	Mar-02	Phase I	project set-up, initial workshops, scope and task definition, teams, reporting structure
41330R02	Semi-Annual Report	Apr-02	Sep-02	Phase I	workshop summary review, develop RFP/CTR's, identify subcontractors, initial planning for drilling
41330R03	Topical Report: Data Collection Workshop Modeling Workshop Drilling & Coring Workshop	Mar-02	May-02	Phase I	detailed summary of workshops
41330R04	Semi-Annual Report	Oct-02	Mar-03	Phase I	progress report on Phase 1 tasks, status of negotiations with Georgia Tech, Scripps and Joint Oceanographic Institute, status report on drill site analysis, wellbore stability modeling, and preliminary drilling plans
41330R05	Topical Report: Protocols for Seismic Data Acquisition and Processing	Oct-01	Mar-04	Phase I	results of Schlumberger WesternGeco seismic processing, modeling and analysis, initial seismic screening of six deepwater GOM blocks for potential hydrates
41330R06	Topical Report: Methane Hydrates R&D Conference JIP Workshop	Sep-03	Oct-03	Phase I	summary of DOE methane hydrates R&D conference and JIP workshop held in Denver , Colorado September-October 2003, discussion of plans to move project to Phase II
41330R07	Topical Report: Measurements for Assessment of Hydrate Related Geohazards	Mar-02	Sep-04	Phase II	measurements for assessment of hydrates and hydrate-related geohazards, includes an extensive list of references
41330R08	Semi-Annual Report	Oct-04	Mar-05	Phase II	progress report on Phase II tasks, hydrate sensores, wellbore stability model, logging and coring procedures, Leg I drilling plans, well objectives, site location information, coring equipment
41330R09	Semi-Annual Report	Apr-05	Sep-05	Phase II	detailed reports of the Leg I drilling, logging and coring operation - data analysis - results

Table-1: Listing of Semi-Annual and Topical Reports

Report #	Report Type	Start Date	End Date	Phase	Topics Included in the Report
41330R10	Semi-Annual Report	Oct-05	Mar-06	Phase II	progress report on Phase II tasks, detailed report on Georgia Tech Pressure Core Measurements, Geotek Pressure Core and Logging Report, meetings to discuss results of drilling Leg I
41330R11	Semi-Annual Report	Apr-06	Sep-06	Phase II	summary of additional core experiments, workshop in April 2006 to further discuss Leg I drilling results, preliminary site selection for next phase of drilling (Leg II) , contracting
41330R12	Semi-Annual Report	Oct-06	Mar-07	Phase II	additional discussion of hydrate coring results, prepare work plan for Phase III, additional Leg II drilling site selection analysis including seismic
41330R13	Semi-Annual Report	Apr-07	Sep-07	Phase II	additional core experiments, prepare application for Phase III, new pressure corer design, detailed seismic analysis of Phase III drilling sites (Leg II) , detailed report on Leg II site selection
41330R14	Semi-Annual Report	Oct-07	Mar-08	Phase III	additional core experiments, redesign of new pressure corer, publication review, additional Leg II site planning, grain size and hydrate distribution
41330R15	Semi-Annual Report	Apr-08	Sep-08	Phase III	additional core experiments, redesign of new pressure corer, publication review, additional Leg II site planning, development of a high pressure temperature corer (HPTC)
41330R16	Semi-Annual Report	Oct-08	Mar-09	Phase III	hazard and well bore stability analysis of drill sites, operational planning
41330R17	Semi-Annual Report	Apr-09	Sep-09	Phase III	Leg II drilling cruise results, LWD logs from Leg II drill cruise
41330R18	Semi-Annual Report	Oct-09	Mar-10	Phase III	continued data analysis from Leg II drilling, prepare publications to share results, planning for future coring and Leg III drilling
41330R19	Semi-Annual Report	Apr-10	Sep-10	Phase III	planning for Leg III drilling, discussion of drilling moratorium impacts, discussion of coring tool development and bottom hole assembly design.
41330R20	Semi-Annual Report	Oct-10	Mar-11	Phase III	description of information sharing from Leg II drilling (website with log data, publication with full results), discussion of drilling moratorium impacts, update on pressure coring tool development

Table-1: Listing of Semi-Annual and Topical Reports

Report #	Report Type	Start Date	End Date	Phase	Topics Included in the Report
41330R21	Semi-Annual Report	Apr-11	Sep-11	Phase III	discussion of new well planning procedures post moratorium, update on timing of Leg III, proposed "block organization" for Leg III, use of PCATS and HPTC in Japan tests, HPTC/PCATS testing
41330R22	Semi-Annual Report	Oct-11	Mar-12	Phase III	detailed discussion regarding new drilling regulations and well design, discussion of pressurized coring, discussion of funding issues related to increased drilling costs and requirements, continued development of the IPTC/PCCT
41330R23	Semi-Annual Report	Apr-12	Sep-12	Phase III	completed modifications to IPTC and construction of PCCT, discussion of project funding and pace, completed lab testing of IPTC and PCCT, discussion of testing prototype Hybrid PCS by JOGMEC, evaluated options for service vans.
41330R24	Semi-Annual Report	Oct-12	Mar-13	Phase III	completion of testing of IPTC and PCCT on pressurized cores in Japan, design modifications to Hybrid PCS, onshore test planning for Catoosa site
41330R25	Semi-Annual Report	Apr-13	Sep-13	Phase III	completion of Hybrid PCS system and factory testing, planning for onshore test of Hybrid PCS at Catoosa, delivery of reports on IPTC and PCCT successful tests
41330R26	Semi-Annual Report	Oct-13	Mar-14	Phase III	completion of the Hybrid PCS onshore test at Catoosa, fabrication of service vans and heavy vans, Technical Review Team assessment of Hybrid PCS test results, Project close-out planning
41330R27	Topical Report: Phase IIIB Topical Report	Jan-10	Mar-14	Phase III	detailed report on the development of the IPTC and PCCT, development of the HPTC and Hybrid PCS, planning and design of an offshore Hydrate pressure coring operation, Catoosa onshore test of the Hybrid PCS, Technical Review Team findings and post-test modifications to the Hybrid PCS

2. PHASE I

Phase I was initiated in the fourth quarter of 2001. The objectives of Phase I involved data collection and analyses of existing information on hydrates and the development of protocol for an offshore expedition to collect field data. Work in Phase I consisted of a number of key tasks:

- Research Management Plan and Project Management
- Data Collection and Organization
- Development of New Gas Hydrate Sensors
- Develop Well Bore Stability Model
- Seismic Modeling and Analysis
- Kinetics and Thermodynamics Analysis
- Determine Data Requirements for Geo-Models
- Develop Drilling and Coring Test Plans
- Core Handling and Core Tests
- Review Data and Select Locations of 3 Field Test Sites
- Hold conference to solicit input from industry, academic, government and other qualified professionals on the planned field testing

The organizational structure and participants in the JIP and the Phase I high level work plan are summarized in the report "Gulf of Mexico Joint Industry Project" and in the first Semi-Annual Report #41330R01 [2] for the period October 2001 – March 2002. All the Phase I tasks were completed successfully by the end of the third quarter of 2003, and the results were reported in the Semi-Annual Report #41330R04 [5]. Protocols for seismic data acquisition and processing to characterize natural gas hydrate deposit in deep water were developed. The protocols were reported in the Topical Report #41330R05 [6]. Work on geo-modeling and analysis for gas hydrate quantification in the Gulf of Mexico was conducted by Schlumberger Reservoir Services Group. The results were provided in the Schlumberger technical report "Theoretical Modeling and Analysis for Gas Hydrate Quantification from Prestack Seismic Data in the Northern Deepwater Gulf of Mexico" (2003) [7]. Work on hydrate related geohazards were reported in Topical Report #41330R07 (2002) [8].

The above referenced reports provide details of the activities and results. The key results are summarized as follows:

- The Phase I project sub-teams and governance structure was established. Key teams included: Executive Board, Hydrates Characterization Team, Drilling and Coring Team, and the Seafloor Stability Team. Activities and results from these teams are detailed in the Phase I Semi-Annual and Topical Reports.

- Developed the GOM Hydrates database.
- Investigated and reported on the feasibility of developing MWD (measurement while drilling) sensors for gas hydrates during drilling operations.
- Contracted with Georgia Tech to run laboratory tests on synthetic cores containing gas hydrates. These tests evaluated the physical property changes during formation and dissociation of gas hydrate, which corresponds to pressure and/or temperature cycling. Additionally, properties of sediment/hydrate mixtures were characterized, and the effects of coring/sampling on properties of gas hydrates were investigated.
- Negotiated with Scripps Oceanographic Institute to be a key science provider for Phase II and to help prepare the plans and protocols for Phase II of the project.
- Negotiated with the Joint Oceanographic Institute to help write the drilling, coring, and core handling protocols and procedures that would be required for Phase II of the project.
- WesternGeco completed the evaluation of six potential sites for Phase II drilling expedition. Follow-up meetings with the JIP resulted in the selection of two sites for more detailed review. During this exercise, methods to acquire, process, and interpret seismic data for gas hydrates were investigated. WesternGeco used its scientific information, processing and interpretation expertise to develop methods that enable the study of shallow formations in the deep water GOM so that hydrates can be located and imaged.
- Schlumberger completed the feasibility study of developing a well bore stability model for shallow holes drilled through soft formations containing natural gas hydrates. On the basis of this study the development of a prototype well bore stability model was pursued.
- Negotiated with Fugro to provide the drill ship for the Leg I drilling expedition in Phase II of the project.

A DOE Research and Development Conference and a JIP Workshop on Hydrates were held at the end of September 2003. The purpose of the conference and workshop was to review research and development results from various DOE projects, to review the research results from Phase I of the JIP project, and to critique plans for Phase II of the JIP project. The combined meeting generated significant interest in the gas hydrates technical community. The results of the conference and workshop are documented in the Topical Report #41330R06 (2003) [9].

3. PHASE II

Phase II began in the fourth quarter of 2003. The focus of Phase II was on the selection of specific sites for field programs, the execution of field programs at those sites, and analysis and reporting of the data to be collected. The work in this phase consisted of the following key tasks:

- Research Management Plan and Project Management
- Validation of New Gas Hydrate Sensors to be used in field tests
- Validation of Wellbore Stability Model to be used in drilling for hydrates in deep water GOM
- Core and Well Log Data Collection in deep water GOM
- Analysis of Field Data
- Development of Field Sampling Device
- Hold technical conference to share the results

A drilling expedition (Leg I) was conducted offshore in 2005. The goal of the expedition was to collect sediment data for scientific analysis and to compare it to the pre-expedition seismic analysis predictions. The Leg I drilling expedition was successful in collecting core and well log data while validating the technical work and methodology developed in Phase I.

Site Selection and Drilling

A key objective of the site selection process for the Leg I expedition was to locate hydrates for drilling that were expected to be typical of the hydrates most commonly encountered by deep water operators. Initial candidate sites were identified based on seismic data interpretation, largely based on methods developed in Phase 1. Another critical part of the site selection activity was to perform a hazard analysis of the locations being considered. The hazard analysis removed some of the most promising locations and restricted drilling in other areas because of potential problems.

The Leg I drilling site selection began in Phase I by overlaying geographic areas of interpreted and known surface and subsurface hydrate occurrences with offshore blocks that were either unleased or leased by a JIP member company. Another consideration was an operational one to insure permission to operate. After a number of potential locations were identified, the JIP invited interested parties to a workshop to discuss the merits of each location and to propose alternate locations. Six possible target locations, Green Canyon 184 and185, Atwater Valley 14, Alaminos Canyon 856, Mississippi Canyon 802, and Keathely Canyon 195, were identified. Additional seismic analysis was conducted and the final two locations (AT14 and KC195) were then selected for more detailed seismic analysis. These two locations were selected because of their different geologic characteristics [5,6].

The Atwater valley location is in the eastern GOM and is associated with a hydrate mound. Hydrates were expected to be located near the surface, and the mound area looked promising to recover hydrate cores. The Keathley Canyon location is in the western GOM. Potential hydrates there were expected to be located about 300-400 meters below the mud line. The two locations were selected because they provided a range of possible hydrate settings in the GOM.

The Leg I drilling expedition was completed in 2005. Wells were drilled using conventional oil field equipment and practices without a casing or a riser. Drilling was completed safely and on time and on budget using a dynamically-positioned drill ship. Drilling muds were used when required and care was taken to use drilling muds that were hydrate-compatible when hydrate zones were being drilled. The open hole wells had some hole stability problems that were likely due to the amount of time required to log and core. Other drilling related problems were overcome by the experienced drilling crew, and these problems were typical of GOM drilling.

The Leg I expedition consisted of a 35 day drilling cruise in Atwater Valley Blocks 13 and 14 and also in Keathley Canyon Block 151. Three holes and two near surface cores were drilled in Atwater Valley and two holes were drilled in Keathley Canyon [10,11].

The Atwater Valley locations were in approximately 1300 meters water depth in the eastern GOM. The three holes were drilled to a depth of 246.3 meters, 199.9 meters, and 286.6 meters. One hole did not reach its target depth and wireline logs were not collected due to borehole stability problems. The two cores collected directly at the mound were about 30 meters in length. A total of 144 meters of core and two surface push cores were collected. LWD data was also obtained. The description of the log and core data are presented in detail in the 2005 Semi Annual Report #41330R09 and the "Cruise Logging Report: GOM Gas Hydrate JIP Drilling Program Downhole Logging Program Report (2005), both available on the DOE-NETL Methane Hydrates Website [12,13].

The Keathley Canyon locations were in approximately 1320 meters water depth in the western GOM. The two holes were drilled to a depth of 459.8 meters and 441.4 meters. The second hole was stopped short of its target depth due to water flow. A total of 228 meters of core and 1 push core were collected. LWD, wireline, and VSP data was also obtained. The description of the log and core data are presented in detail in the 2005 Semi Annual Report #41330R09 and the "Cruise Logging Report: GOM Gas Hydrate JIP Drilling Program Downhole Logging Program Report (2005), both available on the DOE-NETL Methane Hydrates Website [12,13].

Logging and Coring

Logging and coring was conducted in the Leg I drilling expedition. The goal of the logging activity was to collect sediment data for scientific analysis and then compare the results to the pre-expedition seismic analysis predictions. Conventional oil field logging tools were used. The tools selected were optimized to provide data relevant to hydrate detection. Measurements were taken on board the ship on the cores that were collected. The cores underwent further analysis when returned to shore.

Logging consisted of both LWD and wireline tools. The LWD tools proved to be the most useful due to hole re-entry problems to deploy the wireline tools. The LWD tool string provided necessary data for drilling operations as well as data on the sediments and hydrate occurrence.

Log data was of high quality and consisted of resistivity, borehole imaging, gamma ray, density, neutron porosity, and magnetic resonance logs. Dipole sonic logs and a VSP were also collected for the Keathley Canyon #3 hole.

Both unpressurized and pressurized cores were collected in the Leg I drilling expedition. The unpressurized cores were used to obtain general sediment and fluid data. Pressurized cores were used to attempt to measure hydrate concentrations. A total of over 200 meters of core were collected on the cruise. Eighteen pressure cores were attempted with five cores recovered under pressure.

Well Bore Stability Model

The JIP developed and delivered a well bore stability model for use in hydrate drilling. The model incorporated data from the JIP's lab work as well as data from conventional drilling in the GOM. The well bore stability model utilized MWD data from the drilling operation to compare and update the model. The model was used to predict the effects that drilling would have on the sediments [14,15]. The predictions allowed the drilling operations to minimize gas hydrate destabilization and borehole washout while maintaining required drilling performance. After each phase of drilling, the model was compared to MWD data and improved for future drilling. A runtime version of the model was provided to the DOE for public use.

Lab Data on Fine-grained Sediments

Lab data was largely collected by Georgia Tech using synthetic samples containing tetrahydrofuran (THF) hydrate. The JIP selected this option over conducting experiments on synthetic methane-hydrate samples because of the time and expense required for data analysis on methane hydrates and the inability to create methane-hydrate samples over a wide range of grain sizes. Additionally, there was the view that THF hydrate samples may more accurately mimic geomechanical properties of in-situ occurrences than lab-synthesized CH4-hydrate samples. This approach allowed the JIP to obtain a large dataset across a range of hydrate concentrations, pressures, and sediments [16]. These data were also used in the well bore stability and seismic modelling efforts.

Seismic velocities and mechanical and electric properties were obtained on the tetrahydrofuran hydrates by conducting small-strain mechanical properties experiments of hydrate-bearing sediments measured under laboratory conditions. These data provided reference values for calibrating the logging and seismic data results in the hydrate-bearing formations. The data set included compressional (P) and shear (S) velocities of sand, silts, and clay with and without hydrate and subject to vertical effective stresses of 0.01 to 2 MPa.

The results demonstrate that laboratory hydrate formation controls the pattern of P and S velocity. The value of the properties changes with increasing hydrate saturation and that hydrate-bearing sediments are governed by effective stress and sediment specific surface [8].

Seismic Modelling

Seismic modelling for both Phases I and II was completed by WesternGeco (a subsidiary of JIP member Schlumberger). One of the key project objectives was to determine if standard oil field seismic data and modelling would be suitable for hydrate interpretation, or if improvements would be required for hydrate analysis. It was determined that standard processed seismic data (for oil field exploration) typically lacks the information most useful for hydrate analysis because it has been filtered out during processing (in favour of the signals required to better image the deeper sediments and deeper exploration prospects). Because of this filtering the JIP found it necessary to revert the seismic signals back to its base data (this is commonly referred to as pre-stack data). The pre-stack data is most suitable for hydrate analysis.

A five-step seismic analysis process was developed by the JIP [6,8]. The key steps in this process include: seismic data reprocessing (highest resolution); stratigraphic evaluation and geologic interpretation, seismic attribute analysis, full wave form pre-stack inversion of rock properties, and quantitative analysis to obtain estimates of hydrate saturation.

The seismic analysis was also used to develop pseudo well logs to compare to the field logs obtained during drilling. The model was improved after the Leg I drilling. The analysis illustrated the need for improved sediment properties as well as the need to use long offset seismic data.

Hydrate Sensors and Tool Development

The JIP continued to investigate technologies for detecting hydrates using tools and sensors. A core measurement vessel / tool was developed to conduct measurements on pressurized core on-board a drill ship [17]. In order to install the core into this measurement vessel from a pressure core, a transfer vessel also was developed. These two devices when combined with a pressure coring device allowed for the first measurement of core strength, acoustic, and electrical properties on a hydrate core that has never been depressurized [18]. The tools were available for use during the Leg I drilling, one sample was successfully tested with the tool, but because very few pressure cores were recovered the tools were not used extensively on the Leg I expedition. However, the JIP enabled further testing of the tools in the fall of 2006 during an expedition led by the Indian Government’s Natural Gas Hydrate Program in collaboration with the USGS.

Workshops

The JIP conducted a number of workshops during the execution of Phase II. These workshops were used to inform interested parties of progress and planning. The workshops also provided excellent venues to share results and to obtain input from as a wide range of researchers on the areas needed for hydrate research.

4. PHASE IIIA

As a follow-up to the successful Leg I offshore drilling expedition in Phase II, the Phase IIIA activities focused on the characterization and evaluation of hydrate occurrence within coarse grained horizons in the GOM. These could pose additional drilling hazards as well as be potential reservoir quality hydrate deposits. Work included preparation for another offshore drilling expedition (Leg II), additional technology development to identify and characterize hydrates, execution of the drilling program, data analysis, and reporting. The scientific investigations in this phase included:

- Revised Research Management Plan and Project Management
- Detailed geological and geophysical review of potential drilling locations
- Drilling hazard reviews
- Operational planning
- Field program – drilling and logging of multiple boreholes in selected OCS blocks in GOM
- Data analysis of new field data including laboratory analysis and geological modeling of hydrate drilling locations
- Development of prototype coring equipment for improved hydrate recovery, detection, and measurement
- Improvement to the well bore stability model
- Collection and testing of lab samples necessary to improve well bore and reservoir models

Site Selection and Drilling

Phase IIIA site selection for Leg II drilling focused on locations identified by sites previously noted in industry drilling (Blocks AC818 and EB922), in industry GOM shallow hazard surveys (Blocks WR313, GC955, and GC781), and in an ongoing regional gas hydrate assessment being conducted by the BOEM (Block AC21) [17]. Block AC818 was the only site with hydrate-bearing sand occurrence confirmed by prior drilling, however the site posed substantial operational difficulties and was removed from consideration. Blocks WR313, AC21, GC781, and GC955 were selected for drilling; however, Block GC781 could not be considered due to ongoing industry operations in the area. Pre-drill seismic interpretations were conducted for the Block WR313 and GC955 sites.

The site selection committee developed the drilling locations. The committee included personnel from the JIP, BOEM, DOE, USGS, NRL, and Rice University. The committee conducted multiple conference calls and face-to-face meetings to review data and discuss the possible locations. These meetings are documented in Semi-Annual Report #41330R13 [17].

The site selection committee performed an analysis of all potential drilling locations that included drilling hazards, hydrate estimates, scientific value, and sediment description. The analysis was used to rank the drilling locations. Drilling permits were obtained for the high ranked locations. Permits were obtained for 20 potential locations with a flexible plan to modify the targets based on ongoing drilling results. The drilling locations and the technical analysis to support then are provided in "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Operational Summary" [18] and the Semi-Annual Report #41330R16 [19]. There are also predrill and site selection reports and post expedition summary reports for Leg III available on the NETL website.

The Leg II drilling expedition was conducted in 2009. The scientific and operational objectives were met, and the program was executed on budget and without any safety incidents. The expedition consisted of a 21 day cruise to Walker Ridge Block 313, Green Canyon Block 955 and Alaminos Canyon Block 21. A total of seven holes were drilled and logged. In accordance with project plans, only logging was conducted on this cruise (no coring).

Two holes were drilled in Alaminos Canyon at a water depth of approximately 1490 meters. The holes were drilled to a depth of 536.4 meters and 340.2 meters. Three holes were drilled in Green Canyon at a water depth ranging from approximately 1986 to 2063 meters. Hole depths were 460 meters, 589 meters, and 672 meters. Two holes were drilled in Walker Ridge at water depth of approximately 1990 meters. Holes depths were 996 meters, and 1093 meters. The detailed results of Leg II are provided in the "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Operational Summary" [18], and in the Semi-Annual Report #41330R17 [20]. The high-level results are summarized below.

Logging

The objective of the logging program was to collect sediment data for scientific analysis and to compare the results to the pre-expedition predictions (seismic analysis predictions, hydrate concentration predictions, and well bore stability predictions). An advanced, research-level LWD suite was employed, including several experimental devices.

The LWD data were successfully collected on all holes drilled at the selected sites. These data provided a comprehensive set of logs for analysis. The logging program used an advanced set of LWD tools that obtained multi-azimuth images of the hydrate bearing sediments. The string of tools provided shear and compressional wave slowness, resistivity, porosity, density, and gamma ray.

Seismic Modelling

As in Phase II, pre-drill seismic analysis was used to develop pseudo well logs (for WR313 and GC955 drilling locations) which were compared to the actual field logs obtained during drilling. Seismic modeling was used to generate the pseudo well log data by reprocessing long offset seismic data and using that data to calculate hydrate concentrations in the areas selected by the site selection activity. The predictions from this data proved to be accurate based on comparison to the actual LWD data results in six of the seven wells [20]. These pseudo well logs were also determined to be valuable to the drilling planning because they allowed for more accurate pre-drill prediction of the interval to be drilled.

Tool Development

The JIP started the development of a new pressure coring tool based on the design that was used successfully during Japan's 2004 hydrate drilling in the Nankai Trough. The design of this new tool includes adaptors that allow it to connect to the pressure core transfer and measurement tools, which were also designed and/or enhanced as part of the JIP effort. The development of this new coring tool, the High Pressure Temperature Corer (HPTC) by Aumann & Associates is described in Semi-Annual Report #41330R15 [21]. This pressure coring tool is designed to collect longer cores and to withstand higher pressures in the GOM vs. other pressure coring tools that were tested successfully in Japan.

Technology and Information Transfer

As in the previous phases, the JIP conducted a number of workshops during the execution of the project. These workshops were used to inform interested parties of progress and also to obtain input from as a wide range of researchers on the areas needed for hydrate research. The cumulative scientific results of the work related to the Leg II expedition in Phase IIIA were published in a compendium of papers edited by Collett and Boswell [22]. The original and fully processed GOM JIP Leg II well log database was loaded onto the Lamont-Doherty Earth Observatory web site: http://brg.ldeo.columbia.edu/ghp/. The web site includes original and processed data, in the same formats as GOM JIP Leg I.

5. PHASE IIIB

Phase IIIB activities were originally focused on the planning of offshore expedition Leg III to collect hydrate pressure cores at a number of selected locations in the GOM that were previously drilled and logged in Phase IIIA (Leg II). The activities also included work focused on technology development and testing of prototype pressurized coring equipment suitable for characterization and evaluation of hydrate occurrence within coarse grained sediments in the GOM. The tasks completed in this phases were:

- Revised Research Management Plan and Project Management
- Refinement and Testing of Prototype Pressure Core Handling / Analysis Equipment
- Prototype Pressure Coring Equipment Design Update, Development and Testing
- Planning Study of a Potential Marine Pressure Coring Expedition

Prototype Pressure Core Handling / Analysis Equipment

The development and/or enhancement of prototype Pressure Core Handling / Analysis equipment was initiated and completed by two teams of scientists from the United States Geological Survey and Georgia Institute of Technology. Two systems to analyse the pressure cores under in-situ conditions have been successfully developed: the Instrumented Pressure Test Cell (IPTC) (enhanced from the IPTC version originally created during Phase II of the project) and the Pressure Core Characterization Tool (PCCT). The systems have the capability to perform a number of analyses on the pressured hydrate cores under in-situ pressure conditions. A field test of these tools was successfully accomplished at the AIST national hydrate laboratory in Sapporo, Japan, in January 2013. The scientific results of this work are documented in Semi Annual Reports #41330R24 and #41330R25 and in Topical Report #41330R27 which is the Topical Report that describes the Phase III activities in detail [23,24,25]. This Topical Report includes a section titled “Development of Instrumented Pressure Test Cell (IPTC) and the Pressure Core Characterization Tool (PCCT)”.

The IPTC and PCCT equipment have been turned over to DOE and subsequently the title was transferred to USGS Woods Hole (IPTC) and Georgia Institute of Technology (PCCT) where these equipment systems now reside.

Prototype Pressure Coring Equipment Design, Development and Testing

The work on an updated pressure coring system was initiated by the JIP in Phase III, and in 2011 the JIP funded Aumann and Associates, Inc. (AAI) to development a High Pressure Temperature Corer (HPTC) for the JIP. The HPTC specifications included a longer core barrel allowing for more efficient coring operations and increased core diameter to enable improved device robustness and reliability.

Subsequent to the 2011 contract award to AAI, the Deepwater Drilling Department in Chevron reviewed deep water drilling protocols and determined (among other things) that the large diameter of the HPTC design was not compatible with the drill pipes employed by Chevron deep water drill rigs. While it would be possible to make modifications to the HPTC design and the drill pipes, these changes would be complex and difficult. In June 2012, JOGMEC was successful in the acquisition of hydrate pressure cores offshore Japan using a pressure core system built by AAI for JOGMEC employing a smaller core barrel. In April, 2013, AAI was funded by the JIP to build a Hybrid Pressure Core System (Hybrid PCS) based on the Japanese pressure core barrel with additional refinements from lessons learned from JOGMEC coring experiences. The manufacturing of the Hybrid PCS was completed and was factory acceptance tested in September 2013 [23,24]. A Heavy Van and Service Van were also constructed at this time. These vans serve as transport and on-site servicing containers for the Hybrid PCS.

In November 2013 the Hybrid PCS was field tested for functionality at Catoosa Test Facility in Hallett, Oklahoma. A number of performance issues were observed during the Catoosa test. A technical review was subsequently conducted and the root causes of performance issues were identified. AAI has since upgraded the Hybrid PCS to rectify the performance issues observed at Catoosa but the system with these modifications has not been field tested. The Phase IIIB Topical Report [25] provides a detailed description of the Hybrid PCS, the onshore test at Catoosa, the results and recommendations made by the post-test Technical Review Team, and the description of modifications made to the Hybrid PCS following the field test.

The Hybrid PCS, Service Van, Heavy Van and associated drilling and coring equipment have been delivered to the DOE storage facility in Morgantown, West Virginia.

Preliminary Planning Study of a Potential Marine Pressure Coring Expedition

The preliminary planning and design of a Leg III drilling expedition to collect pressure cores of hydrates offshore GOM was initiated in late 2009. A Leg III Science Field Organization Team was established and the kick-off meeting was held in January 2010. Additional teams and contractors (such as Geotek and Aumann and Associates) were also very involved in the expedition planning. Issues with compatibility of the drill pipe and the HPTC pressure corer were identified and discussed. A series of planning meetings were held in first half of 2010 to address this issue, as well as to develop the technical scope and scientific objectives of the Leg III expedition. These are documented in Semi-Annual Reports #41330R18 and #41330R19 [26,27].

The Phase IIIB work was significantly impacted by the GOM Drilling Moratorium that was announced in May 2010 as a result of the Macondo well incident [27]. Prior to the moratorium the project team had been ramping up preparations for the planned 2011 Leg III coring expedition. Shortly after the moratorium was announced the Leg III preparations were put on hold to wait for lifting of the moratorium and to get post-moratorium clarification and assessment of regulatory, legislative, permitting, operational, and commercial changes in GOM drilling.

Following the GOM Macondo well incident, a team of Chevron scientists and the Chevron Deepwater Drilling Operations Group completed a detailed evaluation of new drilling and safety requirements for deep water drilling and coring [28]. The study included a scoping study, a front end engineering study (FEED), a drilling and coring safety review, and a detailed time and cost estimate of an offshore operation to obtain hydrate pressure cores. The main conclusions of the study were:

1) Offshore drilling and pressure coring of hydrates carry inherent considerable safety risks as hydrate accumulations are considered drilling hazards. The study showed that there are many risk factors in a pressure coring operation with an experimental prototype pressure coring tool. To provide adequate safeguards, a sixth generation deep water drill ship should be deployed for Leg III pressure coring operation.

2) Time and cost estimate of the Leg III pressure coring operation using a sixth generation deep water drillship would be expensive as the operational cost would exceed $1MM/day. The total cost of a nominal three well program would exceed $40MM.

Due to the high cost of this potential offshore operation decision was made to not pursue the Leg III expedition. Instead, the Hybrid PCS was field tested at the onshore facility at Catoosa.

A Separate DOE Topical Report, the Phase IIIB Topical Report, has been prepared in order to fully document the tasks completed in Phase IIIB and to provide technical details of the results [25].

6. SUMMARY AND CONCLUSIONS

The work of the JIP to develop technology and collect data to assist in the characterization of gas hydrates in the deep water Gulf of Mexico spread over twelve plus years since 2001. The JIP has developed new tools and techniques to measure hydrate properties. A large body of technical knowledge on hydrates characterization has been developed, together with a very large number of technical and operational insights captured, including:

1. Hydrates are a readily-managed shallow drilling hazard. Hazard mitigation can be accomplished via existing protocols including close monitoring of drilling fluid temperatures.

2. Field data have indicated the occurrence of high-saturation hydrate accumulations in the Gulf of Mexico.

3. Methods employed by the JIP and its federal partners to locate and predict hydrates were effective and accurate. The use of high quality long offset seismic data are valuable for detecting hydrates. Estimates of hydrate concentration from seismic data and rock properties were in agreement with the log data at four of five sites, and high concentrations of hydrates were found in sand bodies at two of three sites. Estimates of hydrate concentrations ranged up to 80% of pore space.

4. Promising prototype tools and methods to collect hydrate pressure cores and analyze them under *in-situ* conditions have been developed. These pressure core data provide important information on properties of hydrates at *in-situ* conditions which are critical for technology development of natural gas production from hydrates.

The scientific results of the JIP have been extensively published. Refer to Appendix A for a complete list of publications. These accomplishments would not have been successful without the collaboration of a large number of scientists from academic institutions, government organizations and industry as well as the support of the Department of Energy and the participant companies in the JIP, all who are recognized in the Acknowledgements.

ACKNOWLEDGEMENTS

List of Joint Industry Participants (JIP) who contributed to the Project:

- Chevron
- ConocoPhillips
- Halliburton
- Japan Oil, Gas and Metals National Corporation (JOGMEC)
- Reliance Industries Limited
- Schlumberger
- Statoil
- The Korean National Oil Company (KNOC)
- Total
- US Bureau of Ocean Energy Management (BOEM)

List of Sub Contractors who contributed to the Project:

- AOA Geophysics
- Argonauta Drilling Services
- Aumann & Associates
- Columbia University
- DOE Cooperative
- Fugro
- Georgia Tech Research
- Geotek
- Helix Energy Solutions
- JIP Joint Industry Project Participants
- Joint Oceanographic Institutions
- Prolog
- Rice University
- Schlumberger
- Specialty Devices
- Texas A&M University
- TH Hill Associates
- University of California San Diego - Scripps
- US Geological Survey
- Vantage Force

List of Students funded by the Project:

Columbia University (in association with the GoM JIP)

• Cook, Ann, Ph.D., 2010, Geophysics

• Grabias, Bryan, B.S., in progress, Chemical Engineering (summer intern)

Georgia Institute of Technology (in association with GoM JIP)

• Cortes, Douglas, Ph.D., 2010

• Dai, Sheng, Ph.D., 2012

• Francisca, Franco, Post-doctoral, 2002-2004

• Jang, Jun Bong, Ph.D., in progress

• Lee, Changho, Post-doctoral, 2008

• Lee, Jong-Sub, Post-doctoral, 2004-2005

• Lee, Joo-Yong, Ph.D., 2007

• Martin, Ana Isabel, M.S., 2004

• Narsilio, Guillermo, Ph.D., 2005

• Papadopoulos, Efthymios, PhD., in progress

• Scribner, Suzanne, URA 2002

• Terzariol, Marco, Ph.D., in progress

• Yun, Tae-Sup, Ph.D., 2005, Post-doctoral until August 2007

Rice University (in association with the Chevron JIP)

• Bhatnagar, Gaurav, Ph.D, 2008, Chemical Engineering

- Chatterjee, Sayantan, Ph.D. in progress, Chemical Engineering

• Daigle, Hugh, Ph.D. Earth Science. 2011

• Gu, Guangsheng, Ph.D. in progress, Chemical Engineering

• Hubbard, L. Ashley, M.S. Earth Science, 2008

• Hustoft, Steinar, visiting Ph.D. student 2008, University of Tromso, Norway

• Jaiswal, Preyank, Ph.D , post-doc, 2008

• O'Hayer, Walter, M.S. Earth Science, 2009

• Stigall, Justin, M.S., Earth Science, 2010

• Yu, Hua, Research Scientist, Earth Science, 2007

San Diego State University (in association with the Chevron JIP)

• Lindemann, Christie, M.S., 2005

Scripps Institution of Oceanography, University of California San Diego (multiple projects)

• Brooks, Laura, Ph.D., in progress

• Fenwick, Rebecca, Ph.D., in progress, Geosciences Division

• Hangsterfer, Alexandra, Ph.D., in progress, Chemical Oceanography

• Kannberg, Peter, Ph.D. Geophysics, in progress

• Solem, Christian, M.S., Marine Geochemistry

• Solomon, Evan, Ph.D., Marine Geochemistry-Geosciences

• Traer, James, Ph.D., in progress

• Weinstein, Yishai, Post-doctoral Fellow

• Weitemeyer, Karen, Ph.D. Geophysics 2008

REFERENCES

1. "Gulf of Mexico Joint Industry Project" (October 2003) – NETL Methane Hydrates Website.
2. DOE Semi-Annual Progress Report #41330R01 (Oct 2001 – Mar 2002) – NETL Methane Hydrates Website.
3. DOE Semi-Annual Progress Report #41330R02 (Apr 2002 – Sep 2002) – NETL Methane Hydrates Website.
4. DOE Topical Report #41330R03 "Results from the Data Collection Workshop, Modeling Workshop, and Drilling and Coring Methods Workshop" (September 2002) – NETL Methane Hydrates Website.
5. DOE Semi-Annual Progress Report #41330R04 (Oct 2002 – Mar 2003) – NETL Methane Hydrates Website.
6. DOE Topical Report #41330R05: "Protocols for Seismic Data Acquisition and Processing to Characterize Natural Gas Hydrate Deposits in Deepwater" (May 2004) – NETL Methane Hydrate Website.
7. Schlumberger Technical Report "Theoretical Modeling and Analysis for Gas Hydrate Quantification from Pre-stack Seismic Data in the Northern Deepwater Gulf of Mexico" (November 2003) – NETL Methane Hydrates Website.
8. DOE Topical Report #41330R07: "Measurements for Assessment of Hydrate Related Geohazards" (September 2004) – NETL Methane Hydrates Website.
9. DOE Topical Report #41330R06: "Documentation of the Results from DOE Methane Hydrates R&D Conference and the ChevronTexaco JIP Workshop, Denver Colorado" (November 2003) – NETL Methane Hydrates Website.
10. DOE Semi-Annual Progress Report #41330R08 (Oct 2004 – Mar 2005) – NETL Methane Hydrates Website.
11. "Thematic Set on Scientific Results of 2005 USDOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico" (November 2008) Marine and Petroleum Geology Volume 25, Issue 9, ISSN 0264-8172.
12. DOE Semi-Annual Progress Report #41330R09 (Apr 2005 – Sep 2005) - NETL Methane Hydrates Web Site.
13. Cruise Logging Report: GOM Gas Hydrate JIP Drilling Program Downhole Logging Program (May 2005) – NETL Methane Hydrates Website.
14. Yun, T. S., J. C. Santamarina, and C. Ruppel (2007), "Mechanical properties of sand, silt, and clay containing tetrahydrofuran hydrate", Journal of Geophysical Research, 112, B04106.
15. DOE Semi-Annual Progress Report #41330R12 (Oct 2006 – Mar 2007) - NETL Methane Hydrates Web Site.

16. Lee, J. Y., F. M. Francisca, J. C. Santamarina, and C. Ruppel (2010), “Parametric study of the physical properties of hydrate-bearing sand, silt, and clay sediments: small-strain mechanical properties, Journal of Geophysical Research, 115, B11105.
17. DOE Semi-Annual Progress Report #41330R13 (Apr 2007 – Sep 2007) - NETL Methane Hydrates Web Site.
18. “Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Operational Summary”, NETL Methane Hydrates Web Site.
19. DOE Semi-Annual Progress Report #41330R16 (Oct 2008 – Mar 2009) - NETL Methane Hydrates Web Site
20. DOE Semi-Annual Progress Report #41330R17 (Apr 2009 – Sep 2009) - NETL Methane Hydrates Web Site.
21. DOE Semi-Annual Progress Report #41330R15 (Apr 2008 – Sep 2009) - NETL Methane Hydrates Web Site.
22. “Resource and hazard implications of gas hydrates in the northern Gulf of Mexico: Results of the 2009 joint industry project LEG II drilling expedition”, Marine and Petroleum Geology Volume 34, issue 1, pages 1-224 (June 2012).
23. DOE Semi-Annual Progress Report #41330R24 (Oct 2012 – Mar 2013) - NETL Methane Hydrates Web Site.
24. DOE Semi-Annual Progress Report #41330R25 (Apr 2013 – Sep 2013) - NETL Methane Hydrates Web Site.
25. DOE Topical Report #41330R27: “Phase IIIB Topical Report” (June 2014).
26. DOE Semi-Annual Progress Report #41330R18 (Oct 2009 – Mar 2010) - NETL Methane Hydrates Web Site.
27. DOE Semi-Annual Progress Report #41330R19 (Apr 2010 – Sep 2010) - NETL Methane Hydrates Web Site.
28. DOE Semi-Annual Progress Report #41330R22 (Oct 2011 – Mar 2012) - NETL Methane Hydrates Web Site

APPENDIX A

List of Publications utilizing JIP collected data

Peer-Reviewed Publications

Boswell, R, Shelander, D., Lee, M.W., Latham, T., Collett, T.S., Guerin, G., Moridis, G., Reagan, M., and Goldberg, D., 2009. Occurrence of gas hydrate in Oligocene Frio sand: Alaminos Canyon Block 818: Northern Gulf of Mexico: Journal of Marine and Petroleum Geology, v. 26, p. 1499-1512.

Boswell, R., Collett, T., Frye, M., Shedd, W., McConnell, D., Shelander, D., 2012. Subsurface gas hydrates in the northern Gulf of Mexico. J. Marine Pet. Geol., v. 34, no. 1, pp. 4-30. DOI:10.1016/j.marpetgeo.2011.10.003.

Boswell, R., Frye, M., Shelander, D., Shedd, W., McConnell, D., and Cook, A., 2012. Architecture of gas-hydrate-bearing sands from Walker Ridge 313, Green Canyon 955, and Alaminos Canyon 21: Northern deepwater Gulf of Mexico. *J. Marine Pet. Geol.*, v. 34, no.1, pp. 134-149.

Coffin, R., L. Hamdan, R. Plummer, J. Smith, J. Gardner, R. Hagen, W. Wood, 2008. "Analysis of methane and sulfate flux in methane-charged sediments from the Mississippi Canyon, Gulf of Mexico," *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 977-987, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.014.

Collett, T.S., Agena, W.F., Lee, M.W., Zyrianova, M.V., Bird, K.J., Charpentier, R.R., Cook, T., Houseknecht, D.W., Klett, T.R., Pollastro, R.M., and Schenk, C.J., 2008. "Assessment of gas hydrate resources on the North Slope, Alaska, 2008: U.S. Geological Survey Fact Sheet 2008–3073, 4 p.

Collett, T., Lee, M., Zyrianova, M., Mrozewski, S., Guerin, G., Cook, A., Goldberg, D., 2012. Gulf of Mexico Gas Hydrate Joint Industry Project Leg II logging-while-drilling data acquisition and analysis. J. Marine Pet. Geol., v. 34, no. 1, pp. 41-61. DOI: 10.1016/j.marpetgeo.2011.08.003

Cook, A., Anderson, B., Rasmus, J., Sun, K., Li, Q., Collett, T., Goldberg, D., 2012. Electrical anisotropy of gas hydrate-bearing sand reservoirs in the Gulf of Mexico. J. Marine Pet. Geol., v. 34, no. 1, pp. 72-84. 10.1016/j.marpetgeo.2011.09.003.

Cook, A., D. Goldberg, R. L. Kleinberg, 2008. “Fracture-controlled gas hydrate systems in the northern Gulf of Mexico,” *Marine and Petroleum Geology,* Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 932-941, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.013.

Cook, A.E. and A. Malinverno (2013) Short migration of methane into a gas hydrate-bearing sand layer at Walker Ridge, Gulf of Mexico. *Geochemistry, Geophysics, Geosystems,* Vol.14 (2), pp. 283-291. doi: 10.1002/ggge.20040.

Cooper, A., and P. Hart, 2003. “High-resolution seismic-reflection investigation of the northern Gulf of Mexico gas-hydrate-stability zone,” *Marine and Petroleum Geology,* Volume 19, p. 1275-1293.

Cortes, D. D., A. I. Martin, T. S. Yun, F. M. Francisca, J. C. Santamarina, and C. Ruppel, 2009, Thermal conductivity of hydrate-bearing sediments, J. Geophys. Res., 114,, B11103, doi:10.1029/2008JB006235.

Dai, J., H. Xu, F. Snyder, and N. Dutta, 2004. “Detection and estimation of gas hydrates using rock physics and seismic inversion: Examples from the northern deepwater Gulf of Mexico,” in Taylor, C., and J. Kwan, eds., *Advances in the study of gas hydrates*, Kluwer Academic/Plenum Publishers, p.117-139.

Dai J., H., Xu, F., Snyder, and N., Dutta, 2004. “Detection and estimation of gas hydrates using rock physics and seismic inversion: Examples from the northern deepwater Gulf of Mexico,” *Leading Edge*, January.

Dai, J., F. Snyder, D. Gillespie, A. Koesoemadinata, N. Dutta, 2008. “Exploration for gas hydrates in the deepwater, northern Gulf of Mexico: Part I. A seismic approach based on geologic model, inversion, and rock physics principles,” *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 830-844, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.02.006.

Dai, J., N. Banik, D. Gillespie, N. Dutta, 2008. “Exploration for gas hydrates in the deepwater, northern Gulf of Mexico: Part II. Model validation by drilling,” *Marine and Petroleum Geology,* Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 845-859, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.02.005.

Dai, S., Lee, C.H. and Santamarina, J.C. Mount Elbert Sediments (With and Without Hydrates): Characteristics, Mechanical Properties and Geophysical Parameters, 2011. Marine and Petroleum Geology, vol. 28, pp. 427-438.

Dai, S., Santamarina, J.C., Waite, W. and Kneafsay, T., 2012. Hydrate Morphology: Patchy Hydrate Saturation in Sands, Journal of Geophysical Research - Solid Earth, vol. 117, B11205, 12 pages.

Ellis, M., R.L. Evans, D. Hutchinson, P. Hart, J. Gardner, R. Hagen, 2008. “Electromagnetic surveying of seafloor mounds in the northern Gulf of Mexico,” *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 960-968, ISSN 0264-8172, DOI: 0.1016/j.marpetgeo.2007.12.006.

Francisca, F., T. Yun, C. Ruppel, and J. Santamarina, 2005. "Geophysical and geotechnical properties of near-seafloor sediments in the northern Gulf of Mexico gas hydrate province," *Earth and Planetary Science Letters*, Volume 237, Issues 3-4, Pages 924-939, ISSN 0012-821X, DOI: 10.1016/j.epsl.2005.06.050.

Hart, P., D. Hutchinson, J. Gardner, R. Carney, and D. Fornari, 2008. "A photographic and acoustic transect across two deep-water seafloor mounds, Mississippi Canyon, northern Gulf of Mexico," *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 969-976, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.020.

Hutchinson, D., P.E. Hart, C.D. Ruppel, F. Snyder, and B. Dugan, 2009. "Seismic and thermal characterization of a bottom simulating reflector in the Northern Gulf of Mexico," in T. Collett, A. Johnson, C. Knapp, and R. Boswell, eds., *Natural gas hydrates—Energy resource potential and associated geologic hazards: AAPG Memoir 89.*

Hutchinson, D.R., Shelander, D., Dai, J., McConnell, D., Shedd, W., Frye, M, Ruppel, C., Boswell, R., Jones, E., Collett, T., Rose, K., Dugan, B., Wood, W., and Latham, T., 2008. "Site Selection for DOE/JIP Gas Hydrate Drilling in the Northern Gulf of Mexico," Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), Vancouver, British Columbia, CANADA, July 6-10, 2008.

Hutchinson, D., C. Ruppel, H. Roberts, R. Carney, and M. Smith, 2011, Gas hydrates in the Gulf of Mexico, in *Gulf of Mexico Origin, Waters, and Biota*, Volume 3: Geology, N.A. Buster and C.W. Holmes, eds., Texas A&M University Press, pp. 247-277.

Hutchinson, D.R., P.E. Hart, T.S. Collett, K.M. Edwards, D.C. Twichell, and F. Snyder, 2008. "Geologic framework of the 2005 Keathley Canyon gas hydrate research well, northern Gulf of Mexico," *Marine and Petroleum Geology,* Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 906-918, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.012.

Kastner, M., G. Claypool, and G. Robertson, 2008. "Geochemical constraints on the origin of the pore fluids and gas hydrate distribution at Atwater Valley and Keathley Canyon, northern Gulf of Mexico," *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 860-872, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.022.

Kwon, T.H., Cho, G.C. and Santamarina J.C., 2007. Hydrate Dissociation in Sediments: Pressure-Temperature Evolution, Geochemistry, Geophysics, Geosystems, vol. 9, No. 2, Q03019, doi:10.1029/2007GC001920.

Kwon, T., Cho, G.C., Santamarina, J.C., Kim, J., and Lee, J., 2009. Stability evaluation of hydrate-bearing sediments during thermally-driven hydrate dissociation, AGU Fall meeting, Abstract.

Lee, J.Y., Yun, T.S., Santamarina, J.C. and Ruppel, C., 2007. Observations Related To Tetrahydrofuran and Methane Hydrate for Laboratory Studies of Hydrate-Bearing Sediments, Geochemistry, Geophysics, Geosystems, vol. 8, no. 6.

Lee, M. and Collett, T., 2008. “Integrated analysis of well logs and seismic data to estimate gas hydrate concentrations at Keathley Canyon, Gulf of Mexico,” *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 924-931, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2007.09.002.

Lee, J.Y., Santamarina, J.C. and Ruppel, C.D., 2008. Mechanical and Electromagnetic Properties of Gulf of Mexico Sediments With and Without THF Hydrates, Marine and Petroleum Geology, vol. 25, no. 9, pp. 884-895.

Lee, J.Y. and Santamarina, J.C., 2010. Electrical Resistivity Tomography in Cylindrical Cells—Guidelines for Hardware Pre-Design, Geotechnical Testing J. vol. 33, pp. 23-32, doi: 10.1520/GTJ102366

Lee, J.Y., Francisca F., Santamarina, J.C. and Ruppel, C.D., 2010. Parametric Study of the Physical Properties of Hydrate-Bearing Sand, Silt, and Clay Sediments. Part II: Small-Strain Mechanical Properties, J. Geophysical Research – Solid Earth. vol. 115, B11105, doi:10.1029/2009JB006670,

Lee, J.Y., Santamarina, J.C., and Ruppel, C.D., 2010. Parametric Study of the Physical Properties of Hydrate-Bearing Sand, Silt, and Clay Sediments. Part I: Electromagnetic Properties. J. Geophysical Research – Solid Earth. vol. 115, B11104, doi:10.1029/2009JB006669.

Lee, J.Y., Santamarina, J.C. and Ruppel, C.D., 2010. Volume change associated with formation and dissociation of hydrate in sediment, Geochemistry, Geophysics, Geosystems, 11, Q03007, doi:10.1029/2009GC002667

Lee, C., Yun, T.S., Lee, J.S., Bahk, J.J. and Santamarina, J.C., 2011. Geotechnical Characterization of Marine Sediments in The Ulleung Basin, East Sea, Engineering Geology, vol. 117, pp. 151-158.

Lee, M. and Collett, T., 2012. Pore- and fracture-filling gas hydrate reservoirs in the Gulf of Mexico Gas Hydrate Joint Industry Project Leg II Green Canyon 955 H well. J. Marine Pet. Geol., v. 34, no. 1, pp. 62-71. doi: 10.1016/j.marpetgeo.2011.08.002

Lee, M., Collett, T., and Lewis, K., 2012. Anisotropic models to account for large borehole washouts to estimate gas hydrate saturations in the Gulf of Mexico Gas Hydrate Joint Industry Project Leg II Alaminos Canyon 21 B well. J. Marine Pet. Geol., v. 34, no. 1, pp. 85-95. doi: 10.1016/j.marpetgeo.2011.06.010.

Lorenson, T., G. Claypool, J. Dougherty, 2008. “Natural gas geochemistry of sediments drilled on the 2005 Gulf of Mexico JIP cruise,” *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 873-883, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.017.

McConnell, D., Zhang, Z., and Boswell, R., 2012. Review of progress in evaluating gas hydrate drilling hazards. *J. Mar. Pet. Geol.*, v. 34, pp. 209-224.

Pasten, C.R., Santamarina, J.C., 2011. Energy Geo-Storage, KSCE Journal of Civil Engineering, vol. 15, no. 4, pp. 655-667.

Paull, C., W. Ussler, T. Lorenson, W. Winters, and J. Dougherty, 2005, Geochemical constraints on the distribution of gas hydrates in the Gulf of Mexico, Geo-marine Letters, Volume 25, p. 273-280.

Pohlman, J., C. Ruppel, D.R. Hutchinson, R. Downer, R.B. Coffin, 2008. “Assessing sulfate reduction and methane cycling in a high salinity pore water system in the northern Gulf of Mexico,” *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 942-951, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.016.

Ruppel, C., 2007. “Tapping methane hydrates for unconventional natural gas,” *Elements*, 3 (3), 193-199.

Ruppel, C., R. Boswell, E. Jones, 2008. “Scientific results from Gulf of Mexico Gas Hydrates Joint Industry Project Leg 1 drilling: Introduction and overview,” *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 819-829, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.02.007.

Ruppel, C., R. Boswell, E. Jones (Editors), 2008. “Special Volume on Scientific Results from 2005 Joint Industry Project Gulf of Mexico Methane Hydrates Drilling,” *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008

Sanchez, M., Shastri, A., and Santamarina, J.C., 2013. Modeling Gas Hydrate Bearing Sediments Using a Coupled Approach, Proc. Pan-American Conf. on Unsaturated Soils, Cartagena, Colombia, Eds. B. Caicedo, et al., pp. 545-550.

Santamarina, J.C., Francisca, F., Yun, T.S., Lee, J.Y., Martin, A.I. and Ruppel, C., 2004. Mechanical, Thermal and Electrical Properties of Hydrate-Bearing Sediments, AAPG Hedberg Conference on Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards, September, Vancouver, BC, Canada (Extended Abstract).

Santamarina J.C., Yun T.S., Lee J.Y., Martin A., Francisca F. and Ruppel C., 2005. Mechanical, Thermal and Electromagnetic Properties of Hydrate-Bearing Clay, Silt and Sand at Various Confining Pressures, AGU Fall meeting, Abstract.

Santamarina, J.C., 2006. The Worldwide Energy Situation, Anales Academia Nacional de Ingenieria., vol. II-06, pp. 79-98.

Santamarina, J.C. Ruppel, C., Lee, J.Y. and Yun, T.S., 2007. Making the Case for In-situ Characterization of Gas Hydrate-Bearing Sediments: Quantifying Degradation Associated with Core Retrieval (Extended Abstract).

Santamarina, J.C. and Jang, J., 2009. Gas Production from Hydrate Bearing Sediments: Geomechanical Implications, DOE Fire in the Ice, vol. 9, no.4, pp. 18-22.

Santamarina, J.C. and Ruppel, C., 2010. The Impact of Hydrate Saturation on the Mechanical, Electrical and Thermal Properties of Hydrate-Bearing Sands, Silts and Clay, in Geophysical Characterization of Gas Hydrates, SEG Geophysical Developments Series No. 14, Editors M. Riedel, E.C. Willoughby, and S. Chopra, pp. 373-384.Santamarina, J.C. and Hyodo, M., 2011. US-Japan Hydrate Meeting at Georgia Tech. Future Research, DOE Fire in the Ice, vol. 10, n. 3, pp. 26-27.

Santamarina, J.C., S. Dai, J. Jang, M. Terzariol, Papadopoulos, E., W.J. Winters, D. Mason,W. Waite, and E. Bergeron, 2012. Pressure Core Characterization Tools to Enhance Gas Hydrate Field Programs, DOE Fire in the Ice, vol. 12, n. 2, pp. 7-9

Santamarina, J.C., Dai, S., Jang, J., and Terzariol, M., 2012. Pressure Core Characterization Tools for Hydrate-Bearing Sediments, Scientific Drilling, vol. 14, September 2012, pp. 44-48. doi:10.2204/iodp.sd.14.06.2012

Shelander, D., Dai, J. Bunge, G., 2010. “Predicting saturation of gas hydrates using pre-stack seismic data, Gulf of Mexico,” *Marine Geophysical Researches* V. 31 (1-2), 39-57.

Schultheiss, P., Santamarina, C., Kumar, K. and Collett, T., 2007. HYACINTH Pressure Cores from India: Analysis and Subsampling Reveals Detailed Methane Hydrate Structures, Fire in the Ice, DOE.

Valdes, J.R. and Santamarina, J.C., 2006. Particle Clogging in Radial Flow: Microscale Mechanisms, J. the Society of Petroleum Engineers SPE, vol. 11, no. 2, pp. 193-198.

Valdes, J.R. and Santamarina, J.C., 2007. Particle Transport in a Non-Uniform Flow Field: Retardation and Clogging, Applied Physics Letters, vol. 90, no. 24.

Valdes, J.R. and Santamarina, J.C., 2008. Clogging: Bridge Formation and Vibration-Based Destabilization, Canadian Geotechnical J., vol. 45, no. 2, pp. 177-184.

Waite, W., C. Ruppel, and S. Kirby, 2006. “Comment on ‘Thermal and visual time-series at a seafloor gas hydrate deposit on the Gulf of Mexico slope,’ by I. MacDonald, L. Bender, M. Vardaro, B. Bernard, and J. Brooks,” *Earth Planet. Sci. Lett*. 233 (2005) 49-59], in *Earth and Planetary Science Letters*, 245, 481- 482, doi:10.1016/j.epsl.2005.11.062.

Waite, W.F., Kneafsey, T.J., Santamarina, J.C., Winters, W.J., Yun, TS, Mason, D.H., Ruppel, C., 2006. Physical property changes in hydrate-bearing sediment samples due to depressurization/repressurization, AGU Fall meeting, Abstract.

Waite W.F., Santamarina J.C., Cortes DD, Dugan B, Espinoza DN., Germaine J., Jang J., Jung J.W., Kneafsey T., Shin HS, Soga K., Winters W., and Yun T-S., 2009. Physical Properties Of Hydrate-Bearing Sediments, Review of Geophysics, vol. 47, doi:10.1029/2008RG000279.

Waite, W.F., J.C. Santamarina, M. Rydzy, S.H. Chong, J.L.H. Grozic, K. Hester, J. Howard, T.J. Kneafsey, J.Y. Lee, S. Nakagawa, J. Priest, E. Rees, C. Koh, E.D. Sloan, A. Sultaniya, 2011. Inter-Laboratory Comparison of Wave Velocity Measurements in a Sand Under Hydrate-Bearing and Other Set Conditions, Proc. 7th International Conference on Gas Hydrates (ICGH 2011), Edinburgh, Scotland, United Kingdom, July 17-21, 2011.

Waite, W.F., J.C. Santamarina, M. Rydzy, S.H. Chong, J.L.H. Grozic, K. Hester, J. Howard, T.J. Kneafsey, J.Y. Lee, S. Nakagawa, J. Priest, E. Rees, C. Koh, E.D. Sloan, A. Sultaniya, 2012. Overview of the Inter-laboratory comparison of wave velocity measurements in sand with gas hydrate and other pore-filling material, DOE Fire in the Ice, vol. 12, n. 1, pp. 16-21

Winters, W.J., Dugan, B., and T. S. Collett, 2008. Physical properties of sediments from Keathley Canyon and Atwater Valley, JIP Gulf of Mexico gas hydrate drilling program, Marine and Petroleum Geology, Volume 25, Issue 9, November 2008, pp. 896–905.

Wood, W., P. Hart, D. Hutchinson, N. Dutta, F. Snyder, R. Coffin, J. Gettrust, 2008. "Gas and gas hydrate distribution around seafloor seeps in Mississippi Canyon, Northern Gulf of Mexico, using multi-resolution seismic imagery," *Marine and Petroleum Geology*, Volume 25, Issue 9, Thematic Set on Scientific Results of 2005 US DOE-Chevron JIP Drilling for Methane Hydrates Objectives in the Gulf of Mexico, November 2008, Pages 952-959, ISSN 0264-8172, DOI: 10.1016/j.marpetgeo.2008.01.015.

Yun, T.S., Francisca, F.M., Santamarina, J.C. and Ruppel, C., 2005. Compressional and Shear Wave Velocities in Uncemented Sediment Containing Gas Hydrate, Geophysical Research Letters, 32(10). May, L10609. DOI:10.1029/2005GL022607.

Yun, T.S., Narsilio, G.A., Lee, J.Y. Santamarina, J.C. and Ruppel, C., 2005. Physical Properties of a Keathley Canyon Pressure Core Maintained at In-situ Pressure - New Instrumented High Pressure Chamber, AGU Fall meeting, Abstract.

Yun, T.S. and Santamarina J.C., 2005. Decementation, Softening and Collapse: Changes in Small-Strain Shear Stiffness in k0 Loading, J. Geotechnical and Geoenvironmental Eng., vol. 131, no. 3, pp. 350-358.

Yun, T.S., Narsilio, G.A. and Santamarina, J.C., 2006. Geotechnical Characterization Of Gulf Of Mexico Sediments, Marine and Petroleum Geology, vol. 23, pp. 893-900.

Yun, T.S., Narsilio, G.A., Santamarina, J.C. and Ruppel, C., 2006. Instrumented Pressure Testing Chamber for Characterizing Sediment Cores Recovered at In-situ Hydrostatic Pressure, Marine Geology, vol. 229, pp. 285-293.

Yun, T.S., Santamarina, J.C. and Ruppel, C., 2007. Mechanical Properties of Sand, Silt, And Clay Containing Tetrahydrofuran Hydrate, J. Geophysical Research. – B: Solid Earth, 112.

Yun, T.S. and Santamarina, J.C., 2008. Fundamental Study of Thermal Conduction in Dry Soils, Granular Matter, vol. 10, no. 3, pp. 197-207. DOI 10.1007/s10035-007-0051-5

Yun T.S., Fratta D. and Santamarina J.C., 2010. Hydrate Bearing Sediments from the Krishna-Godavari Basin: Physical Characterization, Pressure Core Testing and Scaled Production Monitoring, Journal of Energy & Fuels, vol. 24, pp. 5972 -5983.

Yun, T.S. and Santamarina, J.C., 2011. Hydrate Growth in Granular Materials: Implication to Hydrate Bearing Sediments, Geosciences Journal, vol. 15(3), pp. 225~348

Yun, T.S., Lee, C., Lee, J.S., Jang-Jun Bahk, and Santamarina, J.C., 2011. A Pressure Core Based Characterization of Hydrate Bearing Sediments in the Ulleung Basin, East Sea, Journal of Geophysical Research, vol. 117, pp. 151-158. doi:10.1029/2010JB007468

Government Reports

Balczewski, J., 2012. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," Semi-Annual Progress Report, October 2011 – March 2012. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. March, 2012.

Balczewski, J., 2011. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," Semi-Annual Progress Report, April 2011 –September, 2011. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. October, 2011.

Balczewski, J., 2011. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," Semi-Annual Progress Report, October 2010 –March, 2011. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. April, 2011.

Balczewski, J., 2010. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," Semi-Annual Progress Report, April 2010 – September, 2010. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. October, 2010.

Balczewski, J., 2010. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," Semi-Annual Progress Report, October 2009 – March, 2010. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. June, 2010

Balczewski, J., 2012. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," Semi-Annual Progress Report, April 2012 – September 2012. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. October, 2012.

Bent, J., 2014. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," Semi-Annual Progress Report, October 2013 – March 2014. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. March, 2014.

Boswell, R., Collett, T.S., Frye, M., Shedd, W., Mrozewski, S., Gilles, G., and Cook, A., 2009. "The 2009 Gulf of Mexico Gas Hydrate Joint Industry Project — Leg II: Technical Summary," *Proceedings of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project - Leg II*.

Coffin, R. B., Lamontagne, R., Rose-Pehrsson, S., Grabowski, K. S., Knies, D. L., Qadri, SL. B., Yesinowski, J. P., Pohlman, J. W., Yousuf, M., and Linton, J. A., 2002. Ocean Floor Methane Gas Hydrate Exploration. NRL Review 2002:112-115.

Coffin, R. B. 2002. Field Evaluation of Sediment Structure and Content, Relative to Associated Hydrates. NRL Technical Report NRL Technical Report NRL/MR/6110--03-8647.

Coffin, R. B., Masutani, S. M., Uchida, T., and Kvamme, B., 2003. Fiery Ice from the Seas. 2ND International Workshop on Methane Hydrate R&D 29-31 October 2002, Washington Plaza Hotel, Washington, DC. NRL/MR/6114-03-8696.

Coffin, R. B. and R. Chapman. 2006. 4th International Workshop on Methane Hydrate Research and Development. Victoria, BC, Canada, May 9-11, 2005. US Naval Research Laboratory Technical Memorandum, NRL/MR/6110—06-9007

Coffin, R., J. Gardner, J. Pohlman, R. Downer, and W. Wood, 2006. "Methane Hydrate Exploration, Atwater Valley, Texas–Louisiana Shelf: Geophysical and Geochemical Profiles," (2006) NRL/MR/6110-06-9002.

Coffin, RB, Hamdan, LJ, Smith, J, Rose, K, Downer, RC, Edsal, D. Gardner, J. Hagen, R., Wood, WT. 2008. Geochemical evaluation of deep sediment hydrate deposits on Alaminos Canyon, Block 818, Texas-Louisiana Shelf. NRL/MR/6110-11-9294.

Collett, T.S., Boswell, R., Mrozewski, S., Guerin, G., Cook, A., Frye, M., Shedd, W., and McConnell, D., 2009. “Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Operational Summary,” Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Collett, T., 2005. “Cruise Report: ChevronTexaco Gulf of Mexico JIP drilling program: downhole logging program,” DOE-NETL Topical Report.

Cook, A., Guerin, G., Mrozewski, S., Collett, T.S., Boswell, R., 2009. “Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Walker Ridge 313 LWD Operations and Results,” Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Evans, J., D. Fornari, L. Gilbert, M. Boyle, and J. Dougherty, 2005. “Archive of raw bottom photographs collected during cruise P1-04-GM, northern Gulf of Mexico, June 21-24,” U.S. Geological Survey Open-File Report 2004-1285.

Frye, M., Shedd, W., Godfriaux, P., Collett, T.S., Lee, M., Boswell, R., Dufrene, R., 2009. “Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Alaminos Canyon 21 Site Summary,” Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Guerin, G., Cook, A., Mrozewski, S., Collett, T.S., Boswell, R., 2009. “Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Green Canyon 955 LWD Operations and Results,” Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Guerin, G., Cook, A., Mrozewski, S., Collett, T.S., Boswell, R., 2009. “Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Alaminos Canyon 21 LWD Operations and Results,” Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Hart, P., D. Hutchinson, and M. Lee, 2005. “High-resolution seismic-reflection data acquired in the northern Gulf of Mexico, 2003.” *U.S. Geological Survey Open-File Report* 2005-1411.

Holditch, S., and E. Jones, 2004. “Protocols for seismic data acquisition and processing to characterize natural gas hydrate deposits in deepwater,” U.S. DOE Topical Report, Award Number DE-FC26-01NT41330.

Holditch, S., and E. Jones, 2002. “Results from the Data Collection Workshop, Modeling Workshop, and Drilling and Coring Methods Workshop as a part of the Joint Industry Participation (JIP) Project to characterize natural gas hydrates in the deepwater Gulf of Mexico,” U.S. DOE Topical Report, Award Number DE-FC26-01NT41330.

Hutchinson, D., 2005, Final Technical Report to the Department of Energy, National Energy Technology Lab Interagency Agreement, Task DE-AT26-97FT34343, September 8, 1997- April 30, 2005.

Hutchinson, D., Boswell, R., Collett, T.S., Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, D., Rose, K., Ruppel, C., Shedd, W., Shelander, D., Wood, W., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Walker Ridge 313 Site Selection," Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Hutchinson, D., Boswell, R., Collett, T.S., Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, D., Rose, K., Ruppel, C., Shedd, W., Shelander, D., Wood, W., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Green Canyon 955 Site Selection,"Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Hutchinson, D., Boswell, R., Collett, T.S., Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, D., Rose, K., Ruppel, C., Shedd, W., Shelander, D., Wood, W., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Green Canyon 781 Site Selection," Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Hutchinson, D.R., and Hart, P.E., 2004. "Cruise report for G1-03-GM USGS Gas Hydrates cruise, R/V Gyre, 1-14 May, 2003, Northern Gulf of Mexico," U.S. Geological Survey Open-File Report OF 03-474, 103 pp.

Hutchinson, D., P. Hart, B. Dugan, E. Geresi, R. Sliter, and K. Newman, 2003. "Subsurface gas hydrates in the northern Gulf of Mexico," *Proceedings of the Geological Society of America Annual Meeting*, Volume 34, n. 7, November 2-5.

Jones, E., 2009. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," U.S. DOE Semi-Annual Report, October 2008–March 2009.

Jones, E., 2008. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities, U.S. DOE Semi-Annual Report, April 2008–September 2008.

Jones, E., 2007. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," U.S. DOE Semi-Annual Report, October 2006–March 2007.

Jones, E., 2007. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," U.S. DOE Semi-Annual Report, April 2006–September 2006.

Jones, E., 2006. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," U.S. DOE Semi-Annual Report, October 2005–March 2006.

Jones, E., 2006. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities," U.S. DOE Semi-Annual Report, April 2005–September 2005.

Jones, E., 2006. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico, Applications for Safe Exploration and Production Activities," U.S. DOE Semi-Annual Report, October 2004–March 2005.

Kleinberg, R., and E. Jones, 2004. "Measurements for assessment of hydrate related geohazards," U.S. DOE Topical Report, Award Number DE-FC26-01NT41330, ChevronTexaco Energy Technology Company.

Lee, M.W., 2009. Anisotropic velocities of gas hydrate-bearing sediments in fractured reservoirs: U.S. Geological Survey Scientific Investigations Report 2009-5141, 20 pp.

Lee, M.W., 2013. Shear wave velocities of unconsolidated shallow sediments in the Gulf of Mexico: U.S. Geological Survey Scientific Investigations Report 2013–5141, 11 p., http://pubs.usgs.gov/sir/2013/5141/.

McConnell, D., Boswell, R., Collett, T.S., Frye, M., Shedd, W., Guerin, G., Cook, A., Mrozewski, S., Dufrene, R., and Godfriaux, P., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Walker Ridge 313 Site Summary," Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

McConnell, D., Boswell, R., Collett, T.S., Frye, M., Shedd, W., Guerin, G., Cook, A., Mrozewski, S., Dufrene, R., and Godfriaux, P., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Green Canyon 955 Site Summary," Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Mrozewski, S., Guerin, G., Cook, A., Collett, T.S., Boswell, R., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — LWD Methods," Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II

Ruppel, C., 2011, Scientific ocean drilling and gas hydrates studies, in: Scientific Ocean Drilling Accomplishments and Challenges, National Research Council Report, 106-110.

Ruppel, C., J. Robertson, and B. Pierce, 2013, Groundbreaking gas hydrate research, Sound Waves, USGS national newsletter, March/April 2013. http://soundwaves.usgs.gov/2013/04/research.html

Shedd, W., Hutchinson, D., Boswell, R., Collett, T.S., Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, D., Rose, K., Ruppel, C., Shelander, D., and Wood, W., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — East Breaks 991 and Alaminos Canyon 21 Site Selection," Proceedings of the Drilling and Scientific Results of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II.

Schlumberger, 2003. "Theoretical modeling and analysis for gas hydrate quantification from pre-stack seismic data in the northern deepwater Gulf of Mexico," *U.S. DOE Topical Report*, Award Number DE-FC26-01NT41330, ChevronTexaco Energy Technology Company, 130 pp.

Shipboard Science Party, 2006. "Cruise Report for the Gulf of Mexico Gas Hydrate Joint Industry Project: Covering the cruise of the drilling vessel Uncle John - Mobile, Alabama to Galveston, Texas Atwater Valley Blocks 13/14 and Keathley Canyon Block 151," 17 April to 22 May. Individual sections listed below alphabetically by author:

Collett, T., Gulf of Mexico Gas Hydrate JIP Drilling Program Downhole Logging Program.

Conte, A., and B. Bloys, Gulf of Mexico Gas Hydrates Joint Industry Project Operational Summary of 2005 Drilling and Coring Program.

Dugan, B., Geomechanical Characteristics of Sediments from Atwater Valley and Keathley Canyon, Northern Gulf of Mexico.

Hippe, F., Geotechnical Investigation, Chevron Gulf of Mexico Hydrates JIP, Results of Core Sample Analysis Standard and Advanced Laboratory Testing, Report No. 0201-5081, prepared by Fugro-McClelland Marine Sciences for Chevron Texaco Energy Technology Company.

Kastner, M., G. Claypool, and G. Robertson, Pore Water Geochemistry – 2005 Gulf of Mexico JIP Cruise.

Lorenson, T., J. Dougherty, and G. Claypool, Natural Gas Geochemistry – 2005 Gulf of Mexico JIP Cruise.

Ruppel, C., and J. Santamarina, Preliminary Results: Georgia Tech Instrumented Pressure Testing Chamber Deployed on JIP Gas Hydrate Drilling Program in Gulf of Mexico, April-May 2005.

Schultheiss, P., M. Holland, and J. Roberts, Gulf of Mexico Gas Hydrates Joint Industry Project Pressure Coring and Core Logging.

Snyder, G., L. Hubbard, B. Dugan, and G. Dickens. Total iodine, bromine, and barium concentrations in pore waters from the Atwater Valley area, Gulf of Mexico: Preliminary results from the Gas Hydrates JIP Cruise.

Twichell, D.C., Cross, V.A., Paskevich, V.F., Hutchinson, D.R., Winters, W.J., and Hart, P.E., 2005. GIS of selected geophysical and core data in the northern Gulf of Mexico continental slope collected by the U.S. Geological Survey: USGS Open-File Report 2005-1071 (CD-ROM).

Vu, C., 2013. “Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities,” Semi-Annual Progress Report, October 2012 – March 2013. Chevron, DOE Award No.: DE- DE-FC26-01NT41330. April, 2013.

Theses/Dissertations

Lee, J.Y., 2007. “Hydrate-Bearing Sediments: Formation And Geophysical Properties,” *Ph.D. Thesis*, Civil and Environmental Engineering, Georgia Tech, 241 pp., 2007.

Martin, A.I., 2004. “Hydrate Bearing Sediments - Thermal Conductivity,” *M.S. Thesis*, Civil and Environmental Engineering, Georgia Tech, 151 pp.

Yun, T.S., 2005. “Mechanical and Thermal Study of Hydrate Bearing Sediments,” *Ph.D. Thesis*, Civil and Environmental Engineering, Georgia Tech, 179 pp.

Other Publications

Balczewski, J.T., Boswell, R., Collett, T.S., and Baker, R., 2011, International collaboration on deepwater natural gas hydrate continues – Gulf of Mexico Gas Hydrate JIP: past, present, and future: Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), July 17-21, 2011, Edinburgh, Scotland, United Kingdom, 6 p.

Birchwood, R., Dai, J., Shelander, D., Boswell, R., Collett, T., Cook, A., Dallimore, S., Fuji, K., Imasato, Y., Fukuhara, M., Kusaka, K., Murray, D., and Saeki, T., 2010, Developments in gas hydrates: Oilfield Review, Published by Schlumberger, Spring, 2010, p. 18-33.

Boswell, R., Collett, T.S., McConnell, D., Frye, M., Shedd, B., Mrozewski, S., Guerin, G., Cook, A., Godfriaux, P., Dufrene, R., Roy, R., and Jones, E., 2009, Joint industry project leg II discovers rich gas hydrate accumulations in sand reservoirs in the Gulf of Mexico: Fire in the Ice, DOE/NETL Newsletter, Summer, 2009, p. 1-35.

Boswell, R., Collett, T.S., Frye, M., Shedd, W., Mrozewski, S., Guerin, G.., and Cook, A., 2009, The 2009 Gulf of Mexico Gas Hydrate Joint Industry Project - Leg II: Technical Summary: Proceedings of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project - Leg II, 30 p.

Boswell, R., Collett, T.S., McConnell, D., Frye, M., Shedd, B., Godfriaux, P., Dufrene, R., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., Jianchun, D., and Jones, E., 2009, Initial results of Gulf of Mexico Gas Hydrate Joint Industry Project Leg II logging-while-drilling operations: Proceedings of the 29th Annual Gulf Coast Section Foundation, Bob F. Perkins Research Conference, December 6-8, 2009, Houston, Texas, 21 p. (on CD-ROM).

Boswell, R., Moridis, G., Reagan, M., and Collett, T., 2011, Gas hydrate accumulation types and their application to numerical simulation: Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), July 17-21, 2011, Edinburgh, Scotland, United Kingdom, 12 p.

Boswell, R., Collett, T.S., McConnell, D., Frye, M., Shedd, B., Godfriaux, P., Dufrene, R., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., Jianchun, D., and Jones, E., 2010, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Overview of Leg II LWD Results, OTC 20560, Proceedings 2010 Offshore Technology Conference, Houston, Texas May 3-6, 2010, 12 p.

Boswell, R., Collett, T.S., McConnell, D., Frye, M., Shedd, B., Mrozewski, S., Guerin, G., Cook, A., Godfriaux, P., Dufrene, R., Roy, R., and Jones, E., 2009, Joint industry project leg II discovers rich gas hydrate accumulations in sand reservoirs in the Gulf of Mexico: Fire in the Ice, DOE/NETL Newsletter, Summer, 2009, p. 1-5.

Collett, T.S., 2005, Gulf of Mexico Gas Hydrate JIP Drilling Program downhole logging program, 65 p.

Collett, T.S., Boswell, R., Frye, M., Shedd, W., Godfriaux, P., Dufrene, R., McConnell, D., Mrozewski, S., Jones, E., and Roy, R., 2009, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Operational Summary: Proceedings of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project - Leg II, 30 p. (http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/2009Reports/LWDMethods.pdf)

Collett, T.S., 2009, Gas hydrate petroleum systems in marine and Arctic permafrost environments: Proceedings of the 29th Annual Gulf Coast Section Foundation, Bob F. Perkins Research Conference, December 6-8, 2009, Houston, Texas, 12 p. (on CD-ROM).

Collett, T.S., Boswell, R., Frye, M., Shedd, W., Godfriaux, P., Dufrene, R., McConnell, D., Mrozewski, S., Jones, E., and Roy, R., 2009, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Operational Summary: Proceedings of the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project - Leg II, 30 p.

Collett, T.S., and Boswell, R.M., 2010, Results of the Gulf of Mexico Gas Hydrate Joint Industry Project Leg II Drilling Expedition: Impact on Global Energy Development, Proceedings of Petrotech-2010, October 31 through November 3, 2010, New Delhi, India, 8 p.

Collett, T.S., Boswell, R., Frye, M., Shedd, W., Godfriaux, P., Dufrene, R., McConnell, D., Mrozewski, S., Guerin, G., and Cook, A., 2010, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Logging-While-Drilling Operations and Challenges, OTC 20452, Proceedings 2010 Offshore Technology Conference, Houston, Texas May 3-6, 2010, 12 p

Collett, T.S., and Boswell, R.M., 2011, Results of the Gulf of Mexico Gas Hydrate Joint Industry Project Leg II Drilling Expedition: impact on global energy development, Proceedings of the 241th American Chemical Society National Meeting, March 27-30, 2011, Anaheim, California, 4 p.

Cook, A., Rasmus, J., Li, Q., Sun, K., Anderson, B., Collett, T., and Goldberg, D., 2011, Analyzing electrical anisotropy in gas hydrate reservoirs using logging-while-drilling directional resistivity data from the Gulf of Mexico Gas hydrate Joint Industry Project: Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), July 17-21, 2011, Edinburgh, Scotland, United Kingdom, 13 p.

Claypool, G., 2005. “Joint industry project (JIP) Gulf of Mexico gas hydrate coring update,” U.S. DOE-NETL Fire in the Ice Newsletter, Summer, pgs. 9-13.

Dai, J., H. Xu, F. Snyder, and N. Dutta, 2004. “Detection and estimation of gas hydrates using rock physics and seismic inversion – examples from the northern deepwater Gulf of Mexico,” *The Leading Edge*, Volume 23, p. 60-66.

Frye, M.C., Shedd, W.W., Godfriaux, P.D., Dufrene, R., Collett, T.S., Lee, M.W., Boswell, R., Jones, E., McConnell, D.R., Mrozewsli, S., Guerin, G., and Cook, A., 2010, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: results from the Alaminos Canyon 21 Site, OTC 20552, Proceedings 2010 Offshore Technology Conference, Houston, Texas May 3-6, 2010, 21 p.

Haines, S.S., Lee, M.W., and Collett, T.S., 2011, Multicomponent seismic methods for characterizing gas hydrate occurrences and systems in deep-water Gulf of Mexico: Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), July 17-21, 2011, Edinburgh, Scotland, United Kingdom, 10 p.

Hart, P., D. Hutchinson, and B. Dugan, 2003. “USGS conducts deepwater gas hydrate research cruise in the northern Gulf of Mexico,” U.S. DOE-NETL Fire in the Ice Newsletter, Fall, pgs. 6-8.

Hutchinson, D.R., Boswell, Ray, Collett, Tim, Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, Dan, Rose, K., Ruppel, C., Shedd, W., Shelander, D., and Wood, W., 2009, Gulf of Mexico gas hydrate Joint Industry Project Leg II: Green Canyon 781 site selection: Department of Energy, 2009 Gulf of Mexico JIP – Leg II Reports, http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/2009Reports/GC781SiteSelect.pdf , 28 pp.

Hutchinson, D.R., Boswell, Ray, Collett, Tim, Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, Dan, Rose, K., Ruppel, C., Shedd, W., Shelander, D., and Wood, W., 2009, Gulf of Mexico gas hydrate Joint Industry Project Leg II: Walker Ridge 313 site selection: Department of Energy, 2009 Gulf of Mexico JIP – Leg II Reports, http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/2009Reports/WR313SiteSelect.pdf , 35 pp.

Hutchinson, D.R., Boswell, Ray, Collett, Tim, Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, Dan, Rose, K., Ruppel, C., Shedd, W., Shelander, D., and Wood, W., 2009, Gulf of Mexico gas hydrate Joint Industry Project Leg II: Green Canyon 955 site selection: Department of Energy, 2009 Gulf of Mexico JIP – Leg II Reports, http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/2009Reports/GC955SiteSelect.pdf , 51 pp.

Hutchinson, D.R., Shelander, D., Dai, J., McConnell, D., Shedd, W., Frye, M, Ruppel, C., Boswell, R., Jones, E., Collett, T., Rose, K., Dugan, B., Wood, W., and Latham, T., 2008, Site Selection for DOE/JIPGas Hydrate Drilling in the Northern Gulf of Mexico: Sixth International Conference on Gas Hydrates, Vancouver, BC., 7-10 July, 2008.

Jones, E., and S. Holditch, 2004. “Characterizing natural gas hydrates in the deepwater Gulf of Mexico,”Proceedings of the Fourth International Symposium on Methane Hydrates, Yokohama, Japan.

Kwon, T.-H.; Cho, G.-C.; Santamarina, J. C., 2008. Gas hydrate dissociation in sediments: Pressure-temperature evolution. Geochem., Geophys., Geosyst. v. 9, No. Q03019.

Lee, M.W., and Collett, T.S., 2011, Three types of gas hydrate reservoirs in the Gulf of Mexico identified in LWD data: Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), July 17-21, 2011, Edinburgh, Scotland, United Kingdom, 12 p.

McConnell, D.R., Collett, T.S., Boswell, R., Frye, M.C., Shedd, W.W., Dufrene, R., Godfriaux, P., Mrozewski, S., Guerin, G., Cook, A., and Jones, E., 2010, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: initial results from the Green Canyon 955 Site, OTC 20801, OTC 20552, Proceedings 2010 Offshore Technology Conference, Houston, Texas May 3-6, 2010, 14 p.

Moridis, G.J., Reagan, M.T., Boswell, R., Collett, T.S., and Zhang, K., 2010, Preliminary evaluation of the production potential of recently discovered hydrate deposits in the Gulf of Mexico, OTC 21049, Proceedings 2010 Offshore Technology Conference, Houston, Texas May 3-6, 2010, 27 p.

Mrozewski, S., Cook, A., Guerin, G., Goldberg, D., Collett, T.S., Boswell, R., and Jones, E., 2010, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: LWD logging program design, data acquisition and evaluation, OTC 21023, Proceedings 2010 Offshore Technology Conference, Houston, Texas May 3-6, 2010, 27 p.

Ruppel, C., 2011. Methane hydrates and the future of natural gas, Supplementary Paper 2.4, "The Future of Natural Gas", MIT Energy Initiative.

Ruppel, C., Collett, T., Boswell, R., Lorenson, T., Buckzowski, B., W. Waite, 2011. A new global gas hydrate drilling map based on reservoir type, Fire in the Ice, US Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory, 11, 1, 15-19.

Santamarina, J.C. and C. Ruppel, 2010, The impact of hydrate saturation on the mechanical, electrical, and thermal properties of hydrate-bearing sand, silts, and clay, *Proceedings of the 6th International Conference on Gas Hydrates* (ICGH), Vancouver, Canada, 6-10 July, 12 pp.

Santamarina, J.C., Winters, W.J., Dai, S., Jang, J., Terzariol, M., Papadopoulos, E., Mason, D., Waite, W., Bergeron, E., 2012. Pressure core characterization tools to enhance gas hydrate field programs. Fire in the Ice Newsletter, v. 12, no. 2, pp. 7-9.

Santamarina, J.C., Dai, S., Jang, J., Terzariol, M., Papadopoulos, Winters, W.J., Mason, D., Waite, W., and Bergeron, E., 2012. Pressure core characterization tools to enhance gas hydrate field programs, Fire in Ice, DOE/National Energy Technology Lab Gas Hydrates Newsletter, 12(2), pp.7-9.

Schultheiss, P., C. Santamarina, P. Kumar, and T. Collett, 2007. “HYACINTH Pressure Cores from India: Analysis and Subsampling Reveals Detailed Methane Hydrate Structures,” U.S. DOE-NETL Fire in the Ice Newsletter, Winter, pgs. 11-13.

Shedd, W.W., and Hutchinson, D.R., 2006, Gas hydrate potential of the mid-Atlantic outer continental shelf: Fire in the Ice Newsletter Fall, 2006, p. 8-9.

Shedd, W., Hutchinson, D.R., Boswell, Ray, Collett, Tim, Dai, J., Dugan, B., Frye, M., Jones, E., McConnell, Dan, Rose, K., Ruppel, C., Shelander, D., and Wood, W., 2009, Gulf of Mexico gas hydrate Joint Industry Project Leg II: East Breaks 992 and Alaminos Canyon 21 site selection: Department of Energy, 2009 Gulf of Mexico JIP – Leg II Reports, 18 pp.

Shedd, B., P. Godfriaux, M. Frye, R. Boswell, and D. Hutchinson, 2009. “Occurrence and variety in seismic expression of the base of gas hydrate stability in the Gulf of Mexico, “ U.S. DOE-NETL Fire in the Ice Newsletter, Winter 2009.

Shedd, W., Frye, M., Godfriaux, P., Dufrene, R., McConnell, D., Boswell, R., Collett, T., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., and Dai, J., 2010, Gulf of Mexico Gas Hydrates Joint Industry Project Leg II: results from the Walker Ridge 313 Site, OTC 20806, Proceedings 2010 Offshore Technology Conference, Houston, Texas May 3-6, 2010, 15 p.

Shelander, D., Dai, J., Bunge, G., Boswell, R., Collett, T.S., Balczewski, J., and Jones, E., 2011, predictions of gas hydrates using pre-stack seismic data, deepwater Gulf of Mexico: Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), July 17-21, 2011, Edinburgh, Scotland, United Kingdom, 10 p.

Smith, S., R. Boswell, T. Collett, M. Lee, and E. Jones, 2006. “Alaminos Canyon Block 818: A Documented Example of Gas Hydrate Saturated Sand in the Gulf of Mexcio,” U.S. DOE-NETL Fire in the Ice Newsletter, Fall, pgs. 12-13.

Schultheiss, P., C. Santamarina, P. Kumar, and T. Collett, 2007. “HYACINTH Pressure Cores from India: Analysis and Subsampling Reveals Detailed Methane Hydrate Structures,” U.S. DOE-NETL Fire in the Ice Newsletter, Winter, pgs. 11-13.

Smith, S., R. Boswell, T. Collett, M. Lee, and E. Jones, 2006. “Alaminos Canyon Block 818: A Documented Example of Gas Hydrate Saturated Sand in the Gulf of Mexico,” U.S. DOE-NETL Fire in the Ice Newsletter, Fall, pgs. 12-13.

Suzuki, K., Nakatsuka, Y., Fujii, T., Santamarina, J.C, Waite, W.F., Winters, W.J., Ito, K, Konno, Y, Yoneda, J., Kida, M., Jin, Y., Egawa, K., Nagao, J., 2013. P-wave velocity features of methane hydrate-bearing turbidity sediments sampled by a pressure core tool, from the first offshore production test site in the eastern Nankai Trough, Japan, AGU 2013 Fall Meeting.

Waite, W.F., Santamarina, J.C., Rydzy, M., Chong, S.H., Grozic, J.L.H., Hester, K., Howard, J., Kneafsey, T.J., Lee, J.Y., Nakagawa, S., Priest, J., Rees, E., Koh, C., Sloan, E.D., and Sultaniya, A., 2012. Overview of the Inter-laboratory comparison of wave velocity measurements in a sand with gas hydrate and other pore-filling material. Fire in the Ice Newsletter, v. 12, no. 1, pp. 16-21.

Presentations

Birchwood, R., Singh, R., Mese, A., 2008. "Estimating the In-situ Mechanical Properties of Sediments Containing Gas Hydrates," *Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008)*, Vancouver, British Columbia, CANADA, July 6-10, 2008.

Birchwood, R., Noeth, S., Sayers, C., Hooyman, P., and Jones, E., 2005. "Results of Wellbore Stability Modeling for the Gulf of Mexico Joint Industry Project on Hydrates Leg I," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS31D-05.

Birchwood, R., 2005. "Wellbore Stability Model for Marine Sediments Containing Gas Hydrates," *American Association of Drilling Engineers National Drilling Technology Conference*, Houston, TX, April 5-7.

Boswell, R., Collett, T.S., McConnell, D., Frye, M., Shedd, W., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., Dai, J., Godfriaux, P., Dufrene, R., Jones, E., Roy, R., 2010. "Gulf of Mexico Gas Hydrates Joint Industry Project: Overview of Leg II LWD Results," Offshore Technology Conference, Houston, Texas, May 3-6, 2010. OTC 20560

Boswell, R., Collett, T.S., McConnell, D., Shedd, W., Shelander, D., Dai, J., Mrozewski, S., Guerin, G., Cook, A., Dufrene, R., Godfriaux, P.D., Roy, R., and Jones, E., 2009. "Initial Results of the Gulf of Mexico Gas Hydrate Joint Industry Program Leg II Logging-While-Drilling Operations," *Eos Trans.* AGU, 90(52), Fall Meet. Suppl. OS24A-02.

Boswell, R., 2006. "U.S. DOE/Chevron Gulf of Mexico Gas Hydrates Joint Industry Project," *Methane Hydrates Federal Advisory Committee*, Washington, D.C., November 8.

Boswell, R., 2006. "U.S. DOE/Chevron Gulf of Mexico Gas Hydrates Joint Industry Project," *Methane Hydrates Federal Advisory Committee*, Washington, D.C., April 24.

Boswell, R.M., [invited] Collett, T.S., Frye, M., McConnell, D., Shedd, W., Shelander, D., Dai, J., Mrozewski, S., Guerin, G., Cook, A., Dufrene, R., Godfriaux, R., Roy, R., and Jones, E., 2009, Initial results of Gulf of Mexico Gas Hydrate Joint Industry Program Leg II logging-while-drilling operations: Fall Meeting of the American Geophysical Union, December 14-18, 2009, San Francisco, California, Proceedings, Abstract OS24A-02.

Boswell, R. [invited], Balczewski, J., and Collett, T.S., 2010, United States National Strategy in Gas Hydrate Research and Development, Gulf of Mexico Gas Hydrate Joint Industry Project - International Deepwater Natural Gas Hydrate Research Collaboration: Proceedings of the International Symposium on Methane Hydrate Resources: From Mallik to the Nankai Trough, November 15-17, 2010, Tokyo, Japan, 2 p.

Chuvilin, E., E. Kozlova, O. Boldina, and W. Winters, 2004, Stability of methane gas hydrate formed in marine sediment from the northern Gulf of Mexico, St. Petersburg, Russia, Minerals of the Ocean – Integrated Strategies, April 25-30.

Claypool, G., Wood, W., 2005. "Natural Gas Hydrates: Modeling, Laboratory Studies, Recent JIP Drilling, and Other Field Investigations I," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS31D-Poster.

Claypool, G., Wood, W., 2005. "Natural Gas Hydrates: Modeling, Laboratory Studies, Recent JIP Drilling, and Other Field Investigations IV," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS42A-Poster.

Coffin, R., J. Gardner, J. Pohlman, R. Downer, and W. Wood, 2005. "Methane Hydrate Exploration, Atwater Valley, Texas-Louisiana Shelf: Geophysical and Geochemical Profiles," *Fourth International Methane Hydrate Research and Development Workshop*, Victoria, BC, Canada, May.

Coffin, R., J. Pohlman, W. Wood, J. Gardner, R. Plummer, and J. Gettrust, 2005. "Geochemical Evaluation of Piston Core Porewater on Atwater Valley, Gulf of Mexico, Variation in Vertical Methane Gradients," *Eos Trans*. AGU, 86(52), Fall Meet. Suppl., OS42A-03.

Collett, T.S., 2008, Assessment of gas hydrate energy resources: December 2, 2008, MIT (Cambridge, MA). Presentation in the MIT/USGS ENI Methane Hydrate Seminar Series.

Collett, T.S., et al., 2009, U.S. Geological Survey gas hydrate energy resource studies: Proceedings of the NRC Committee reviewing the activities authorized under the Methane Hydrate research Development Act (renewal) of 2005 (presentation only).

Collett, T.S., 2011, Gas hydrates energy resources - gas hydrate petroleum systems: Proceedings of the 7th International Conference on Asian Marine Geology, October 11-14, 2011, CSIR-National Institute of Oceanography, Goa, India, 2 p.

Collett, T.S., Boswell, R., Frye, M., Shedd, W., Godfriaux, P., Dufrene, R., McConnell, D., Mrozewski, S., Guerin, G., Cook, A., Jones, E., Roy, R., 2010. "Gulf of Mexico Gas Hydrates Joint Industry Project: Logging-While-Drilling Operations and Challenges," Houston, Texas: Offshore Technology Conference, May 3-6, OTC 20452

Collett, T. S., and Boswell, R., 2009. "Gas Hydrate Research Site Selection and Operational Research Plans," *Eos Trans.* AGU, 90(52), Fall Meet. Suppl., OS24A-01.

Collett, T., A. Conte, L. Loh, H. Hoong, D. Goldberg, 2005. "Preliminary analysis of the downhole of Mexico Gas Hydrate JIP cruise," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS31D-02.

Cook, A., Rasmus, J., Li, Q., Sun, K., Anderson, B., Collett, T., and Goldberg, D., 2011. "Analyzing Electrical Anisotropy in Gas Hydrate Reservoirs Using Logging-While-Drilling Directional Resistivity Data from the Gulf of Mexico Gas Hydrate Joint Industry Project." *Proc. of the 7th International Conference on Gas Hydrates (ICGH 2011). Edinburgh, Scotland, United Kingdom, July, 17-21, 2011.*

Cook, A., Malinverno, A., 2010. Can in-situ methanogenesis explain a 3 m-thick gas hydrate-filled sand in Walker Ridge Block 313, Gulf of Mexico?, Abstract OS53A-1353 Poster presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Cook, A., and Goldberg, D., 2009. "Two Kinds of Gas Hydrate Reservoirs: Pore-filling Sand vs. Fractured Clay," *Eos Trans*. AGU, 90(52) Fall Meet. Suppl., OS31A-1174.

Cook, A., D. Goldberg, and R. Kleinberg, 2006. "Cohesive strength of gas hydrate-bearing marine sediments," *The American Association of Petroleum Geologists Annual Meeting*, April 9-12.

Cook, A. E., Goldberg, D., 2005. "Cohesive Strength of Gas-hydrate-bearing Marine Sediments," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS42A-07.

Dai, J. and N., Dutta, 2007. "Exploration For Gas Hydrates In Deepwater Northern Gulf Of Mexico," *Eos Trans.* AGU, 88(23), Jt. Assem. Suppl., NS54A-02.

Dai, J. and N., Dutta, 2007. "Exploration for gas hydrates based on seismic information: with examples from Northern Gulf of Mexico," *69th EAGE*, London, UK, June.

Dai, J., N. Dutta, and H. Xu, 2006. "Gas hydrate estimation using rock physics modeling and seismic inversion," *Eos Trans.* AGU, 87(36), Jt. Assem. Suppl., NS44A-03.

Dai, J., R. Kleinberg, H. Xu, and N. Dutta, 2005. "Rock physics models of gas hydrates and their implications in seismic detection," Houston, TX: *Offshore Technology Conference*, May 2-5, OTC 17266-MS.

Dai, J., H. Xu, F. Snyder, and N. Dutta, 2004. "Detection and quantification of gas hydrates in the Gulf of Mexico: An integrated five-step workflow," *66th European Association of Geoscientists & Engineers*, Paris, France, June 7-10.

Dai, J., H. Xu, F. Snyder, L. Muller, A. Koesoemadinata, D. Gillespie, G. Wool, and N. Dutta, 2004. "Physical Rock Properties of Gas Hydrate Bearing Sediments, Geophysical Modeling, Inversion and Quantitative Volumetric Estimation in the Deepwater Gulf of Mexico," Dallas, TX, *The American Association of Petroleum Geologists Annual Meeting*, April 18-21.

Dai, J., R. Kleinberg, H. Xu, and N. Dutta, 2004. "Seismic Detection and Quantification of Gas Hydrates," Vancouver, BC, Canada, *The American Association of Petroleum Geologists Hedberg Conference*, September 12-16.

Dugan, B., J. Germaine, W. Winters, and P. Flemings, 2003, Near-seafloor overpressure in the Deep water Gulf of Mexico interpreted from laboratory experiments, San Francisco, CA, American Geophysical Union Fall Meeting, December 8-12.

Dugan, B., J. Germaine, W. Winters, and P. Flemings, 2004, Laboratory constraints and models of pressure, hydrate, and stability in shallow Mississippi Canyon sediments (MC 855), deepwater Gulf of Mexico, Dallas, TX, The American Association of Petroleum Geologists Annual Meeting, April 18-21.

Dutta, N., 2004. "Gas hydrates – detection and quantification for resource assessment and risk mitigation," Houston, TX, *Global Energy Forum*, Rice University, October 12.

Dutta, N., 2005. “Emerging technology application aimed at characterization of gas hydrates and free gas underneath BSR,” *Second International Congress on Geosciences in Petroleum Industry, AMGE*, September 4-7.

Dutta, N., 2006. “Methane Hydrates Exploration Technology,” Houston, TX, *Hart Energy Publishing Methane Hydrates Conference*, Dec. 5-6.

Dutta, N., J. Dai, and X. Haibin, 2004. “Seismic detection and quantification of gas hydrates in the Gulf of Mexico,” Florence, Italy, *32nd International Geological Conference*, August 23-27.

Dutta, N., R. Kleinberg, J. Dai, and H. Xu, 2005. “Natural gas hydrates estimation using seismic inversion and rock physics,” *Eos Trans.* AGU, 86(18), Jt. Assem. Suppl., NS11A-05.

Dutta, N., H. Xu, and J. Dai, 2005. “Seismic detection and quantification of gas hydrate using rock physics and inversion,” New Delhi, India, *PetroTech*, January 15-19.

Dutta, N., L. Muller, J. Dai, and R. Utech, 2003. “Seismic detection of gas hydrates,” *The American Association of Petroleum Geologists International Conference*, Barcelona, Spain, September 21-24.

Ellis, M., Evans, R., L., Hutchinson, D.R., Hart, P., 2005. “An Electromagnetic Survey of the JIP Drill Sites in Atwater Valley,” *Eos Trans*. AGU, 86(52), Fall Meet. Suppl., OS31D-07.

Frye, M., Shedd, B., and Boswell, R., 2012. Gas Hydrate Resources of the Terrebonne Basin, Northern Gulf of Mexico. *J. Mar. Pet. Geol.*, v. 34, pp. 150-168.

Frye, M., Shedd, W., Godfriaux, P., Dufrene, R., McConnell, D., Boswell, R., Collett, T.S., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., Dai, J., 2010. “Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Initial Results From the Alaminos Canyon 21 site.” Houston, Texas: *Offshore Technology Conference*, May 3-6, OTC 20552.

Gardner, J.M., Hagen, R., Hart, P., Czarnecki, M., Nishimura, C., Hutchinson, D. R., 2005. “High Resolution Seafloor Environmental Characterization of Methane Seeps in the Mississippi Canyon Near Atwater Valley 13/14, Gulf of Mexico,” *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS43A-0618.

Gilbert, L., W. Waite, W. Winters, and D. Mason, 2004, Characterization of Gulf of Mexico sediment in hydrate and non-hydrate bearing cores using specific surface area, San Francisco, CA, American Geophysical Union Fall Meeting, December 13-17.

Gilhooly, W.P., C. Ruppel, G.R. Dickens, P. Berg, and S.A. Macko, 2010, Flux rates and sulfur isotopic composition of pore fluids from three mud volcanoes in the northern Gulf of Mexico, AGU Fall Meeting, Abstract OS52B-03.

Godfriaux, R. [invited], Shedd, W., Frye, M., Collett, T.S., Lee, M.W., Boswell, R.M., Cook, A., Mrozewski, S., Guerin, G., McConnell, D., Dufrene, R., and Jones, E., 2009, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Results from the Alaminos Canyon 21 Site: Fall Meeting of the American Geophysical Union, December 14-18, 2009, San Francisco, California, Proceedings, Abstract OS31A-1202.

Gullapalli, I., Moridis, G. J., Silpngarmlert, S., Reik, B., Kamal, M., Jones, E., Collett, T. S., 2008. “Designing a Reservoir Flow Rate Experiment for the GOM Hydrate JIP Leg II LWD Drilling,” *Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008),* Vancouver, British Columbia, CANADA, July 6-10, 2008.

Hagen, R., J. Gardner, and W. Wood, 2004. "Thermal Measurements Over Hydrate Mounds in Atwater Valley, Gulf of Mexico," *Eos Trans.* AGU, 85(47), Fall Meet. Suppl., OS41C-0490.

Hart, P., Pecher, I. A., 2005. "Natural Gas Hydrates: Modeling, Laboratory Studies, Recent JIP Drilling, and Other Field Investigations II," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS33B-Poster.

Hart, P., Waite, W., 2005. "Natural Gas Hydrates: Modeling, Laboratory Studies, Recent JIP Drilling, and Other Field Investigations III," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS41C-Poster.

Hart, P., D. Hutchinson, G. Dugan, M. Fowler, W. Wood, F. Snyder, N. Dutta, R. Coffin, J. Gardner, R. Hagen, R. Evans, and D. Fornari, 2005. "A multidisciplinary investigation of a deepwater gas hydrate mound, Atwater Valley, northern Gulf of Mexico," Victoria, BC, Canada, *Fourth International Workshop on Methane Hydrate R&D*, May 9-11.

Holland, M., Schultheiss, P., Roberts, J., Druce, M., 2008. "Observed Gas Hydrate Morphologies In Marine Sediments," Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), Vancouver, British Columbia, CANADA, July 6-10, 2008. .

Hutchinson, D.R., Shelander, D., Dai, J., McConnel, D., Shedd, W., Frye, M., Ruppel, C., Boswell, R., Jones, E., Collett, T. S., Rose, K., Dugan, B., Wood, W., and Latham, T., 2008. "Site Selection for DOE/JIP Gas Hydrate Drilling in the Northern Gulf Of Mexico," Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), Vancouver, British Columbia, CANADA, July 6-10, 2008.

Hutchinson, D., P. Hart, F. Snyder, M. Lee, N. Dutta, L. Muller, B. Dugan, C. Ruppel, W. Wood, R. Coffin, R. Evans, and E. Jones, 2003. "Evidence of subsurface gas hydrate in the northern Gulf of Mexico," *Eos Trans.* AGU, 84(46), Fall Meet. Suppl., OS42C-04.

Hutchinson, D., C. Ruppel, J. Pohlman, P. Hart, B. Dugan, F. Snyder, and R. Coffin, 2004. "An integrated geological, geophysical, and geochemical analyses of subsurface gas hydrates in the northern Gulf of Mexico," Vancouver, BC, Canada, *The American Association of Petroleum Geologists Hedberg Research Conference*, September 12-16.

Hutchinson, D., F. Snyder, P. Hart, C. Ruppel, J. Pohlman, W. Wood, R. Coffin, and M. Edwards, 2005. "Geologic and site survey setting for JIP Gulf of Mexico gas hydrate drilling,"*Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS31D-01.

Hutchinson, D., C. Ruppel, J. Pohlman, P. Hart, F. Snyder, N. Dutta, B. Dugan, and R. Coffin, 2005. "Geophysical and geochemical characterization of the hydrate stability zone in a region of active salt tectonics, Keathley Canyon, Northern Gulf of Mexico," *Fourth International Workshop on Methane Hydrate Research and Development*, Victoria, BC, Canada, May 2005.

Hutchinson, D., 2006. "Heterogeneity and dynamics in gas hydrate occurrence: lessons learned from the northern Gulf of Mexico," Kauai, HI: *Engineering Conferences International, Science and Technology Issues in Methane Hydrates R&D*, March 5-9.

Hutchinson, D., C. Ruppel, T. Collett, J. Pohlman, P. Hart, and F. Snyder, 2006. "Minibasins and subsurface gas hydrate in the Gulf of Mexico, Fukuoka, Japan, *17th International Sedimentological Congress*, August 27-September 1, V. B, p. 6.

Hutchinson, D.R., Hart, P.E., Collett, T.S., Edwards, K.M., Twichell, D.C., and Snyder, F., 2007. “Geologic Framework of the 2005 Keathley Canyon Gas Hydrate Research Well, Northern Gulf of Mexico,” *Eos Trans*. AGU, 88(23), Jt. Assemb. Suppl., NS54A-03.

Hutchinson, D. et al., 2008, Site selection for the Next Phase of JIP Deepwater Gulf of Mexico Methane Hydrates Drilling, Testimony to the NRC Committee reviewing the activities authorized under the Methane Hydrate research Development Act (renewal) of 2005, Washington, DC, March 4.

Jones, E., 2006. “Overview of GOM JIP Leg 1 Drilling,” Kauai, HI, *ECI Science and Technology Issues in Methane Hydrate R&D*, March 5-9.

Jones, E., 2006. “Technology Needs for Commercial Production of Hydrates,” Houston, TX, *Hart Energy Publishing Methane Hydrates Conference*, Dec. 5-6.

Jones, E., 2005. “Pre-cruise Estimates of Sediment Properties for the 2005 ChevronTexaco Gulf of Mexico Gas Hydrate Research Coring Project,” Vancouver, BC, Canada, *The American Association of Petroleum Geologists Hedberg Research Conference*, September 12-16.

Kastner, M., Claypool, G., Robertson, G., Schultheiss, P., and Holland, M., 2005. "Geochemical Evidence for Gas Hydrates at Atwater Valley and Keathley Canyon, Gulf of Mexico," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS31D-03.

Kleinberg, R., and J., Dai, 2005. “Estimation of the Mechanical Properties of Natural Gas Hydrate Deposits from Petrophysical Measurements,” Houston, TX: Offshore Technology Conference. OTC 17205-MS.

Latham, T., Shelander, D., Boswell, R., Collett, T. S., Lee, M., 2008. “Subsurface Characterization of the Hydrate Bearing Sediments near Alaminos Canyon 818,” Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), Vancouver, British Columbia, CANADA, July 6-10, 2008.

Lorenson, T., J. Dougherty, G. Claypool, 2005. “Preliminary results from the ChevronTexaco Gulf of Mexico Gas Hydrates JIP: Hydrocarbon Gases in Sediments,”*Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS42A-04.

Lorenson, T.D., Winters, W., Hart, P.E., and Paull, C.K., 2002, Gas Hydrate Occurrence in the Northern Gulf of Mexico Studied with Giant Pistion Cores: EOS, Transactions, American Geophysical Union, v. 83, n. 51, Dec., p. 601, 607-608.

Lorenson, T., W. Winters, C. Paull, and W. Ussler, 2003, Gas hydrate occurrence in the northern Gulf of Mexico studies with giant piston cores from sea-floor vents to minibasins, Seattle, WA, The American Association of Petroleum Geologists Annual Meeting, November 2-5.

Lorenson, T., W. Winters, C. Paull, and W. Ussler, 2003, Gas hydrate occurrence in the northern Gulf of Mexico studies with giant piston cores from sea-floor vents to minibasins, Nice, France, EGS-AGU-EUG Joint Assembly, April 6-11.

Lorenson, T., W. Winters, C. Paull, and W. Ussler, 2006, Is gas hydrate and the Storegga Slide offshore Norway connected to an active petroleum system?, Houston, TX, The American Association of Petroleum Geologists Annual Meeting, April 9-12.

Lorenson, T., W. Winters, C. Paull, W. Ussler, and J. Dougherty, 2003, Modeling gas hydrate occurrences in the northern Gulf of Mexico from giant piston cores, Seattle, WA, Geological Society of America Annual Meeting, November 2-5.

Lorenson, T., W. Winters, C. Paull, W. Ussler, and the Shipboard Scientific Party, 2003, Gas hydrate occurrence in the northern Gulf of Mexico: new insights learned from giant piston coring, Salt Lake City, UT, The American Association of Petroleum Geologists Annual Meeting.

Lorenson, T., W. Winters, P. Hart, and C. Paull, 2002, Gas hydrate occurrence in the Northern Gulf of Mexico studied with giant piston cores, American Geophysical Union Fall Meeting, December 6-10.

McConnell, D., Collett, T.S., Boswell, R., Frye, M., Shedd, W., Dufrene, R., Godfriaux, P., Mrozewski, S., Guerin, G., Cook, A., Jones, E., 2010. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Initial Results From the Green Canyon 955 Site." Houston, Texas: Offshore Technology Conference, May 3-6, OTC 20801.

McConnell, D. [invited], Boswell, R.M., Collett, T.S., Frye, M., Shedd, W., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., Dai, J., Dufrene, R., Godfriaux, R., Roy, R., and Jones, E., 2009, Initial results of Gulf of Mexico Gas Hydrate Joint Industry Program Leg II logging-while-drilling operations in Green Canyon Block 955: Fall Meeting of the American Geophysical Union, December 14-18, 2009, San Francisco, California, Proceedings, Abstract OS24A-03.

Mrozewski, S., Cook, A., Guerin, G., Goldberg, D., Collett, T.S., Boswell, R., Jones, E., Roy, R., 2010. “Gulf of Mexico Gas Hydrates Joint Industry Project: LWD Logging Program Design, Data Acquisition and Evaluation,” Houston, Texas: Offshore Technology Conference, May 3-6, OTC 21023.

Paull, C., W. Ussler, W. Winters, and T. Lorenson, 2003, Constraints on the distribution of gas hydrates in the Gulf of Mexico, Nice, France, EGS-AGU-EUG Joint Assembly, April 6-11.

Pohlman, J., C. Ruppel, D. Hutchinson, P. Hart, R. Plummer, D. Kniew, K. Grabowski, and R. Coffin, 2005. “The effects of mass deposition, gas flux and salt diapirs on surface sediment geochemistry in Keathley Canyon (northern Gulf of Mexico),” *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS31D-04.

Pohlman, J., W. Wood, T. Boyd, R. Coffin, C. Ruppel, D. Hutchinson, P. Hart, and B. Dugan, 2004. “Interstitial sulfate gradients as indicators of gas hydrates: How reliable are they?,” Florence, Italy, *International Geological Conference*, August 20-28.

Ruppel, C., (Invited) 2008, Multiscale heterogeneity in methane flux regimes between and within major marine gas hydrate provinces, EOS Trans. AGU, 89(53), Fall Mtg Supplement, Abstract OS31D-02.

Ruppel, C., 2008, “Before Production….The Challenges of Finding and Evaluating Gas Hydrates,” October, 2008, MIT (Cambridge, MA). Presentation in the MIT/USGS ENI Methane Hydrate Seminar Series.

Ruppel, C., 2008, “Methane Hydrates and Methane Seeps: The Potential of Biogeophysical Measurements for Identifying Microbial Hotspots”, AGU Chapman Conference on Biogeophysics, Portland, ME, October 2008.

Ruppel, C., D. Hutchinson, B. Dugan, and P. Hart, 2004. "Predicting the subsurface distribution of gas hydrate in the Northern Gulf of Mexico," *The American Association of Petroleum Geologists Annual Meeting*, Dallas, TX, April 18-21.

Ruppel, C., 2009, An assessment of methane hydrates as an energy resource, MIT Energy Initiative Natural Gas Study, MIT, February 2.

Ruppel, C., 2009, Non-seismic geophysical methods for detection and characterization of resource-grade marine hydrates, Testimony to the NRC Committee reviewing the activities authorized under the Methane Hydrate research Development Act (renewal) of 2005, Washington, DC, March 4.

Ruppel, C., 2009, Methane Hydrate Resource Asssessment, Presentation to the Advisory Committee for the MIT Energy Initiative Natural Gas Study, MIT, March 24.

Ruppel, C. et al., 2009, Site selection for JIP Phase III drilling, JIP meeting, Houston, TX, August 18.

Ruppel, C., 2010, USGS activities under the DOE-USGS interagency agreement, DOE Investigators' Meeting, Atlanta, January 25.

Ruppel, C. 2010, Gas hydrates and scientific ocean drilling, testimony to the NRC review of Scientific Ocean Drilling, Texas A&M University, July 2010. [remotely]

Santamarina, J., T. Yun, J. Lee, A. Martin, F. Francisca, and C. Ruppel, 2005. "Mechanical, Thermal and Electromagnetic Properties of Hydrate-Bearing Clay, Silt, and Sand at Various Confining Pressures," *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS41C-07.

Santamarina, J., F. Francisca, T. Yun, J. Lee, A. Martin, and C. Ruppel, 2004. "Mechanical, thermal, and electrical properties of hydrate-bearing sediments," *The American Association of Petroleum Geologists Hedberg Research Conference*, Vancouver, BC, Canada, September 12-16.

Santamarina, J., C. Ruppel, J. Lee, and T. Yun, 2007, Making the Case for In-situ Characterization of Gas Hydrate-Bearing Sediments at Observatories: Laboratory and Catwalk Results Testing the Impact of Core Retrieval, presented at the JOI Gas-Hydrate Observatories Workshop, July 18-20.

Schultheiss, P., Holland, M., Roberts, J., Humphrey, G., 2008. "Pressure Core Analysis: The Keystone of a Gas Hydrate Investigation," Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), Vancouver, British Columbia, CANADA, July 6-10, 2008.

Shedd, W., Frye, M., Godfriaux, P., Dufrene, R., McConnell, D., Boswell, R., Collett, T.S., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., Dai, J., 2010. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Initial Results From the Walker Ridge 313 Site." Houston, Texas: Offshore Technology Conference, May 3-6, OTC 20806.

Shedd, W., Frye, M., Godfriaux, P., Dufrene, R., McConnell, D., Boswell, R., Collett, T.S., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., Dai, J., 2009. "Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Initial Results from the Walker Ridge 313 Site," *Eos Trans.* AGU, 90(52) Fall Meet. Suppl., OS24A-04.

Shedd, W. [invited], Frye, M., Boswell, R.M., Collett, T.S., McConnell, D., Jones, E., Shelander, D., Dai, J., Mrozewski, S., Guerin, G., Cook, A., Dufrene, R., Godfriaux, R., and Hutchinson, D., 2009, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Results from Walker Ridge 313 Site: Fall Meeting of the American Geophysical Union, December 14-18, 2009, San Francisco, California, Proceedings, Abstract OS24A-04.

Smith, M., 2004. "Seismic Prediction and Operational Results for Gulf of Mexico Wells in Gas-Hydrate Areas," Vancouver, BC, Canada, *The American Association of Petroleum Geologists Hedberg Research Conference*, September 12-16.

Smith, J., L. Hamdan, W. Wood, R. Coffin. 2008. "Geologic Controls on Porewater Geochemistry in Gas Hydrate Bearing Sediments in the Gulf of Mexico."*Eos Trans.* AGU, Fall Meet., San Francisco, December 2008.

Smith, M., and W. Shedd, 2004. "Effects of Gas Hydrate on Seafloor and Borehole Stability in the Deepwater Gulf of Mexico – Seismic Prediction and Drilling Results," Dallas, TX, *The American Association of Petroleum Geologists Annual Meeting*, April 16-21.

Smith, M., W. Shedd, and J. Hunt, 2003. "Identification of Deepwater Gulf of Mexico Gas Hydrates – From Seismic Prediction to Joint Industry Project Drilling and Coring," Barcelona, Spain, *The American Association of Petroleum Geologists International Conference*, September 21-24.

Smith, M., W. Kou, A. Ahmed, and R. Kuzela, 2005. "The Significance of Gas Hydrate as a Geohazard in Gulf of Mexico Exploration and Production," Houston, TX, Offshore Technology Conference, May 3. OTC 17655-MS

Snyder, F., L. Muller, N. Dutta, D. Hutchinson, P. Hart, M. Lee, B. Dugan, C. Ruppel, W. Wood, R. Coffin, R. Evans, and E. Jones, 2004. "Seismic analysis and characterization of gas hydrates in the northern deepwater Gulf of Mexico," Dallas, TX, *The American Association of Petroleum Geologists Annual Meeting*, April 16-21.

Snyder, F., 2005. "Seismic analysis and characterization of gas hydrates in the northern deepwater Gulf of Mexico," Dallas, TX, *The American Association of Petroleum Geologists Annual Meeting*, April 16-21.

Subramanian, S., E. Jones, 2007. "Comparison of Pre-Cruise Predictions to Ground Truth Measurements for Leg I of the GOM Hydrate JIP," New Delhi, India, *Petrotech 2007*, January 14-16.

Sun, K., D. Omeragic, C. Minh, J. Rasmus, J. Yang, A. Davydychev, T. Habashy, R. Griffiths, G. Reaper, Q. Li, 2010. "Evaluation of Resistivity Anisotropy and Formation Dip from Directional Electromagnetic Tools While Drilling," *SPWLA 51st Annual logging Symposium*, June 19-23, 2010.

Ussler, W., C. Paull, S. Hallam, E. Delong, Y. Chen, R. Matsumoto, T. Lorenson, and W. Winters, 2003, The anatomy of the sulfate-methane interface in a methane-rich core form the Gulf of Mexico, Seattle, WA, Geological Society of America Annual Meeting, November 2-5.

Ussler, W., C. Paull, Y. Chen, R. Matsumoto, T. Lorenson, and W. Winters, 2005, The consequences of methane oxidation at the sulfate-methane interface in a methane-rich core from the northern Gulf of Mexico, Trondheim, Norway, Fifth International Conference on Gas Hydrates, June 12-16.

Winters, W., I. Novosel, O. Boldina, W. Waite, T. Lorenson, C. Paull, and W. Bryant, 2002, Physical properties of sediment related to gas hydrate in the northern Gulf of Mexico, San Francisco, CA, American Geophysical Union Fall Meeting, December 6-10.

Winters, W., I. Novosel, O. Boldina, W. Waite, T. Lorenson, C. Paull, and W. Bryant, 2002, Physical properties of sediment related to gas hydrate in the Northern Gulf of Mexico, San Francisco, CA, EOS Transactions, American Geophysical Union, Volume 83, n. 47, December 6-10.

Winters, W., W. Waite, D. Mason, T. Lorenson, C. Paull, I. Novosel, O. Boldina, S. Dallimore, and T. Collett, 2003, Physical properties of northern Gulf of Mexico sediment and laboratory samples containing natural and synthetic methane gas hydrate, Nice, France, EGS-AGU-EUG Joint Assembly, April 6-11.

Winters, W., W. Waite, I. Pecher, D. Mason, D. Hutchinson, L. Gilbert, R. Birchwood, S. Noeth, and E. Jones, 2004. “Comparison of methane gas hydrate formation on physical properties of fine- and coarse-grained sediments,” Vancouver, BC, Canada, *The American Association of Petroleum Geologists Hedberg Research Conference*, September 12-16.

Wood, W., P. Hart, R. Coffin, J. Gardner, and J. Gettrust, J., 2005. “High Resolution Seismic Images of the Gulf of Mexico Joint Industry Program Drilling Transect,” *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS43A-0619.

Wood, W., Kirby, S. H., 2005. “Natural Gas Hydrates: Modeling, Laboratory Studies, Recent JIP Drilling, and Other Field Investigations V,” *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS43A-Poster.

Wood, W., D. Hutchinson, P. Hart, F. Snyder, C. Voss, N. Dutta, L. Muller, M. Lee, J. Gardner, B. Dugan, C. Ruppel, R. Coffin, R. Evans, and E. Jones, 2003. “Constraints on Subsurface gas and gas Hydrate Distribution in a Gulf of Mexico Mound,” *Eos Trans*. AGU, 84(46), Fall Meet. Suppl., OS51B-0857.

Wood, W., J. Gardner, R. Hagen, R. Coffin, J. Pohlmann, P. Hart, and D. Hutchinson, 2004. “Modeling heat and fluid flux of seafloor mounds in the Gulf of Mexico,” *Eos Trans.* AGU, 85(47), Fall Meet. Suppl., OS34B-08.

Yun, T., G. Narsilio, J. Lee, J. Santamarina, and C. Ruppel, 2005. “Physical properties of a Keathley Canyon pressure core maintained at in-situ pressure and measured in a new instrumented pressure testing chamber,” *Eos Trans.* AGU, 86(52), Fall Meet. Suppl., OS31D-06.

Zhang, Z., McConnell, D. “Seismic Modeling Analysis and Characterization for a Gas Hydrate and Free Gas Mixed System in Green Canyon, Gulf of Mexico.” Houston, Texas: *Offshore Technology Conference*, May 3-6, OTC 20659-MS