"Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities Third Semi-Annual Report"

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ABSTRACT

In 2000, Chevron began a project to learn how to characterize the natural gas hydrate deposits in the deepwater portions of the Gulf of Mexico. A Joint Industry Project (JIP) group was formed in 2001, and a project partially funded by the U.S. Department of Energy (DOE) began in October 2001. The **primary objective** of this project is to develop technology and data to assist in the characterization of naturally occurring gas hydrates in the deep water Gulf of Mexico (GOM). These naturally occurring gas hydrates can cause problems relating to drilling and production of oil and gas, as well as building and operating pipelines. Other objectives of this project are to better understand how natural gas hydrates can affect seafloor stability, to gather data that can be used to study climate change, and to determine how the results of this project can be used to assess if and how gas hydrates act as a trapping mechanism for shallow oil or gas reservoirs.

During October 2002 – March 2003, the JIP concentrated on:

- Completing two reports which are as follows:
    - "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities", DOE Semi-Annual Report, October 2001 – March 2002
    - "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities", DOE Semi-Annual Report, April 2002 – September 2002
- Contracted with Georgia Tech to run laboratory tests on synthetic cores containing gas hydrates. Specifically, Georgia Tech is looking at the "Effect of Thermal History on the Properties of Hydrate Core Samples". Initial results are included in this report. Several progress reports and the Georgia Tech proposal are on the JIP website.
- Negotiated with the Scripps Oceanographic Institute to be the science provider for Phase II and to help prepare the plans and protocols for Phase II of this project.

- Negotiated with the Joint Oceanographic Institute to help write the drilling, coring, and core handling protocols and procedures that will be required for Phase II of this project.

- WesternGeco has evaluated six potential sites for Phase II drilling. Meetings were held which resulted in a short list of two sites, which are Keathley Canyon 195 and Atwater Valley 14 for more detailed review by WesternGeco.

- Schlumberger Data and Consulting Services (DCS) has completed its feasibility study of developing a well bore stability model for shallow holes drilled through soft formations containing natural gas hydrates. On the basis of the study, DCS is proceeding with the development of a prototype well bore stability model. The project has expanded to cover a more broad approach to the well bore and seafloor stability problem.

- Negotiations have continued with the Joides Resolution and Fugro to provide the drill ship for Phase II of this project. The JIP decided to work with Fugro and is in the process of negotiating a contract.

- The JIP Executive Board and the Project Manager have begun working on a detailed Management Plan for Phase II of the project.

More information can be found on the JIP website.

http://qpext.chevrontexaco.com/QuickPlace/wwuexpl_gashydrates/Main.nsf?OpenDatabase.

Table of Contents

Table of Contents

Table of Contents

List of Tables

List of Figures

1.0 Introduction

In 2000, Chevron Petroleum Technology Company (Chevron) began a project to learn how to characterize the natural gas hydrate deposits in the deepwater portion of the Gulf of Mexico. 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 working closely with the National Energy Technology Laboratory (NETL) of the United States Department of Energy (DOE) 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.

On the basis of the workshop held in August 2000, Chevron formed a Joint Industry Project (JIP) to write a proposal and conduct research concerning natural gas hydrate deposits in the deepwater portion of the Gulf of Mexico. The proposal was submitted to NETL on April 24, 2001, and Chevron was awarded a contract on the basis of 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".

1.1 Objectives

The **primary objective** of this project is to develop technology and data to assist in the characterization of naturally occurring gas hydrates in the deep water Gulf of Mexico (GOM). These naturally occurring gas hydrates can cause problems relating to drilling and production of oil and gas, as well as building and operating pipelines. Other objectives of this project are to better understand how natural gas hydrates can affect seafloor stability, to gather data that can be used to study climate change, and to determine how the results of this project can be used to assess if and how gas hydrates act as a trapping mechanism for shallow oil or gas reservoirs.

1.2 Project Phases

The project is divided into phases. **Phase I** of the project is devoted to gathering existing data, generating new data, and writing protocols that will help the research team determine the location of existing gas hydrate deposits. During **Phase II** of the project, ChevronTexaco will drill data collection wells in at least two (2) locations to improve the technologies required to characterize gas hydrate deposits in the deep water GOM using seismic, core and logging data.

1.3 Research Participants

In 2001, Chevron (now ChevronTexaco) organized a Joint Industry Project (JIP) to plan and conduct the tasks necessary for accomplishing the objectives of this research project. As of March 2002, the members of the JIP were ChevronTexaco, Schlumberger, ConocoPhillips, Halliburton, the Minerals Management Service (MMS), Total, Japan National Oil Corporation, and Reliance Industries Ltd.

1.4 Research Activities

The research project began officially on October 1, 2001. Two previous Semi-Annual Reports have been written that cover the activity of the JIP from October 2001 through September 2002. A third report was written to summarize the three (3) workshops held by the JIP during 2002. All three reports are available from the U.S. Department of Energy and from the JIP website.

1.5 Purpose of This Report

The purpose of this report is to document the activities of the JIP during the third semi-annual period of this project, October 2002 – March 2003. It is not possible to put everything accomplished during the period into this Semi-Annual report. However, many of the important results are included and references to the JIP website are used to point the reader to more detailed information concerning various aspects of the project. The discussion of the work performed during October 2002 – March 2003 is organized by task and subtask for easy reference to the technical proposal and the DOE contract documents.

2.0 Executive Summary

Chevron formed a Joint Industry Project (JIP) group to write a proposal and conduct research concerning natural gas hydrate deposits in the deepwater portion of the Gulf of Mexico. The proposal was submitted to NETL on April 24, 2001, and Chevron was awarded a contract on the basis of 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 **primary objective** of this project is to develop technology and data to assist in the characterization of naturally occurring gas hydrates in the deep water Gulf of Mexico (GOM). **Other objectives** of this project are to better understand how natural gas hydrates can affect seafloor stability, to gather data that can be used to study climate change, and to determine how the results of this project can be used to assess if and how gas hydrates act as a trapping mechanism for shallow oil or gas reservoirs.

The project is divided into phases. **Phase I** of the project is devoted to gathering existing data, generating new data, and writing protocols that will help the research team determine the location of existing gas hydrate deposits. During **Phase II** of the project, ChevronTexaco will drill several data collection wells to improve the technologies required to characterize gas hydrate deposits in the deep water GOM using seismic, core and logging data.

The original plan called for drilling three data collection wells using conventional deepwater drillships and gas exploration protocol requirements. However, due to the success of the Ocean Drilling Project (ODP) in conducting scientific studies in gas hydrate areas, it is likely the approach by the JIP to the data collection wells will mirror the ODP approach used on Leg 204, offshore Oregon. Thus, it should be possible to drill considerably more than three data collection wells during Phase II within the budget limitations.

A website has been developed to house the data and information that were collected in the Data Collection Workshop, as well as other items submitted during the course of this research endeavor. The link to the JIP website is as follows:

http://qpext.chevrontexaco.com/QuickPlace/wwuexpl_gashydrates/Main.nsf?OpenDatabase

2.1 2002 JIP Workshops

During 2002, three workshops were held by the JIP. The **Data Collection Workshop** was held in March 2002 to determine what data are available concerning natural gas hydrate deposits in the deep water Gulf of Mexico. The **Drilling and Coring Workshop** focused on the current state of the art with respect to cutting cores in gas hydrate zones, safety issues, core sampling and preservation and core analysis. The workshop on **Modeling, Measurements and Sensors** focused on the current state of the art with respect to the stability of hydrate sediments, data required to improve modeling, the impact of local seafloor instabilities and the use and role of seismic and reservoir modeling to improve our understanding of hydrates. Details concerning the three workshops are contained in a DOE Topical Report entitled

"Results from the (1) Data Collection Workshop, (2) Modeling Workshop and (3) Drilling and Coring Methods Workshop as part of the Joint Industry Participation (JIP) Project to Characterize Natural Gas Hydrates in the Deep Water Gulf of Mexico"

This topical report can be found on the JIP website in the public viewing area.

2.2 Tasks and Subtasks

The following tasks and subtasks will be accomplished by the JIP during Phase I and Phase II of this research project. This Semi-Annual report uses the tasks and subtasks as a way of reporting the progress during October 2002 – March 2003 on Phase I of the project. **Table 2.1** presents these tasks and subtasks.

Table 2.1 – Task and Subtask List

PHASE I: Data Collection, Analyses and Protocol Development
✓ Task 1.0 -- Research Management Plan (Completed)*
Task 2.0 -- Project Management and Oversight
Task 3.0 -- Data Collection and Organization ✓ Subtask 3.1 -- Data Committee ✓ Subtask 3.2 -- Workshop Attendance/Participation ✓ Subtask 3.3 -- Conduct Data Collection and Case Histories Workshop ✓ Subtask 3.4 -- Identify Data Platform ✓ Subtask 3.5 -- Data Protocol Subtask 3.6 -- Gulf of Mexico Natural Gas Hydrate Database
Task 4.0 -- Development of New Gas Hydrate Sensors ✓ Subtask 4.1 -- MWD Sensors for Gas Hydrates ✓ Subtask 4.2 -- Gas Hydrate Disassociation Sensor ✓ Subtask 4.3 -- Gas Hydrate Formation Sensor Subtask 4.4 -- Tech Transfer/Sensor Specifications
Task 5.0 -- Develop Well Bore Stability Model ✓ Subtask 5.1 -- Well Bore Stability Model Evaluation Subtask 5.2 -- Prototype Well Bore Stability Model Subtask 5.3 -- Well Bore Stability Model Evaluation/Tests Subtask 5.4 -- Well Bore Stability Model Validation
Task 6.0 -- Seismic Modeling and Analysis ✓ Subtask 6.1 -- Identify and Obtain Existing 2D and 3D Seismic Data Subtask 6.2 -- Theoretical Seismic Modeling Subtask 6.3 -- Protocol Development for Seismic Data ✓ Subtask 6.4 -- Specify Seismic Data Laboratory Tests Subtask 6.5 -- Seismic/Petrophysical Laboratory Tests
Task 7.0 -- Kinetics and Thermodynamics Analyses ✓ Subtask 7.1 -- Literature Analysis of Hydrate Kinetic/Thermodynamic Properties ✓ Subtask 7.2 -- Gas Hydrate Kinetic/Thermodynamic Data Analysis ✓ Subtask 7.3 -- Laboratory Test Specifications - Kinetic/Thermodynamic Data ✓ Subtask 7.4 -- Laboratory Test Specifications - Chemical/Physical Properties Subtask 7.5 -- Laboratory Testing - Kinetic/Thermodynamic Data Subtask 7.6 -- Laboratory Testing - Chemical/Physical Properties
✓ *Task or Sub-Task Completed

Task 8.0 -- Determine Data Requirements for GeoModels
✓ Subtask 8.1 -- Geoscience/Reservoir Modeling Committee ✓ Subtask 8.2 -- Geoscience/Reservoir Modeling Workshop Planning ✓ Subtask 8.3 -- Geoscience/Reservoir Modeling Workshop Subtask 8.4 -- Geoscience/Reservoir Modeling White Paper Subtask 8.5 -- Data Collection Requirements for Future Phases
Task 9.0 -- Develop Drilling and Coring Test Plans ✓ Subtask 9.1 -- Drilling/Coring Committee ✓ Subtask 9.2 -- Drilling/Coring Modeling Workshop Planning ✓ Subtask 9.3 -- Drilling/Coring Modeling Workshop Subtask 9.4 -- Current Drilling Practices in Hydrates Areas Subtask 9.5 -- Scenarios for Drilling and Coring Gas Hydrates in Deep Water Subtask 9.6 -- Cost/Risk Analysis Subtask 9.7 -- Drilling/Coring Guidelines and Protocols
Task 10.0 -- Core Handling and Core Tests Subtask 10.1 -- Core Sample Information Subtask 10.2 -- Core Sample Protocols
Task 11.0 -- Review Data and Select Locations of 3 Field Test Sites ✓ Subtask 11.1 -- Field Test Sites - Short List ✓ Subtask 11.2 -- Comprehensive Database Evaluation Subtask 11.3 -- Additional Data Analysis Subtask 11.4 -- Field Test Sites Selection - 3 Sites Subtask 11.5 -- Prioritize Field Test Sites - 3 Sites
Task 12.0 -- Conference – Field Testing
PHASE II: Initial Field Tests and Analyses
Tentative tasks are presented for the Phase II activities. The tasks are provided to describe the generally anticipated work scope. Work will not proceed into Phase II until a continuation application (technical and cost) is submitted and approved by DOE/NETL.
Task 1.0 -- Research Management Plan
Task 2.0 -- Project Management and Oversight
Task 3.0 -- Validation of New Gas Hydrate Sensors
Task 4.0 -- Validation of the Well Bore Stability Model
Task 5.0 -- Core and Well Log Data Collection - Area A
Task 6.0 -- Data Analysis - Area A
Task 7.0 -- Update Models, Plans and Protocols
Task 8.0 -- Integrate New and Old Seismic Data in Test Areas Task 9.0 -- Conference - Information Transfer
✓ *Task or Sub-Task Completed

3.0 Technical Teams

This research project is managed by ChevronTexaco, whose Program Manager is Dr. Emrys Jones. An Executive Board meets monthly and assists Dr. Jones. The Executive Board has the power to control the direction of the research, and suggest contractors and subcontractors for various portions of this research effort.

Reporting to the Executive Board are four technical committees. Each of these committees has a chairman and participants from the other JIP member companies. The member companies pay the salaries and expenses of their own representatives on the technical committees as part of the cost sharing for this project. Time and expenses required in excess of the agreed contributions for each company may be paid for by the project. These funds will come from the portion of funds allocated for each task of the project.

The JIP has formed the following four technical teams. These technical teams manage the tasks that are outlined in **Table 2.1**. The following documents the tasks that each team is responsible for planning and executing. The technical teams can do the work themselves or can subcontract the work, when desirable.

- The **Seafloor Stability Team** is responsible for conducting Tasks 4, 8, and 11.
- The **Drilling and Coring Team** is responsible for Tasks 5, 9, and 10.
- The **Hydrates Characterization Team** is responsible for Tasks 3, 6, and 7.
- A fourth team, called the **Technology Transfer Team**, is in charge of writing the technical reports and papers to describe the research, and for planning Task 12.

After the three workshops held during March and May 2002, the technical teams prepared Cost, Time and Resource (CTRs) estimates for all of the tasks and subtasks listed above. The JIP member companies then worked with the Executive Board to determine who could and should do the work required by the JIP. Requests for Proposals (RFPs) were prepared and bids were submitted for various tasks and subtasks. Some of the work was awarded to JIP member companies after appropriate bids were received and thoroughly evaluated. Much of the work was put out for bid by placing RFPs on the JIP website, and sending out notices of the RFPs to interested parties, many of whom participated in one or all of the JIP Workshops. **Table 3.1** lists the RFPs and the contracts awarded by the JIP.

Table 3.1 – Contractors Working for the JIP

Contract	Contractor
Technology Transfer	Schlumberger
Gas Hydrate Seismic Modeling and Analysis	WesternGeco
Well Bore Stability Modeling	Schlumberger
Effect of Thermal History on the Properties of Hydrate Core Samples	Georgia Tech
Drilling and Coring Well Plan	Joint Oceanographic Institute
Core Handling and Testing Plan	Joint Oceanographic Institute

3.1 Executive Board

The Executive Board assists the Chevron Program Manager when it comes to determining which tasks are accomplished, and how the contracts and subcontracts are handled within this research project. The Executive Board consists of one person from every company participating in this joint industry project. From October 2002 through March 2003, the Executive Board consisted of the following individuals.

- Craig Lewis — ChevronTexaco, Chairman
- Steve Holditch — Schlumberger
- Lewis Norman — Halliburton
- Ravi Aurora — ConocoPhillips
- Jesse Hunt — Minerals Management Service
- Pierre Montaud — Total
- Tesuo Yonezawa — Japan National Oil Corporation
- I. L. Budhiraja — Reliance Industries Ltd.

The Executive Board met three times from October 2002 – March 2003. **Table 3.2** shows when the Board met and the essence of the topics at the meetings.

Table 3.2 – Record of Executive Board Meetings

Number	Date	Topics
1	12/6/02	• Accounting update • Discuss in-kind contributions • Discuss budget for Phase II • Discuss status of Joides-Resolution • Discuss status of Fugro ship • Discuss short list of 6 sites that WesternGeco are working on
2	2/18/03	• Technical Team updates • Site selection update • In-kind contribution and JIP accounting update • Discuss Phase II Tasks and Sub-tasks • New member update
3	3/19/03	• Technical Team updates • Site selection update • In-kind contribution and JIP accounting update • Update on Scripps Institute negotiations • Update on selection of drill ship for Phase II • Final discussion on Phase II Tasks and Sub-tasks

During October 2002 – March 2003, the final few contractors were selected. The Joint Oceanographic Institute (JOI) was chosen to prepare the protocols and procedures required for drilling, coring, core handling and core testing of gas hydrate deposits. On the basis of their experience in running the Ocean Drilling Program (ODP), and in particular, their success in coring and logging gas hydrate deposits during Leg 204 of the ODP, JOI was the logical choice to assist the JIP in this task.

Negotiations concerning which ship to use for the field work during Phase II of this project left the Executive Board to choose between Fugro and the Joides Resolution. Due to the many uncertainties concerning availability and cost with the Joides Resolution, the Executive Board decided to use Fugro as the contractor for Phase II. Contract negotiations are ongoing as of March 31, 2003.

In addition to the drill ship, the JIP also needed to find a general science contractor for Phase II. After considering several possibilities, the Executive Board authorized the JIP to negotiate with Scripps Oceanographic Institute to fill the role as science contractor. Contract negotiations are ongoing as of March 31, 2003.

3.2 Hydrates Characterization Team

During October 2002 – March 2003, the Hydrates Characterization Team consisted of the following individuals.

- Jesse Hunt — MMS
- Siva Subramanian — ChevronTexaco
- Steve Primeau — ConocoPhillips
- P. Montaud — Total
- Rick Coffin — NRL
- Peter Eick - Chairman — ConocoPhillips
- Nader Dutta — WesternGeco
- Mike Curtis — Halliburton
- Bill Hottman — Halliburton
- Tim Collett — USGS
- Lecia Muller — WesternGeco

The Gas Hydrates Characterization Team Charter can be found on the JIP website. The Gas Hydrates Characterization Team met three times between October 2002 – March 2003.

Table 3.3 – Record of Gas Hydrates Characterization Team Meetings

Number	Date	Topics
1	10/25/02	• Discussion of status of contract with WesternGeco • Refined the requirements for the experimental matrix • Discussed best ways to find gas hydrates using seismic • Discussed issue of BSRs in the Gulf of Mexico (GOM)

		• Decided to focus on Structure 2 gas hydrates • Reviewed work on several GOM sites – the Atwater Valley 14, Alaminos Canyon 856 and Green Canyon 185 • Discussed other laboratories doing mechanical properties testing on gas hydrate samples • Discussed importance of looking at the mechanical properties of sediments containing gas hydrates • Discussed the kinds of soils and sediments that the JIP should be testing
2	12/6/02	• Provided update of Tasks 3, 6 and 7 in Phase I to the Executive Board
3	1/27/03	• Emrys Jones provided update on overall progress of JIP • WesternGeco provided status of initial screening and analysis of areas in the GOM • Reviewed the kinetics and thermodynamics core testing matrix • Discussed general geochemistry of proposed sites

3.3 Drilling and Coring Team

From October 2002 – March 2003, the Drilling and Coring Team consisted of the following individuals.

- Jim Schumacher — ChevronTexaco
- Jacques Bourque — Schlumberger
- Tetsuo Yonezawa — JNOC
- Gary Weaver — Halliburton
- Ben Bloys — ChevronTexaco
- G. Leon Holloway — ConocoPhillips
- Terry Cook — Phillips
- Larry Williamson — NRL MMS
- Carole Fleming — ChevronTexaco
- Brian Jonasson — ODP
- Terry Shawchuk — Orion

The Drilling and Coring Team Charter can be found on the JIP website. The following meetings were held by the Drilling and Coring Team during October 2002 – March 2003.

Table 3.4 – Record of Drilling and Coring Team Meetings and Activities

Number	Date	Topics
1	12/3/02	• Review and finalize CTRs • Discuss in-kind contributions • Discuss status of Joides-Resolution • Discuss status of Fugro ship • Discuss short list of 6 sites that WesternGeco are working on
2	12/6/02	• Update Executive Board
3	12/12/02	• Visit Fugro Explorer and evaluate for drilling and coring
4	1/15/03	• Visit MMS on drilling and coring permit issues
5	2/5-7/03	• Attended ODP pressure coring workshop
6	2/17/03	• Met to discuss rig contracting process
7	3/20/03	• Met to discuss proposals for writing the protocols and procedures for drilling, coring, core handling and testing • Chose JOI as the sub-contractor

3.4 Seafloor Stability Team

From October 2002 – March 2003, the Seafloor Stability Team consisted of the following individuals.

- Jen-Hwa Chen ChevronTexaco
- Jeff Mueller ConocoPhillips
- John Matson Halliburton
- Michael A. Smith MMS
- Bob Kleinberg Schlumberger
- Jorge Manrique Schlumberger

The Seafloor Stability Team Charter can be found on the JIP website. The following meetings were held by the Seafloor Stability Team during October 2002 – March 2003. Details of the meetings can be found on the JIP website.

Table 3.5 – Record of Seafloor Stability Team Meetings

Number	Date	Topics
1	10/7/02	• Reviewed CTR's • Discussed seismic analysis planned by WesternGeco and site selection procedures Selected 3 sites for WesternGeco to use in initial seismic screening
2	11/5/02	• Reviewed possible BSR identified by TFE in AC856 Selected 3 additional sites and alternate block for WesternGeco to use in initial screening in their seismic analysis and modeling project
3	12/6/02	Updated Executive Board on CTR's and site selection
4	1/15/03	• Meeting at MMS to discuss drilling/coring, permitting, and environmental issues • Discussed the initial 6 blocks chosen for review • MMS recommended drilling wells in Phase II under 30 CFR Part 251 "Geological and Geophysical (G&G) Explorations of the Outer Continental Shelf"
5	2/19/03	• Site selection meeting. Attended by members from all the Technical Teams • Reviewed process to select 6 blocks for preliminary screening • Reviewed WesternGeco results for the 6 blocks • Selected 2 blocks for more detailed analysis • Discussed USGS and other gas hydrate cruises for 2003 • Discussed assignments for writing modeling white paper

4.0 Results and Discussion – Phase I – Tasks for Data Collection, Analyses and Protocol Development

4.1 Task 1.0 – Research Management Plan (Completed)

ChevronTexaco developed a work plan and supporting narrative that concisely addressed the overall project as set forth in the Technical Proposal and DOE Contract. The Research Management Plan ("The Plan") provides a concise summary of the technical objectives and the technical approach for each Task and, where appropriate, each Subtask. The Plan provides detailed schedules and planned expenditures for each Task using graphs and tables as needed. The plan contains all major milestones and decision points. The Plan was submitted to DOE on January 31, 2002. **Table 4.1** presents the milestones and decision points that were part of the Plan. Due to a delay in getting the JIP formed and the DOE contract signed, the timing of the project and milestones have been pushed back approximately six (6) months. **Table 4.1** shows the current timing.

Table 4.1 – Milestones for Phases I and II

	Year	Timing	Milestone
Phase I	2001	Q4	Technical Teams formed and staffed
	2002	Q1	Hold a data and case histories workshop
	2002	Q2	Construct data and case histories database
	2002	Q3	Meet with industry to discuss specifications on gas hydrates sensors
	2003	Q1	Develop prototype well bore stability model
	2003	Q3	Publish laboratory test results on kinetic, physical, and chemical properties of cores saturated with gas hydrate
	2002	Q2	Conduct geomodeling workshop
	2002	Q2	Conduct drilling and coring workshop
	2003	Q3	Develop protocols and plans for data collection wells
	2003	Q3	Develop protocols for core handling and testing
	2003	Q1	Select and prioritize sites for data collection wells

	Year	Timing	Milestone
	2003	Q3	Hold 2-day conference to review Phase I results and solicit input and interest for data collection wells
	2003	Q3	Final report on Phase I
Phase II	2003	Q3	Meet with service companies to review new sensor design
	2004	Q4	Produce and distribute protocols for new gas hydrate sensors
	2004	Q1	Publish and distribute well bore stability model
	2004	Q1	Drill Well A1
	2004	Q1	Drill Well A2
	2005	Q1	Drill Well A3
	2004	Q4	Hold 2-day conference to present results from data collection wells
	2005	Q1	Final report on Phase II

4.2 Task 2.0 – Project Management and Oversight

Dr. Emrys Jones was appointed Project Manager by ChevronTexaco to manage the JIP and the DOE Contract. The work has been delegated to Technical Teams and to Contractors. Dr. Jones manages the day-to-day operation of the project, and reports verbally and by written report on the progress of the project to the DOE, as required. The organization chart for this project for the time period of October 2002 – March 2003 is given in **Fig. 4.1.**

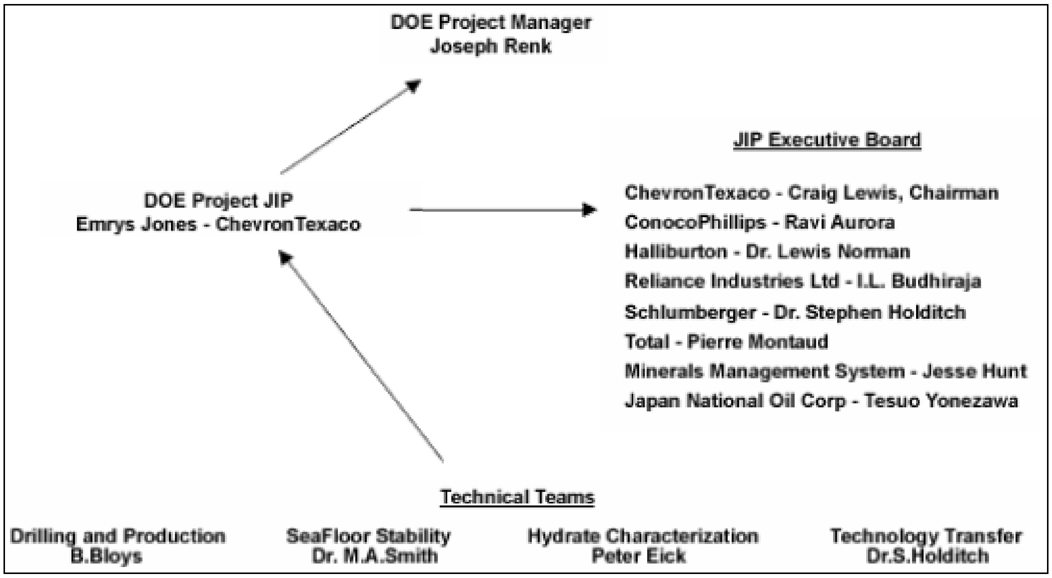

Fig. 4.1. Organization Chart for "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico"

4.3 Task 3.0 – Data Collection and Organization

A committee was formed to plan a data and case histories workshop. The committee solicited interest from the oil and gas, scientific, and academic communities to participate in the data and case histories workshop. The committee organized and held a workshop to collect data and case histories on the successes, failures, and lessons learned from field operations where hydrates may have been encountered in drilling, production, or pipeline installation and operation. After the workshop, the JIP collected the information, and developed a JIP website for storing the data and making it available to all.

4.3.1 Subtask 3.1 – Data Committee (Completed)

During January 2002, the Gas Hydrates Characterization Team planned the workshop for compiling data and case histories concerning operations in the deep water Gulf of Mexico, as it relates to gas hydrates on or near the seafloor. The Team defined objectives for the workshop and prepared a very detailed agenda. The Team solicited the keynote speakers and presenters for the breakout sessions.

4.3.2 Subtask 3.2 – Workshop Attendance (Completed)

The Hydrates Characterization Team solicited interest from the oil and gas, scientific, and academic communities to participate in the data and case histories workshop. Using email lists from the DOE, and personal communication, the Team contacted oil and gas operators who have interest in deep water prospects in all parts of the world, service companies, national research laboratories, private research institutes, certain consulting organizations, government organizations, and academic communities and solicited interest in participating in a data and case histories workshop.

4.3.3 Subtask 3.3 – Conduct Data Collection Workshop (Completed)

A workshop to collect data and case histories on the successes, failures, and lessons learned from field operations where hydrates may have been encountered in drilling, production, or pipeline installation and operation was held in Houston in March 2002**.** The JIP obtained information that documents where the gas hydrates are located (at least based on then current information), how many wells have been drilled through areas that could possibly contain gas hydrates, various drilling problems encountered that could possibly be attributed to gas hydrates, and other pertinent information in the Deep Water GOM.

The purpose of the data collection task was to obtain the information required (and available) to select the sites for collecting cores and well log data, and to actually plan and conduct the remaining tasks in this research project. The data collection task also highlighted for the JIP what additional data are required (that currently do not exist) to properly conduct this research project.

4.3.4 Subtask 3.4 – Identify Data Platform (Completed)

The JIP, following the recommendations of the Project Manager and the Hydrates Characterization Team, decided to use the third party QuickPlace platform for collecting and disseminating the information obtained in the data and case histories workshop, as well as all other information generated by the JIP. The JIP website can be accessed using the following Web address.

http://qpext.chevrontexaco.com/QuickPlace/wwuexpl_gashydrates/Main.nsf?OpenDatabase.

4.3.5 Subtask 3.5 – Data Protocol (Completed)

The Hydrates Characterization Team, working with ChevronTexaco developed the protocols needed for collecting, storing, and disseminating data on natural gas hydrates in the Gulf of Mexico. Essentially, the QuickPlace website tools of ChevronTexaco have been used to store data using software such as Microsoft Word, Power Point and Excel.

4.3.6 Subtask 3.6 – Build Gulf of Mexico Gas Hydrates Database

The database of information concerning natural gas hydrates in the deep water Gulf of Mexico has been constructed. JIP members have access to all of the information. In time, essentially all of the data will be available to anyone with Internet access. The database is a central repository for all data that will be generated and/or obtained during the remainder of this research project. The database can be accessed using the following Web address.

http://qpext.chevrontexaco.com/QuickPlace/wwuexpl_gashydrates/Main.nsf?OpenDatabase.

4.4 Task 4 – Development of New Gas Hydrates Sensors

The Seafloor Stability Team has investigated the feasibility of developing MWD sensors for gas hydrates. A draft report has been prepared concerning sensors that can be used to locate and evaluate formations containing gas hydrates.

4.4.1 Subtask 4.1 – MWD Sensors for Gas Hydrates (Completed)

The Seafloor Stability Team has looked into the feasibility of developing MWD sensors for gas hydrates. At the Modeling, Measurements and Sensor Workshop held in Houston in March 2002, a portion of the workshop dealt with sensors. Dr. Robert Kleinberg made a keynote presentation and a breakout session was devoted entirely to discussing existing sensors and the need for new sensors.

4.4.2 Subtask 4.2 – Gas Hydrate Disassociation Sensor (Measurements) (Completed)

Gas hydrates found in the formation near the seafloor may begin to disassociate into gas and water as the pressure and temperature change during drilling or producing conditions. The exact values of pressure and temperature when disassociation occurs is a complicated issue and depends on a number of parameters. The Seafloor Stability Team has been discussing what occurs when gas hydrates begin to disassociate, and will be reporting on what measurements can be made to determine when gas hydrates begin to disassociate.

4.4.3 Subtask 4.3 – Gas Hydrate Formation Sensor (Measurements) (Completed)

Gas hydrates will form as gas and water are mixed under certain pressure and temperature conditions. The formation of gas hydrates is a very complicated issue, one that depends on many parameters. However, as gas hydrates form, chemical and physical reactions occur that could possibly be detected by sensors. The Seafloor Stability Team has been discussing what occurs when gas hydrates form, and will be reporting on what measurements can be made to determine when gas hydrates begin to form.

4.4.4 Subtask 4.4 – Sensor Specification and Technology Transfer

The Seafloor Stability Team has written a rough draft of a white paper that will address certain issues concerning existing sensors, and requirements to measure the properties of gas hydrate deposits in situ. After the white paper has been completed, the JIP will conduct a series of meetings with any service company and/or research organization that would like to receive the information. The plan would be for the companies or organizations to take the information in the white paper, and then develop the technology to measure what is needed to sense hydrate formation and hydrate disassociation using their own research dollars. The JIP does not plan to fund any sensor development during this research project.

The first draft of the report entitled **"Sensors for Assessment of Hydrate Related Geohazards"** has been written and is currently under review by the Seafloor Stability Team. The direction of the report and the work of the Seafloor Stability Team is somewhat different than envisioned in the JIP Technical Proposal; however, the report is more thorough and more informative than envisioned in the original Technical Proposal. In the Technical Proposal, the JIP was looking for possible new measurements that would help the industry know when gas hydrates were forming and when gas hydrates were disassociating. As it turns out, a combination of existing sensors that measure pressure, temperature, resistivity, conductivity and motion could provide the information one needs to tell when hydrates are melting and when they are forming. Much more detail will be provided when the reference report is completed and published.

4.5 Task 5 – Develop Well Bore Stability Model

The JIP contracted with Schlumberger Data and Consulting Services (DCS) on October 1, 2002, to determine the feasibility of building a well bore stability model for boreholes that penetrate zones containing natural gas hydrate. Assuming the task is feasible, Schlumberger DCS will oversee the development of a prototype well bore stability model. To provide data required for the model, laboratory tests from work at Georgia Tech have been authorized under another JIP sub-contract. The JIP is also looking at other research projects, funded by the DOE, that are measuring mechanical properties of sediments containing natural gas hydrates are being measured. The JIP hopes to validate the prototype well bore stability model with both laboratory and field test data from Phase II.

4.5.1 Subtask 5.1 – Well Bore Stability Model Evaluation (Completed)

Well bore stability models are commonly used to design slanted, horizontal and multilateral wells. Well bore models can also be used to determine if sand control measures are required and to assist engineers in designing stimulation treatments. The data for these well bore stability models have been measured in both the laboratory using core samples and in the field using wire line conveyed tools. For conventional formations, well bore stability models are very reliable.

However, when the JIP began, we did not know if any models existed that could be used to estimate the stability of well bores that penetrate formations containing gas hydrates. The JIP awarded a contract to Schlumberger DCS to find out what models have been developed, and if such models can be modified to handle the problem for a well bore penetrating a formation containing gas hydrates.

The contract with DCS has actually taken a broader view of the problem than just borehole stability. Schlumberger DCS is looking at how to develop a practical method for engineering wells that will safely penetrate formations containing natural gas hydrates. A status report on Phase I (Task 5.1) was presented to the JIP as of January 31, 2003. At this time, the report is part of the JIP website that is open only to JIP members.

From the Schlumberger DCS report, the following 'Summary' has been copied.

“This report documents results of the feasibility study that addresses Task 5.1 of the JIP Gulf of Mexico Gas Hydrates project. It aims at identifying

(a) existing well bore stability modeling (WBS) software that can be used in formations containing gas hydrates,

(b) capabilities of potential sub-contractors to develop such WBS modeling software,

(c) appropriate datasets to use for evaluating WBS modeling software.

The feasibility study started with a **literature review** of gas hydrates focused on defining and outlining the numerous factors that have to be considered when assessing well bore stability problems related to gas hydrate bearing sediments. Modeling results indicate that the hydrate stability zone (HSZ) can reach depths of about 1,000 meters below the seafloor. In these shallow depths, gas hydrates occur in numerous textural modifications and distributions; but in the GOM only 0.5 vol % of sediments in the HSZ actually consist of gas hydrates.

Gas hydrates have a very specific pressure temperature (pT) field that is also dependent on the type of gas that is incorporated. Drilling or production related heating of hydrate bearing sediments could cause hydrates to dissociate. Since 1 volume of gas hydrate is equivalent to 164 volumes of gas, hydrate dissociation can produce uncontrolled release of gas and gas flows potentially resulting in blowouts and/or well bore casing collapse.

In order to **scorecard** existing well bore stability models, a questionnaire was sent to 41 individuals in industry, government organizations and universities, as well as to the board of the American Rock Mechanics Association (ARMA). Twenty-one responses were received and are summarized in detail in the Appendix. From the results of the questionnaire, we can conclude that at present there is no existing software that has the necessary features for modeling well bore stability in gas hydrate bearing sediments although several groups are working on different aspects of gas hydrates.

Based on the literature review of gas hydrates and discussions with gas hydrate experts, the **necessary requirements** for a well bore stability model in gas hydrate bearing sediments have been identified and outlined below. The following comprise necessary main features:

(a) Some assessment of the size, amount and distribution (veins, nodules, disseminated) of gas hydrates in the sediments. Gas hydrates contribute to the total sediment strength and the amounts of dissociating hydrates contribute to gasifying the sediment and to borehole instability.

(b) Physical properties of sediments that contain gas hydrates and control thermal and hydraulic transport. This includes knowledge of thermal conductivity: thermal capacity, porosity and permeability of different unconsolidated sediments (clay, silts, etc.)

(c) The WBS software model must enable simulation of changes in temperature and stresses during drilling along the well bore and radially away from the well bore into the formation. In this context it is important to consider that hydrate dissociation is an energy consuming reaction, thus cooling the formation and reducing the rate of dissociation.

(d) The WBS software should preferably include elasto-plastic behavior, as gas hydrates in the Gulf of Mexico are associated with shallow unconsolidated sediments that have a ductile-compactive mechanical behavior.

Based on the major findings of our review, we recommend that a well bore stability model be used that incorporates aspects of elasto-plastic behavior of the sediments. This model should be enhanced by the addition of incorporating the pressure-temperature (pT) behavior of gas hydrates. Five basic schemes for doing this are described. The well bore stability model could either be an existing elasto-plastic model, a poromechanical model or a modified soil mechanics model. The incorporation of the equilibrium and kinetic considerations of gas hydrate dissociation would be feasible by coupling, for example, the EOSHYDR2 module or the WhiteCoal_T software package via an interface to the well bore stability model. An alternate approach would be to work with a university in order to implement the relevant pressure-temperature hydrate kinetics into the chosen well bore stability model.

An appropriate dataset for modeling and verification of well bore stability in gas hydrates has not been identified in the public domain. Verification and validation of the model(s) should be done in a laboratory setting, though incorporating physical properties of gas hydrate bearing sediments is likely to be time consuming and expensive. Possible collaboration partners would be MIT, Durham, Moridis and Kirby (JIP proposal), CSIRO, Professor Sloan (Colorado School of Mines).

Further testing of the model, during a second stage, should include using hydrate datasets from the Ocean Drilling Program such as ODP, Leg 164: Blake Ridge and Leg 204: Hydrate Ridge."

4.5.2 Subtask 5.2 – Prototype Well Bore Stability Model

The results of the feasibility study did not reveal any singular group that was best prepared to build a prototype well bore stability model. After discussing the situation with the Drilling and Coring Team and the ChevronTexaco project manager, the decision was made for Schlumberger DCS to continue working on the project, using the existing contract, and to prepare the prototype well bore stability model. DCS has been negotiating with Japan National Oil Corporation (JNOC), another JIP member, to get a copy of the WhiteCoal_T model. Hopefully, some of the code in WhiteCoal_T can be beneficial to the overall modeling effort. This work is ongoing.

4.5.3 Subtask 5.3 – Well Bore Stability Model Testing

In the first quarter Status Report by Schlumberger DCS they stated "An appropriate dataset for modeling and verification of well bore stability in gas hydrates has not been identified in the public domain." As such, the JIP has to generate the data from laboratory tests needed to verify the accuracy and calibrate the well bore stability model. These tests are ongoing at Georgia Tech. Also, other laboratories under contract to DOE are generating data that will be helpful to DCS in calibrating and verifying the prototype, once it is completed. Part of the field and laboratory experiments in Phase II need to be designed to generate data and information that will be helpful to DCS as they verify their prototype well bore stability model.

4.5.4 Subtask 5.4 – Well Bore Stability Model Validation

As the laboratory work is being conducted, the data generated will be supplied to the sub-contractor who is building the well bore stability model. The data will be used to both calibrate and validate the model, as well as to guide the future laboratory experiments.

4.6 Task 6 – Seismic Modeling and Analysis

The JIP has a contract with WesternGeco to obtain existing three-dimensional seismic data in selected areas of the deep water Gulf of Mexico for review of the gas hydrate zones. These data are being used to conduct theoretical seismic modeling. The seismic modeling should lead to the development of protocols for acquiring, recording, processing, and analyzing seismic data to better image the gas hydrate zones. The JIP has contracted with Georgia Tech to conduct laboratory tests on cores that will provide useful data to the modeling efforts of WesternGeco.

The seismic modeling and analysis study is designed to test the detection of and quantification of natural methane gas hydrates in sediments of the deepwater portion of the Gulf of Mexico using rock property inversion of pre-stack seismic data. Synthetic seismic modeling will be conducted on a series of generated earth models using rock physics in order to develop an improved process of seismic gas hydrate delineation and quantification. While conducting this research, WesternGeco is using datasets from six areas of interest to the JIP. The results so far have led to a much better understanding of the problems faced by the JIP and to the selection of drill sites for Phase II of this project.

4.6.1 Subtask 6.1 – Identify and Obtain Existing 3D Seismic Data (Completed)

A major goal of this project is to determine the best ways to shoot, record, process and analyze seismic data to characterize the gas hydrates that are located in the deep water GOM. A contract was awarded to WesternGeco to provide existing seismic data in six areas in the deep water GOM and to analyze the data looking for gas hydrates

From a January 15, 2003, report by WesternGeco, the following information was presented.

> "The objectives of the Phase 1 initial screening process were to identify possible key gas hydrate locations for subsequent reprocessing of seismic data and seismic modeling and analysis. This involved a search for hydrate features such as mounds, slumps, trapped gas, BSRs, etc., using post-stack attributes along with seismic structural and stratigraphic interpretation. Digital well logs, mud logs and drilling reports were not available for Phase 1. Only literature and published articles were used. Known seismic characteristics indicative of hydrates are listed below.

1. Presence of a BSR at base of the stability zone.
2. Underlying areas showing amplitude attenuation or "wipe out" zones.
3. Possible polarity reversals at or near the water bottom interface.
4. Elevated P-wave velocity of the sediments as opposed to the background.
5. Large variability in amplitude reflection strength, continuity and lateral consistency within the hydrate stability zone.

6. "Shingling" of reflectors with increased amplitudes at shallow depths.

7. Seafloor gas hydrate mounds, seafloor failures and slumping.

8. Gas chimneys.

9. Mud volcanoes.

10. Presence of gas and water in near surface sediments.

11. Thermal-pressure analysis to define the temporal and spatial limits of the hydrate stability zone.

Many of these indicators were found on the five surveys strongly suggesting the presence of hydrates. However, this early Phase 1 work cannot positively confirm or deny the existence of hydrates at any of the locations. More definite and quantitative analysis will be forthcoming in the subsequent work. A summary of each area follows along with a ranking as to the abundance and quality of hydrate characteristics."

The following images illustrate typical WesternGeco analyses of several promising areas in the GOM for Phase II of this project **(Fig. 4-2, Fig. 4-3, and Fig. 4-4).**

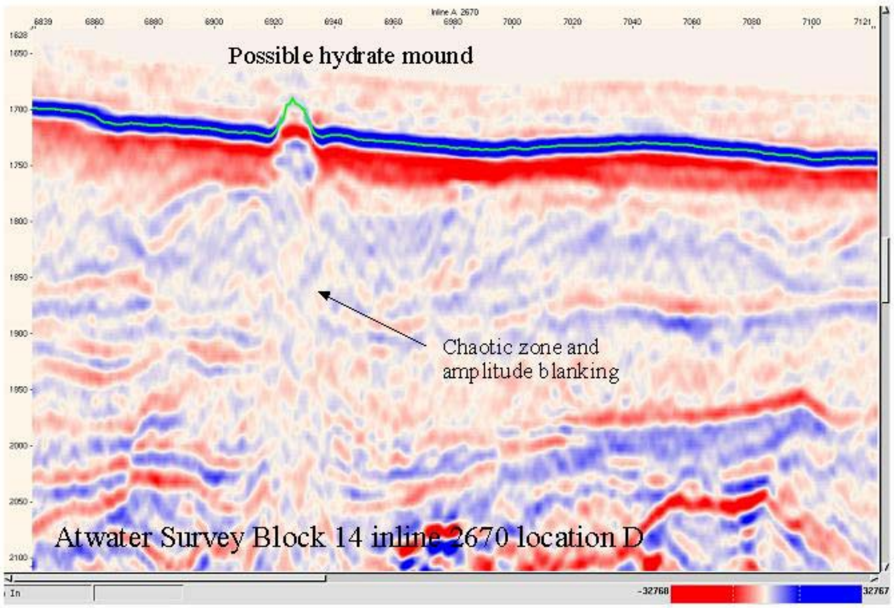

Fig.4.2. Possible Hydrate Mound at Atwater 14.

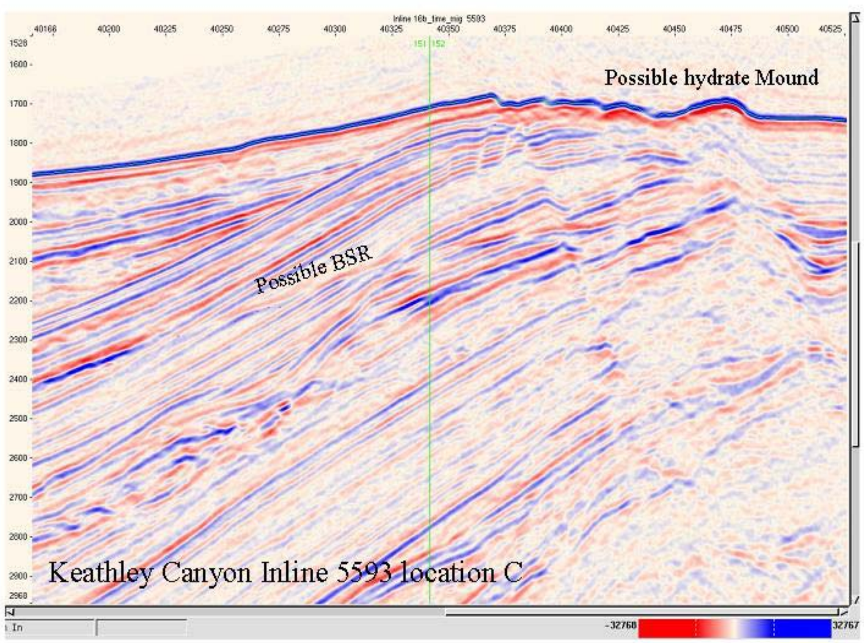

Fig. 4.3. Possible BSR at Keathley Canyon 153

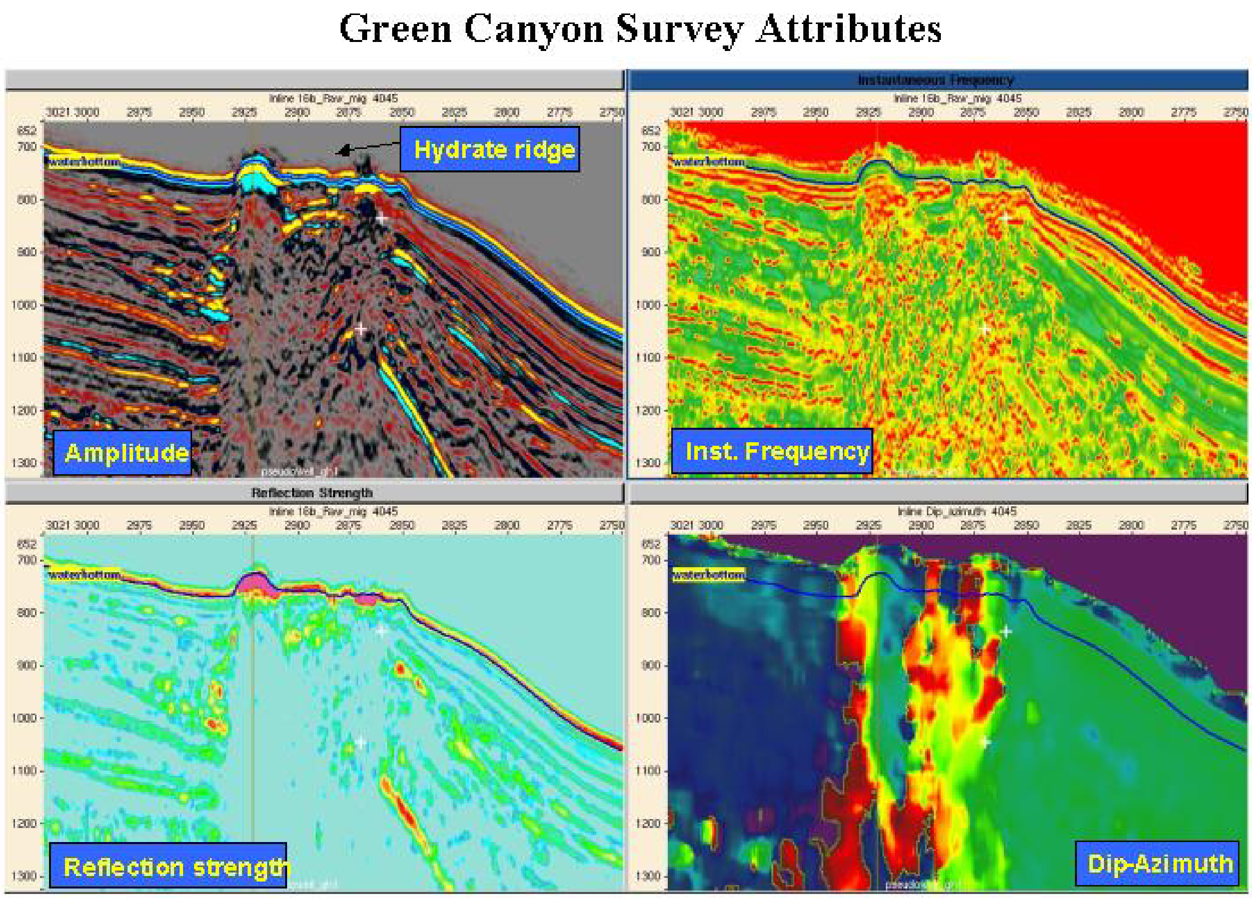

Fig. 4.4. Sismic Diagrams of Green Canyon

Using data from the WesternGeco report, a short-list of six sites was created. These six sites are as follows:

OCS Block	Water Depth (m)
Green Canyon 184, 185	538
Atwater Valley 14	1297
Alaminos Canyon 856	2243
Mississippi Canyon 802	1036
Keathley Canyon 195	1305
Mississippi Canyon 757 – Alternate	

The data for these six areas have been screened to look for bottom simulating reflectors (BSRs), shallow water flow type features, high reflectivity zones (HFZs) which may appear within the gas hydrate stability zone, widespread strongly attenuated blanking zones, and lateral changes and variations in seismic character within the gas hydrate stability zone.

4.6.2 Subtask 6.2 – Theoretical Seismic Modeling

Virtually all of the seismic data shot in the deep water GOM has been optimized to find oil and gas formations deep below the mud line. Since gas hydrate deposits are located at or near the seafloor, it is likely that the seismic data that we will obtain will not have been optimized to image the seafloor and the gas hydrate zones that lie beneath the seafloor. WesternGeco has been conducting theoretical seismic modeling, using their 3-D data sets in the six areas of interest. The objectives of the seismic modeling are to determine how seismic data must be shot, recorded, processed and analyzed to accurately image the naturally occurring gas hydrate deposits near the seafloor.

4.6.3 Subtask 6.3 – Protocol Development for Seismic Data

Once the geophysical modeling has been concluded, WesternGeco will prepare protocols that can be used in future research to shoot, record, process and analyze seismic data to better image the gas hydrate zones in the deep water GOM. As we proceed into Phases II and III of this project, we can discuss the protocols with various seismic and/or operating companies who will be shooting seismic in our areas of interest. Ideally, we can obtain additional 3D seismic data shot using the protocols developed during this portion of our research.

4.6.4 Subtask 6.4 – Specify Seismic Data Laboratory Tests (Completed)

To calibrate seismic data and to improve analyses procedures, it is useful to have information concerning sonic travel times (both P-wave and S-wave) through any sediment that affects the interpretation of the seismic data. The JIP would like to have laboratory data concerning how gas hydrate saturation in cores affects the acoustic properties of the core.

Using information from the JIP workshops, the technical teams have prepared specifications for laboratory tests to develop information needed by the JIP. The specifications were used to prepare the request for proposal in Task 6.5.

4.6.5 Subtask 6.5 – Seismic and Petrophysical Laboratory Tests

A request for proposal for conducting laboratory tests to generate data to help interpret the seismic and petrophysical properties of cores containing natural gas hydrates was prepared. Ten proposals were reviewed and Georgia Tech was selected to conduct the necessary laboratory work. This work is ongoing.

4.7 Task 7 – Kinetics and Thermodynamics Analyses

We have conducted a comprehensive literature search to summarize existing information and data on gas hydrate kinetic and thermodynamic properties in porous media, as well as other gas hydrate topics. The resulting bibliographies can be accessed through the JIP website. We have determined what kinetic and thermodynamic data are needed by the models that are used to understand and predict the geologic, reservoir, and geomechanical behavior of formations containing natural gas hydrates. We have specified the laboratory tests required to measure the needed kinetic and thermodynamic data from cores containing gas hydrates required by the geoscientist and engineering modeling community. We have also specified the laboratory tests required to measure the needed physical and chemical data from cores containing gas hydrates required by the geoscientist and engineering modeling community. Georgia Tech has been contracted to make the measurements required by the JIP.

4.7.1 Subtask 7.1 – Literature Review of Hydrate Kinetic and Thermodynamic Properties (Completed)

Over the years, scientific data have been generated and published concerning both the kinetic and thermodynamic properties of gas hydrates. However, it was not clear how much data exist concerning how gas hydrates in porous media affect the properties of the porous media. As such, we have conducted a thorough investigation of what information lies in the published literature. We have searched journals in all possible disciplines. The results of our literature search are posted on the JIP website at the following address.

http://qpext.chevrontexaco.com/QuickPlace/wwuexpl_gashydrates/Main.nsf?OpenDatabase.

4.7.2 Subtask 7.2 – Gas Hydrate Kinetic and Thermodynamic Data Analysis (Completed)

Eventually, models must be developed to allow engineers and geoscientists to analyze the present conditions in a natural gas hydrate deposit, and to predict the future behavior of the gas hydrates when pressures and temperatures change, or chemicals are injected. We need geologic, reservoir and geomechanical models concerning the behavior of formations containing natural gas hydrates. These models will need data – specifically, kinetic, thermodynamic and physical data measured in the laboratory in order to function properly. To design such tests, we held a Workshop with Geoscience and Reservoir modelers in May 2002 to find out what data they require for their models. The results from that workshop are posted on the JIP website and are presented in detail in a DOE report. The JIP has used the results of that workshop to design a matrix for conducting the laboratory tests, and to plan our field data collection efforts in Phase II of this project. Our goal is to provide all the data required for existing and future models of natural gas hydrate deposits.

4.7.3 Subtask 7.3 – Specifications for Kinetic and Thermodynamic Laboratory Tests (Completed)

Using the results from the Modeling Workshop, we know what kinetic and thermodynamic data are required by the geoscience and engineering models. Using this information, the Gas Hydrates Characterization Team has developed a core analyses test matrix. The matrix was being used to specify the laboratory tests and the desired results from such tests that will be of the most benefit to the geoscience and reservoir modeling communities.

The Core Analyses Test Matrix is presented in Appendix A.

4.7.4 Subtask 7.4 – Specifications for Chemical and Physical Property Tests (Completed)

The Hydrates Characterization Team also determined what physical and chemical data are required from laboratory measurements by the geoscientists and engineers who will be building and using the models. The Team has specified the laboratory tests and the required results from the tests in the Test Matrix that is given in Appendix A.

4.7.5 Subtask 7.5 – Laboratory Testing for Kinetic and Thermodynamic Properties

Work began at Georgia Tech in October 2002 on a project that is entitled **"Effect of Thermal History on Properties of Hydrate Core Samples: Laboratory and Modeling Studies of Hydrate-Bearing Sediments".** The goals of the laboratory work are described by Georgia Tech as (a) characterize the properties of sediment-hydrate mixtures, (b) track physical property changes during formation and dissociation of gas hydrate, which correspond to pressure and/or temperature cycling, and (c) assess the effect of coring/sampling on the properties of gas hydrates. Through March 2003, Georgia Tech has characterized real GOM marine sediment samples obtained during an NSF-sponsored cruise in October 2002. The samples came from key gas hydrate areas. The core samples used in this work came from other sponsored research at Georgia Tech. However, the JIP is benefiting from the work and will be able to use some of the cores in our research.

Aboard ship, they obtained S-wave velocity, electrical conductivity, and undrained shear strength measurements on sediment and sediment-hydrate mixtures. Later laboratory work included measurements of moisture content, sediment classification, complex permittivity, specific surface and calcium carbonate content.

4.7.6 Subtask 7.6 – Laboratory Testing for Chemical and Physical Properties

The contract with Georgia Tech also covers the tests needed for Subtask 7.6. Georgia Tech has been forming gas hydrates in a cell at atmospheric pressure and has been measuring Vp, Vs, electrical conductivity, and complex permittivity in samples of water + hydrate and water + sediment + hydrate. So far, only preliminary test results are available. As the project continues, more formal reports of the results will be included on the JIP website.

4.8 Task 8 – Determine Data Requirements for GeoModels

The Seafloor Stability Team took on the tasks of planning and soliciting interest in a geoscience/reservoir modeling workshop. A workshop on Modeling, Measurements and Sensors was held in May 2002 for geoscientists and reservoir engineers to determine data requirements for models they use to study gas hydrates. The results of the workshop were recorded in a DOE report and will also be included in a White Paper on data requirements for models. This information will be used to provide input on data collection planning for Phase II, and any possible Phase III of this project

4.8.1 Subtask 8.1 – Form Geoscience/Reservoir Modeling Committee (Completed)

The Seafloor Stability Team formed a group to discuss existing data concerning naturally occurring gas hydrate deposits, and to determine what data that geoscientists and reservoir engineers will likely need in the future to use their models. The group then used this information to plan a workshop.

4.8.2 Subtask 8.2 – Plan a Geoscience/Reservoir Modeling Workshop (Completed)

The Seafloor Stability Team planned a workshop to allow professionals who build or use geoscience and/or reservoir models to discuss the issues surrounding both data needs and data collection methods for the models. The team met several times to set the agenda, identify likely participants, solicit interest, solicit keynote speakers, and finalize the plans for the workshop. Again, the purpose of the workshop was to get together those geoscientists and engineers who are the experts in modeling of sediments containing natural gas hydrates, and let them tell the JIP what data they need to run their models. The workshop also was designed to obtain information on techniques and sensors needed to better measure the properties of sediments containing naturally occurring gas hydrates.

4.8.3 Subtask 8.3 – Conduct a Geoscience/Reservoir Modeling Workshop (Completed)

The workshop was held in March 2002. The results from the workshop have positively affected the planning for the remainder of this research project. The workshop was designed to stimulate discussion and ideas concerning the data requirements for all modelers, the measurement techniques that will provide the best data, and the need for new and better sensors for making measurements. From this workshop, the JIP learned the data requirements most needed from the participants, and the relative importance of each data item or data set. The JIP has used the output from the workshop to prioritize the data we can collect in our fieldwork. The results from the workshop have been documented in detail on the JIP website, and a DOE report.

4.8.4 Subtask 8.4 – Write a Geoscience/Reservoir Modeling White Paper

The results from the Modeling, Measurements, and Sensors Workshop were documented and placed on the JIP website. In addition, a DOE report on this and the other two workshops is also available on the JIP website. However, to guide data collection in Phase II of this project, the Seafloor Stability Team will prepare a White Paper on the data required by geoscientists and engineers who develop and use models to understand the behavior of sediments containing gas hydrates. The White Paper will use the results of the workshop, and provide a guide for the JIP as it makes plans to gather data in both the laboratory and the field.

4.8.5 Subtask 8.5 – Develop Data Collection Requirements for Phase II

As we develop data collection plans for Phase II of this project, the White Paper and the results from the Modeling, Measurements and Sensors Workshop will provide valuable input into the planning process. The Seafloor Stability Team will be instrumental in the planning processes, so that we are assured of maximizing our efforts at collecting data that will be useful to the modeling community.

4.9 Task 9 – Develop Drilling and Coring Test Plans

The Drilling and Coring Team planned and solicited interest in the Drilling, Coring and Core Analysis Workshop. The JIP held the workshop in May 2002. The results of the workshop were included in a DOE report and will be used to document current drilling practices in areas where hydrates are known to or thought to exist. The workshop also helped the JIP to develop scenarios for drilling and coring gas hydrates in deep water, and to determine costs and risks of the various scenarios. Finally, we plan to develop guidelines and issue protocols to be used when drilling or coring through natural gas hydrates, then prepare detailed plans for drilling and coring gas hydrates in deep water.

4.9.1 Subtask 9.1 – Form a Drilling and Coring Committee (Completed)

Everyone agrees that the industry needs to know more about how to drill through or core through formations containing natural gas hydrates. Several methods have been discussed during various JIP planning sessions, and costs have been estimated, but substantial progress is required to meet the objectives of this research project. As such, the Drilling and Coring Team was charged with organizing and conducting a workshop concerning drilling and coring practices through formations containing gas hydrates in deep water.

4.9.2 Subtask 9.2 – Plan a Drilling and Coring Workshop (Completed)

The Drilling and Coring Team met several times to plan the Drilling and Coring Workshop, to set the agenda, identify likely participants, solicit interest, and find keynote speakers. The purpose of the workshop was to get the drilling community together to discuss the important issues and help lay the groundwork for developing plans that can be used in Phase II of this project.

4.9.3 Subtask 9.3 – Conduct a Drilling and Coring Workshop (Completed)

The Drilling and Coring Workshop was held May 2002. The results of the workshop have been instrumental in organizing the remaining tasks in Phase I, and for planning Phase II. The workshop was organized to allow participants to discuss the state of the art in drilling and coring practices in deep water, and how those practices are affected by the presence of natural gas hydrates. Safety issues were also thoroughly discussed and documented. In addition, time was spent looking at relevant drilling and coring issues from the Mallik project and other projects of interest. The results from the Drilling and Coring Workshop are documented in detail on both the JIP website and in the DOE report.

4.9.4 Subtask 9.4 – Publish a White Paper Documenting Current Practices

In addition to the workshop report on the JIP website and the DOE report documenting the results from the workshop, the Drilling and Coring Team will be preparing a White Paper concerning how to best drill and core through formations containing natural gas hydrates. The importance of this task cannot be overstated. Safety is the primary concern in all deepwater operations. This white paper will prove to be extremely beneficial to all parties associated with this research project. This subtask will be contracted to the Joint Oceanographic Institute (JOI). The contract is still under negotiation.

4.9.5 Subtask 9.5 – Develop Scenarios for Drilling and Coring Gas Hydrates

One important result from the Drilling and Coring Workshop was the discussion of scenarios concerning how we can best drill through and core formations containing gas hydrates. These discussions will help the Drilling and Coring Team prepare plans for drilling and coring wells during Phase II of this project. In addition to the workshop, members of the Drilling and Coring Team have been reviewing data and specifications for several vessels that could be used in Phase II of the project. This subtask will be contracted to the Joint Oceanographic Institute (JOI). The contract is still under negotiation.

4.9.6 Subtask 9.6 – Conduct a Cost/Risk Analyses on the Various Scenarios

All feasible scenarios concerning how the JIP can drill and core wells during Phase II of this project are currently being defined and analyzed to determine the costs and risks associated with each scenario. A meeting with the Minerals Management Service (MMS) in New Orleans was held on January 15, 2003, to discuss several topics concerning the operation, drilling, environmental considerations, and goal of the JIP gas hydrates drilling program. From the discussion with MMS, it appears that the JIP can drill "Geological and Geophysical (G&G) Exploration Wells on the Outer Continental Shelf" with fewer limitations than the JIP would have trying to permit routine wells in the same locations.

More work will be needed to fully define how to drill the experimental wells and to be sure a proper cost and risk analysis is done on each scenario. This subtask will be contracted to the Joint Oceanographic Institute (JOI). The contract is still under negotiation.

4.9.7 Subtask 9.7 – Develop Drilling and Coring Protocols for Gas Hydrates

From the workshop and other meetings held by the Drilling and Coring Team, the team has discussed several likely scenarios for drilling and coring natural gas hydrates in deep water that will lead to a logical field data collection process in Phase II of this project. The JIP watched ODP Leg 204 and the success they had in coring and logging gas hydrate zones offshore Oregon in 2002. It is likely that the JIP will conduct its Phase II operations in a manner similar to ODP Leg 204.

This subtask will be contracted to the Joint Oceanographic Institute (JOI). The contract is still under negotiation. Once the drilling and coring protocols and procedures are approved by the MMS, they will be documented and put out to industry for comments.

4.10 Task 10 – Core Handling and Core Tests

We have conducted a detailed literature search to determine what information is required from tests of cores containing gas hydrates. We are in the process of preparing protocols for coring, core handling, core preservation, core transport, and core testing for cores containing natural gas hydrates. Much of the information the JIP needed was presented and recorded in the Drilling and Coring Workshop in May 2002, which was documented in a DOE Report.

4.10.1 Subtask 10.1 – Core Sample Information

During Phase II of this project, we will be cutting cores in formations containing natural gas hydrates. To prioritize how the core is handled, preserved, transported and distributed, the Drilling and Coring Team have been working on determining the exact core tests that will be required, and how much core will be required to conduct those tests. It was clear from the discussions during the Drilling and Coring Workshop that advanced planning will be crucial to the coring and core handling portion of Phase II.

To design core sampling and core preparation work plans, the JIP must develop a flow chart that clearly enumerates what measurements will be needed, where, when and by what process they will be obtained. Only after knowing exactly (1) how much core is needed, (2) where the core is needed and (3) for what purposes the core will be used can the JIP come up with a realistic plan to preserve and transport that core. Several gas hydrate coring projects, Mallik 2L-38, ODP Leg 204, BP's Arctic Project, and Anadarko's Arctic Project, have all preceded the JIP project. As such, the JIP will be watching these projects very closely and will apply the best practices from the prior projects during our fieldwork.

Preserving core temperature is critical. There was some concern identified during the Drilling and Coring Workshop, however, over the use of liquid nitrogen to keep the cores cold because of the potential of the nitrogen to change the hydrate properties due to molecular interaction. Transportation of pressurized core samples should be by land or sea and not by air. Once the core is taken, there is a high degree of interest in instrumenting the hole and surrounding seafloor and gathering additional data over time. This should help in the integration of the core, log and seismic data, and provide information on the dynamics of hydrate sediments.

This subtask will be contracted to the Joint Oceanographic Institute (JOI). The contract is still under negotiation.

4.10.2 Subtask 10.2 – Core Sample Protocols

The results from the Drilling and Coring Workshop clearly showed that protocols already exist in the Ocean Drilling Program and other programs, such as the Mallik project, concerning how to core, handle, preserve and transport cores containing natural gas hydrates. The JIP plans to use existing protocols as much as feasible during Phase II of the project. We will combine the ODP protocols with information we obtain elsewhere and will prepare comprehensive plans that will be used in Phase I of this project for core handling, preservation and transportation.

This subtask will be contracted to the Joint Oceanographic Institute (JOI). The contract is still under negotiation.

4.11 Task 11 – Select Locations for 3 Field Tests

A site selection meeting was held on February 19, 2003. Dr. Emrys Jones told those in attendance to plan on drilling approximately 14-16 boreholes, drilled in pairs at 7-8 locations during Phase II. The pair of wells will be required because one will be drilled and logged, then it will be twinned and cored. Dr. Jones also said that a recent interpretation of regulations concluded that the boreholes do not have to be located in OCS blocks leased by one of the JIP participants or on an un-leased block, as previously thought.

Using the database we have created, and all available information from the three workshops we have held, the JIP has developed a short list for potential field test sites. The shortlist was provided to WesternGeco so they could determine what seismic data are available and begin looking at how these areas fit the requirements of the JIP and the DOE. The shortlist is presented in **Table 4.2**.

Table 4.2 – List of Sites That Are Being Evaluated

Green Canyon 184, 185
Atwater Valley 14
Alaminos Canyon 856
Mississippi Canyon 802
Keathley Canyon 195
Mississippi Canyon 757 - Alternate

4.11.1 Subtask 11.1 – Develop Short List of Field Test Sites (Completed)

At the February 19, 2003, meeting, the attendees, which included both JIP members and outside experts, a consensus was reached that OCS blocks Keathley Canyon 195 and Atwater Valley 14 should be singled out for further, detailed analyses by WesternGeco. Keathley Canyon 195 was selected because of an apparent BSR and as a representative block in a low flux setting. Atwater Valley 14 was selected as a representative block in a high flux setting. The attendees recommended that 3-5 pairs of boreholes in a pattern leading away from the target area (BSR or a seafloor feature) in each block be drilled.

4.11.2 Subtask 11.2 – Comprehensive Database Evaluation (Completed)

Of the original six (6) sites, two (2) have been selected for further review. WesternGeco has the 3-D seismic data for all six sites. The JIP has been evaluating the data in the database to evaluate each site. The JIP has been acquiring additional data from service companies, operating companies, academia and government organizations to assist our evaluation of the two sites on the shortlist.

4.11.3 Subtask 11.3 – Additional Data Analysis

Now that we have chosen the two sites for our Phase II field tests, which are the Keathley Canyon 195 and the Atwater Valley 14, WesternGeco and other JIP members are gathering as much data as possible on the two sites. The additional data collection and analyses will continue all the way into and through Phase II operations.

4.11.4 Subtask 11.4 – Selection of Field Test Sites

Using all available information, especially the results from the seismic modeling studies being conducted by WesternGeco, the JIP will need to select several sites for conducting field tests during Phases II and III of this project. Site selection will be critical to our success and should be based upon costs, risks and the ability of our project to succeed. Obviously, the operators of the sites selected will need to be contacted and included in our planning processes.

The exact selection of drilling sites will be based on a thorough evaluation of all data available. Preliminary drill site selection for the first set of wells to be drilled should be completed by the end of Phase I. The selection of drilling sites for the second set of wells in Phase II will be accomplished after the first set of wells has been drilled, cored, logged and analyzed.

4.11.5 Subtask 11.5 – Prioritize Field Test Sites

Since only a limited number of test sites will be drilled in Phase II, it will be necessary to prioritize the field test sites in order of preference. We will be conducting a pilot test during Phase II so we can test our protocols, our methodology and our technology. It is important that the best site be chosen to maximize our chances of success. Costs, risks and the quality of the technical information must all be evaluated to prioritize the field test sites.

4.12 Task 12 – Document Results and Conduct Conference on Field Test Plans

Semi-Annual and Topical research reports will be written to document this project. We plan to hold a 2-day conference to solicit input from industry on the plans for conducting field tests. This 2-day conference will be held in September 2003 in Denver, Colorado. In addition, technical papers will be written and presented at various technical meetings as warranted. The reports that will be written during Phase I of this project are given in **Table 4.3**.

Table 4.3 – Reports to be Written During Phase I

	Subtask	Title	Due Date
1	3.3	Results from the Data Collection Workshop, the Drilling and Coring Workshop, and the Modeling, Measurements and Sensors Workshop.	Completed
2		Semi-Annual Report for October 2001 – March 2002	Completed
3		Semi-Annual Report for April 2002 – September 2002	Completed
4		Semi-Annual Report for October 2002 – March 2003	May 2003
5	4.4	Sensors for Assessment of Hydrate Related Geohazards	Sept 2003
6	6.3	Protocols for Seismic Data and Acquisition and Processing	Sept 2003
7	8.4	Geoscience/Reservoir Modeling White Paper	Sept 2003
8	9.4	Current Drilling Practices White Paper	Sept 2003
9	12.0	Results from the Field Testing Workshop	Nov 2003
10		Final Report for Phase I	Dec 2003

5.0 Phase II – Initial Core and Well Log Collection and Analyses

Phase II of this project will commence after the successful conclusion of Phase I. Phase II should begin in 2003.

5.1 Task 1 – Research Management Plan

We will develop a work plan and supporting narrative that concisely addresses Phase II of the project as set forth in the Technical Proposal and DOE Contract. The Research Management Plan ("The Plan") will provide a concise summary of the technical objectives and the technical approach for each Task and, where appropriate, each Subtask. The Plan will provide detailed schedules and planned expenditures for each Task using graphs and tables as needed. The plan will contain all major milestones and decision points.

Once the Phase II management plan is completed, the tasks in Phase II will be updated to reflect the approved management plan.

5.2 Task 2 – Project Management and Oversight

A Project Manager will be appointed by ChevronTexaco to manage Phase II of the project for the JIP. The Project Manager will supervise the technical committees and the contractors and will handle the day-to-day operation of the project. The Project Manager will report verbally and in writing to the DOE as needed.

5.3 Task 3 – Validation of New Gas Hydrate Sensors

We will meet with all interested parties to discuss the new sensors that are being developed (assuming that someone has taken on this task). Once the prototype sensors are ready, we will plan to test the sensors in our data wells and to produce and distribute protocols for using the new sensors.

5.4 Task 4 – Validation of the Well Bore Stability Model

The well bore stability model will be revised using laboratory data and will be validated using all available information. Changes or improvements will be made and the model will be distributed for use by organizations that are drilling wells in the Deep Water GOM.

5.5 Task 5 – Core and Well Log Data Collection – Area A

Using our best area selected during Phase I, we plan to drill twin wells in the most favorable location for gas hydrates in Area A. Well A-1 will be drilled without well control and will gather drilling, MWD and open hole logging information. Well A-2 will be drilled with well control and will gather drilling, MWD, core and open hole logging information. The wells will be surveyed and the core will be sent to laboratories for analyses. We will then drill Well A-3 in the least favorable location for gas hydrates in Area A, and obtain appropriate core, logging and drilling data.

5.6 Task 6 – Data Analysis – Area A

We will conduct appropriate laboratory tests of cores from Wells A-2 and A-3 to generate data to assist in the interpretation of the seismic data, the petrophysical properties, the sedimentology, the distribution of the hydrates in the cores, and the chemical and physical properties of the cores. We will also analyze data from the MWD and open hole geophysical logs from Wells A-1, A-2, and A-3. Finally, we plan to integrate log, core and seismic data from all three wells.

5.7 Task 7 – Update Models, Plans and Protocols

Using all of the new data from Area A, we will update all theoretical models, as well as all protocols concerning drilling, coring, and seismic operations. These protocols and models can be used to update plans for drilling future data collection wells.

5.8 Task 8 – Integrate New and Old Seismic Data in Test Analyses

The results of the previous data collection and lab analysis effort may indicate changes to or improvements in the type and method on seismic data needed for natural gas hydrate collection. Based on these results, we will determine the need for and collect additional seismic data in the test areas and integrate these new data into our existing database.

5.9 Task 9 – Conference and Information Transfer

We plan to write topical and annual reports, plus a final report and appropriate technical papers to document the work we will do during this project. We will also hold a 2-day technical conference to present all information to industry and solicit opinions and interest in continuing with Phase III.

5.10 Phase III – Comprehensive Core and Well Log Data Collection and Analyses (2005-2006)

Phase III is not included in this research project. If Phase II is successful and all parties agree to continue this research, Phase III will be a continuation of Phase II in more gas hydrate sites in the Deep Water GOM. If all parties agree to proceed with Phase III, a detailed technical and cost proposal will be prepared and presented.

6.0 Experimental

No experimental data was collect during this period. However, experimental equipment was manufactured and is undergoing initial shakedown. The equipment and procedures will be reported on after the design is finalized.

7.0 Conclusions

The original plan called for drilling three data collection wells using conventional deep-water drill ships and gas exploration protocol requirements. However, due to the success of the Ocean Drilling Project (ODP) in conducting scientific studies in gas hydrate areas, it is likely the approach by the JIP to the data collection wells will mirror the ODP approach used on Leg 204, offshore Oregon. Thus, it should be possible to drill considerably more than three data collection wells during Phase II within the budget limitations.

Georgia Tech's experimental equipment should be able to perform the tests specified. The experimental equipment has been assembled and preliminary tests conducted but no conclusions can currently be made concerning the thermal effects on hydrate cores.

The JIP members determined that enlisting the assistance of an oceanographic institute would help ensure the efficient collection of scientific information during the drilling and coring in Phase II. Scripps Oceanographic Institute was selected to be the science provider for Phase II and to help prepare the plans and protocols for Phase II of this project.

Based on WesternGeco's analysis of the six potential sites for Phase II drilling, the Sea Floor Team and several invited outside experts selected Keathley Canyon 195 and Atwater Valley 14 for further analysis.

Schlumberger Data and Consulting Services (DCS) completed its feasibility study of developing a wellbore stability model for shallow holes drilled through soft formations containing natural gas hydrates. On the basis of the study, the JIP has decided that no currently available model can be used. The JIP is proceeding with the development of a prototype well bore stability model based on the best available models. In addition the project has expanded to cover a more broad approach to the wellbore and seafloor stability problem.

A technical and availability bid for drilling contractors was conducted and Fugro was selected to provide the drill ship for Phase II of this project.

8.0 References

No external references were used in this report.

APPENDIX A

TEST MATRIX FOR CORE ANALYSES

CASE: Fresh Water in Pores, No Salt, Pure Methane Hydrate Assumed

Geothermal gradient (^oC/100 meters)	Variable
Pore water salinity (wt %)	0

Hydrate Stability Zone Characteristics	Water Depth (feet)				
	2000'	**3000'**	**4000'**	**6000'**	**8000'**
Thickness (mbsf)	154	452.5	693	1140	1602
Thickness (ft below seafloor)	505	1485	2274	3740	5256
Hydrostatic pressure @ seafloor					
$P_{seafloor}$ (psi)	907	1353	1800	2691	3584
$T_{seafloor}$ (^oC)	6.3	4.9	4.2	3.3	2.7
Hydrostatic pressure @ BHSZ					
P_{BHSZ} (psi)	1123	2009	2810	4363	5938
T_{BHSZ} (^oC)	10.4	15.3	18.1	21.8	24.4
Average hydrostatic HSZ Pressure (psi)	1015	1681	2305	3527	4761
Average HSZ Temperature (^oC)	8.4	10.1	11.2	12.6	13.6

For 2000 feet WD	2.68	^oC/100 meters
For 3000 feet WD	2.29	^oC/100 meters
For 4000 feet WD	2.02	^oC/100 meters
For 6000 feet WD	1.63	^oC/100 meters
For 8000 feet WD	1.35	^oC/100 meters

Experimental Program Needed to Fulfill GOM JIP Objectives

Assuming sI methane hydrate

Refer worksheet "HSZ calculation" for details

Water Depth (ft)	Predicted Thickness of Methane HSZ (ft below seafloor)	Average P-T Condition in Methane HSZ	Depth below seafloor corresponding to average P-T condition (ft)	Triaxial Effective Confining Pressure		Samples: Sediment type, Porosity, Methane hydrate pore volume saturation				
					Sand, 35% porosity, 0% hydrate in pore space	Sand, 35% porosity, 25% hydrate in pore space	Sand, 35% porosity, 60% hydrate in pore space	Silt, 45% porosity, 15% hydrate in pore space	Clay, 55% porosity, 5% hydrate in pore space	Clay, 55% porosity, 0% hydrate in pore space
3000	1485	1700 psi hydrostatic 10°C	785 ft	None	X	X	X	X	X	X
				Representative for depth below seafloor	X	X	X	X	X	X
6000	3740	3525 psi hydrostatic, 12.5 °C	1865 ft	None	X	X	X	X	X	X
				Representative for depth below seafloor	X	X	X	X	X	X
				Media for testing:	N.A.	methane	methane	?		N.A.
					N.A.		THF	THF	THF	N.A.

Sand Specification:
Fine quartz, Average grain size ~ 75-100 microns

Clay Specification:
Water saturated Illite, Kaolinite/Montmorillonite mixture,
Average grain size ~ 2-3 microns

Silt Specification: Quartz silt, Average grain size ~ 20 microns; it should be saturated with water

Issues to resolve before release for RFQ

1) Grain size calibration to the GOM
2) Porosity requirements for the GOM

Testing plan

1) Strength test (triaxial rock properties)
2) Acoustic properties triaxial
3) Thermal testing and properties (low priority)

Tests Needed on Each Sample at Each P-T Condition

Property	Specific Tests	Sample Type
Mechanical (Young's Moduli, Poisson's ratio, compressibilities, compaction coeffs., cohesive strengths, grain/ cement interactions, failure-stability surfaces, constitutive behaviors, etc.)	Longitudinal and lateral stress-strain curves Tensile, shear, and compressive strengths Moduli (Young's, Shear, Bulk) through both static and dynamic measurements Elastic-Plastic Transition, Failure/stability envelopes (Mohr-Coulomb) Loading-path (hydrostatic, uniaxial, triaxial) dependent compaction coefficients Volume-Pressure compaction curves	Stable Stable, Decomposing, Decomposed Stable Stable, Decomposing, Decomposed Stable Stable, Decomposing, Decomposed
~~**Dissociation kinetics**~~ ~~(rates, i.d. rate limiting step, intrinsic kinetic dissociation rate constants)~~	~~Subject samples to P-T-time paths simulating (a) hot fluids flowing thru well bore~~ ~~& measure gas evolution and track dissociation front through X-ray CT scan~~ ~~Repeat with P-T-time path simulating core recovery~~	~~Decomposing~~ - ~~Decomposing~~
Thermal (parameters needed for heat transfer modeling)	Thermal Conductivity Thermal Diffusivity Heat Capacity Thermal expansivity	Stable Stable Stable Stable
Seismic	P and S-wave velocities Acoustic impedance	Stable
Electrical	Resistivity Real permittivity at microwave frequencies (gives volumetric free water fraction)	Stable Stable
Geologic/ Rock Physics	Distribution of hydrates within sediments - understanding spatial relationships (pore filling vs. grain boundaries vs. structurally located): SEM, MRI, etc.	Stable

May be looked at by one of the JIP member companies

What frequency range should we consider? <2 MHz, about 500 MHz, about 1,100 MHz, and >20,000 MHz ?