“Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities 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 Participation (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 2004 – March 2005, the JIP concentrated on:

- Planning the drilling leg that was conducted in April and May of 2005;
- Locating and contracting a new drill ship after the one under contract canceled;
- Revising the deliverables and work plan to allow for the increased drilling cost;
- Supplied documents to DOE for Phase II continuation.

More information can be found on the JIP website.

https://cpln-www1.chevrontexaco.com/cvx/gasjip.nsf

Table of Contents

List of Tables

List of Figures

1.0 Introduction

In 2000, Chevron Petroleum Technology Company 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".

1.2 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.

1.3 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, Chevron will drill at least three data collection wells to improve the technologies required to characterize gas hydrate deposits in the deep water GOM using seismic, core and logging data.

1.4 Research Participants

In 2001, Chevron organized a Joint Industry Participation (JIP) group to plan and conduct the tasks necessary for accomplishing the objectives of this research project. As of March 2005 the members of the JIP were Chevron, Schlumberger, ConocoPhillips, and Halliburton, the Minerals Management Service (MMS), Total, JOGMEC, and Reliance Industries Limited.

1.5 Research Activities

The research activities began officially on October 1, 2001. However, very little activity occurred during 2001 because of the paperwork involved in getting the JIP formed and the contract between DOE and Chevron in place. Several Semi-Annual and Topical Reports have been written that cover the activity of the JIP through September 2004.

1.6 Purpose of This Report

The purpose of this report is to document the activities of the JIP during October 2004 – March 2005. It is not possible to put everything 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 2004 – March 2005 is organized by task and subtask for easy reference to the technical proposal and the DOE contract documents.

More detailed information generated by the JIP during October 2004 – March 2005 can be found on the JIP website. The link to the JIP website is as follows:

https://cpln-www1.chevrontexaco.com/cvx/gasjip.nsf

2.0 Executive Summary

Chevron formed a Joint Industry Participation (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.

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"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, Chevron will drill at least three data collection wells to improve the technologies required to characterize gas hydrate deposits in the deep water GOM using seismic, core and logging data.

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:

https://cpln-www1.chevrontexaco.com/cvx/gasjip.nsf.

2.1 Research Plan and Management

A Continuation Application for Phase II was submitted to the DOE on 15 May 2003. Several changes were required to the original plan because of delays due to EPA permitting, and drill ship changes.

2.2 Sensors

A pressurized measure vessel and the equipment required to move a core from a pressure coring device into the measurement vessel was constructed and tested in the lab. The equipment will be used for the first time in a cruise in April of 2005.

2.3 Drilling and Science Planning

Detailed science and drilling plans were developed to allow for conducting an aggressive science work plan within a reasonable estimate of drilling times. The plan should provide for more work than could be accomplished if normal drilling delays are encountered.

3.0 Results and Discussion Phase II

3.1 Task 1.0 – Research Management Plan

The goals of this task are to develop a work breakdown structure and supporting narrative that concisely addresses the overall project as set forth in the agreement. Provide a concise summary of the technical objectives and technical approach for each Task and, where appropriate, for each subtask. Provide detailed schedules and planned expenditures for each task including any necessary charts or tables, and all major milestones and decision points.

A Continuation Application for Phase II was submitted to the DOE on 15 May 2003. Additional documentation was supplied to the DOE in November and December of 2003, March, July, and December of 2004, and the research plan was revised again in January 2005 to allow for the additional cost of the drilling vessel. Several changes were required to the original plan because of delays due to EPA permitting, and drill ship changes.

3.2 Task 2.0 – Project Management and Oversight

A project manager appointed by the Joint Industry Project (JIP) Recipients will manage the technical teams, contractors, and the day to day operation of the project. Project manager will report, verbally and through required reporting, on the progress of the program to the DOE and the JIP as required.

During the period of the progress report the JIP and DOE project managers were in regular contact discussing changes to the research plan due to a last minute change in the drill ship.

3.3 Task 3.0 – Validation of New Gas Hydrate Sensors

Review and evaluate new hydrate sensor development (Phase I – Task 4, Subtasks 4.1 – 4.4). Prototype sensors, if available, will be field-tested in well bores and protocols for use will be developed and distributed to all entities involved in drilling wells in the Gulf of Mexico.

No particular sensors were identified in Phase 1, but during the delay for the EPA Water Discharge Permit, a measurement vessel was developed to conduct measurements on a core while under pressure on board a drill ship. 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 will allow for the first measurement of core strength, acoustic, and electrical properties on a hydrate core that has never been depressurized. Additional information on these tools can be found in the appendix of this report.

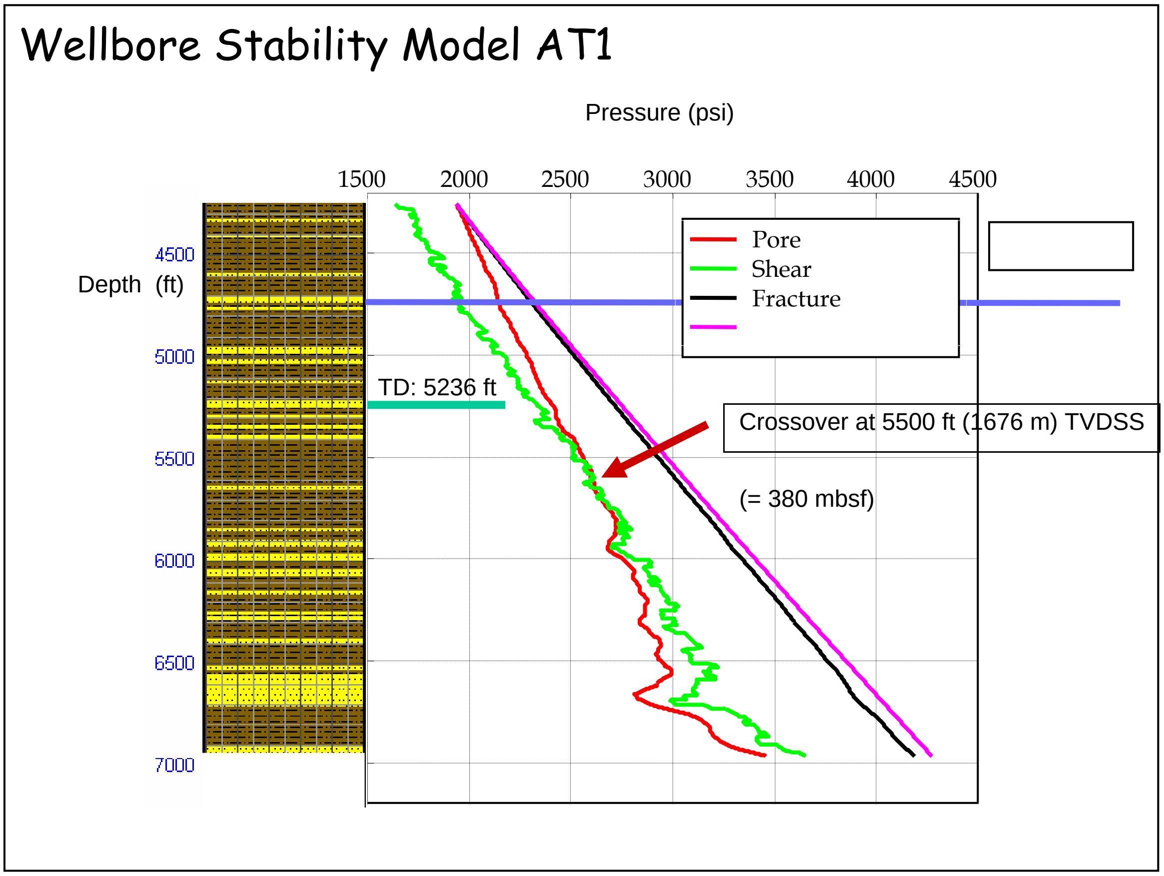
Figure 3.1. Photo of the Pressure Core Measurement Vessel

3.4 Task 4.0 – Validation of the Well Bore Stability Model

The goal of this task is to revise the well bore stability model, developed in Phase I – Task 5.0 – Subtasks 5.1 – 5.4, using laboratory data and to validate the model using all available information. Changes or improvements will be made and the model will be distributed for use by organizations drilling wells in the Deep Water Gulf of Mexico.

The well bore model developed in Phase I was used to predict pore pressure and well bore stability before the Leg 1 Cruise. During the cruise one the staff responsible for the well bore model will collect data necessary to determine the performance of the model.

Figure 3.2. Well Bore Stability Model Prediction for Atwater Valley 1 Hole



3.5 Task 5.0 – Core and Well Log Data Collection – Area A

In order to develop the necessary ground truth data, twin wells in the most favorable location for gas hydrates identified in Phase I – Tasks 11/12 – Subtasks 11.1 – 11.5 (this will be designated Area A) will be drilled. Well A-1 will be drilled without well control and will gather drilling, MWD and openhole logging information. Well A-2 will be drilled with well control and will gather drilling, MWD, core and openhole logging information. The wells will be surveyed and the core will be sent to laboratories for analyses. An additional well, A-3, will be drilled in the least favorable location for gas hydrates in Area A and appropriate core, logging and drilling data will be obtained.

During this reporting period the drilling and science plans were updated. A pre-cruise meeting for the staff on board and other interested parties was held on January 26 and 27, 2005.

Table 3.1. Planned Holes

Pre drill		Water Depth		Penetration		Time		
Site ID	**JIP Hole**	**ft**	**mbsl**	**ft**	**mbsf**	**days**	**Cum days**	**Activity**
KC3L	1A	4375	1333.5	1815	553.3	3+1	4	LWD
KC1L	2A	4301	1311.0	1999	609.2	2	6	LWD
AT2L	3A	4203	1281.1	1035	315.5	1.5+2	9.5	LWD
AT1L	4A	4228	1288.7	1008	307.2	2	11.5	LWD
AT1C	4B	4228	1288.7	1008	307.2	4	15.5	CORE
ATM1	5A	4257	1297.5	99	30.3	0.4	15.9	CORE
ATM2	6A	4210	1283.2	99	30.2	0.4	16.3	CORE
ATM3	7A	4240	1292.4	99	30.2	0.4	16.7	CORE
AT2C	3B	4203	1281.1	1035	315.5	4.8	21.5	CORE
KC1C	2B	4301	1311.0	1999	609.2	1.5+7	30	CORE
KC3C	1B	4375	1333.5	1815	553.3	4.6+1.4	36	CORE

Table 3.2. Scientific Objectives for Each Hole

Hole	Objective
KC3L	Site KC3 was originally intended as a reference site, but now is paired with Site KC1 to log and core comparable sediments at an offset location where there is no well-developed BSR.
KC1L	KC1 targets the highest amplitude portion of the BSR and an underlying, high amplitude layer we interpret as a gas-charged sand layer. This high-reflectivity layer will also be sampled by KC6; however, at KC6 the layer has lower reflectivity and overlies the BSR. KC1 has the additional benefit that it does not cross the fault providing an unfaulted sedimentary section to the BSR. This site will constrain local variability of hydrate above the BSR but also provides an opportunity to sample a high concentration gas layer underneath the hydrate stability zone. Separate analyses of gas and hydrate might provide insights into the formation of the hydrate and whether the gas has been trapped after hydrate formation or if the hydrate was formed during the migration of the gas. KC5 is an alternative location that will penetrate the BSR without penetrating the regional fault system.
AT2L	Site AT2 is intended to penetrate continuous, undisturbed, low reflectivity sediments, a regional unconformity, and underlying disturbed, high amplitude sediments. Seismic data at AT2 lack a geophysical indicator of hydrate, but a BSR could be parallel to the local strata. Drilling will provide measurements of in situ conditions and will document if hydrate is present. If no hydrate is present, AT2 will provide a baseline of geological, physical, and geochemical conditions for comparison to Mound F and will serve as a valuable comparison for the baseline site in the Keathley Canyon 195 region.
AT1L	Logging/coring at AT1 will penetrate a mound structure at which hydrate has previously been recovered (unpublished JIP data) and for which a high-reflectivity feature is interpreted at approximately 100 ft below the sea floor. Coring and logging will recover sediments, hydrate, and pore fluid data to look at vertical variability and its relation to variation in seismic attributes. A velocity pull-down is interpreted in the seismic data, and gas analyses will provide direct measurement of the gas concentration and composition that created the observed pull-down.
AT1C	Logging/coring at AT1C will penetrate sediments adjacent to a mound structure at which hydrate has previously been recovered (unpublished JIP data) and for which a high-reflectivity feature is interpreted at approximately 30 m below the sea floor. Coring and logging will recover sediments, hydrate, and pore fluid data to look at vertical variability and its relation to variation in seismic attributes. A velocity pull-down is interpreted in the seismic data, and gas analyses will provide direct measurement of the gas concentration and composition that created the observed pull-down.

AT2C	Site AT2 is intended to penetrate continuous, undisturbed, low reflectivity sediments, a regional unconformity, and underlying disturbed, high amplitude sediments. Seismic data at AT2 lack a geophysical indicator of hydrate, but a BSR could be parallel to the local strata. Drilling will provide measurements of in situ conditions and will document if hydrate is present. If no hydrate is present, AT2 will provide a baseline of geological, physical, and geochemical conditions for comparison to Mound F and will serve as a valuable comparison for the baseline site in the Keathley Canyon 195 region.
KC1C	KC1 targets the highest amplitude portion of the BSR and an underlying, high amplitude layer we interpret as a gas-charged sand layer. This high-reflectivity layer will also be sampled by KC6; however, at KC6 the layer has lower reflectivity and overlies the BSR. KC1 has the additional benefit that it does not cross the fault providing an unfaulted sedimentary section to the BSR. This site will constrain local variability of hydrate above the BSR but also provides an opportunity to sample a high concentration gas layer underneath the hydrate stability zone. Separate analyses of gas and hydrate might provide insights into the formation of the hydrate and whether the gas has been trapped after hydrate formation or if the hydrate was formed during the migration of the gas. KC5 is an alternative location that will penetrate the BSR without penetrating the regional fault system.
KC3C	Site KC3 was originally intended as a reference site, but now is paired with Site KC1 to log and core comparable sediments at an offset location where there is no well-developed BSR.
ATM1	Site ATM1 (AT14a in site survey) will penetrate a mound structure at which hydrate has previously been recovered (unpublished JIP data) and at which a high-reflectivity amplitude anomaly is located approximately 30 meters below the sea floor. Coring and logging will recover sediments, hydrate, and pore fluid data to investigate vertical variability and its relation to variation in seismic attributes. A velocity pull-down is interpreted in the seismic data, and gas analyses will provide direct measurement of the gas concentration and composition that created the observed pull-down
ATM2	Site ATM2 (AT14 #5 from hazard risk meeting) will penetrate a mound structure at which hydrate has previously been recovered (unpublished JIP data) and at which a high-reflectivity amplitude anomaly is located approximately 30 meters below the sea floor. Coring and logging will recover sediments, hydrate, and pore fluid data to investigate vertical variability and its relation to variation in seismic attributes. A velocity pull-down is interpreted in the seismic data, and gas analyses will provide direct measurement of the gas concentration and composition that created the observed pull-down

Table 3.3. Planned Core Material and Other Data Collection

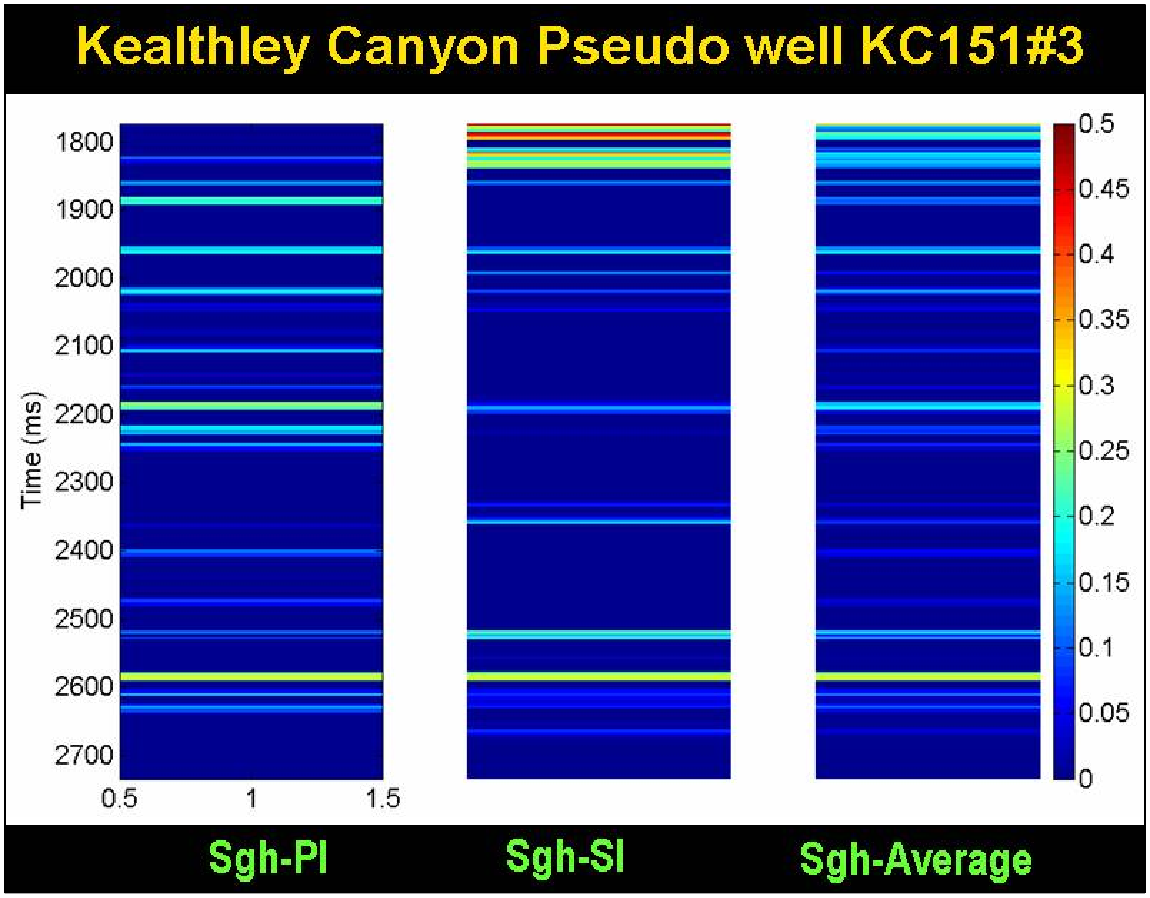
Site ID	JIP Hole	mbsf	FHPC/FC	FPC	PZOPRB	IW
AT1C	4B	307.2	20	7	3	25
ATM1	5A	30.3	2	2		10
ATM2	6A	30.2	2	2		10
ATM3	7A	30.2	2	2		10
AT2C	3B	315.5	18	7	1	22
KC1C	2B	609.2	31	7	3	29
KC3C	1B	553.3	28	7	1	29
		TOTALS	103	34	8	135

Note, Gas analysis for H_2S and hydrocarbons as needed

3.6 Task 6.0 – Data Analysis – Initial Cruise

Work under this task will consist of conducting the appropriate analysis of all data obtained during initial field activities (the April – May 2005 activities at the Atwater Valley and Keathley Canyon sites) and provide an initial Scientific Results report that details the following: a) the pre-cruise seismic interpretations and an analysis comparing those interpretations with actual findings; b) the findings of the geochemical surveys; c) the findings of the well logging efforts and analysis; c) the findings of the borehole geophysical surveys; d) the performance of various sampling devices employed; d) as well as any other appropriate results emanating from shipboard or subsequent analysis of data or samples obtained during the cruise.

Figure 3.3. Pre-cruise Hydrate Concentrations for KC 151



3.7 Task 7.0 – Technical Conference

In order to provide the scientific community with current data from the project, a workshop will be conducted to present all information obtained during the course of the project to industry, academic, government and other interested professionals. This workshop will focus on the opportunities for improving the tools and protocols for effective field investigation of hydrates in the Gulf of Mexico. The output of the workshop will be plans for DOE consideration for acting on specific recommendations arising from this workshop.

A workshop to present the findings to date is being planned for April of 2006.

3.8 Task 8.0 – Field Sampling Device Development

In addition to any specific data/tool needs identified in the Task 7 workshop the acquisition of improved technologies for the acquisition, retrieval and subsequent analysis of samples under in-situ pressure (and possibly temperature) conditions will be pursued. Pressure coring equipment will be evaluated both from the JIP membership and the development of new devices to accomplish these goals (both sample retrieval and extensive analysis of samples in systems capable of minimizing hydrate dissociation and sample alteration from its natural state).

3.9 Task 9.0 – Recommendation for Further Activities

Analysis of initial cruise findings will be used to determine the need for additional field activities to properly characterize the full range of hydrate occurrences in the Gulf. New locations will be selected and evaluation of existing geophysical and well log data will be conducted to evaluate the existence of sites or the location of favorable transects in the Gulf of Mexico that have the best potential to provide the missing data. Recommendations will be prepared for a second phase of field activities, including a description of the sites and a plan for conducting field operations.

4.0 Discussion and Results PHASE III – Follow on Field Activities and Final Reporting

Tentative tasks are provided for Task III activities, which will include the execution of a second field program as identified in Phase II/Task 9.0, and full reporting to both DOE and the broader scientific community.

4.1 Task 1.0 – Research Management Plan

Develop a work breakdown structure and supporting narrative that concisely addresses Phase III activities and includes a concise summary of activities, schedules and costs for each Phase III Task.

4.2 Task 2.0 – Project Management and Oversight

A project manager appointed by the Joint Industry Project (JIP) Recipients will manage the technical teams, contractors, and the day to day operation of the project. Project manager will report, verbally and through required reporting, on the progress of the program to the DOE and the JIP as required.

4.3 Task 3.0 – Field Activities

Conduct field operations as developed in Phase II Task 9.0 and outlined in Phase III Task 1.0.

4.4 Task 4.0 – Data Analysis

Conduct appropriate analysis of all data obtained during the Phase III cruise, integrate these data with those from the Phase II cruise, and provide a detailed Final Report on the findings and their implications. Recommend and pursue options for providing this report as a Special Volume in a manner similar to that provided from other large-scale hydrate research efforts (for example, the special volumes emanating from the Mallik programs).

4.5 Task 5.0 – Technical Conference

Conduct a technical conference to present all information obtained during the course of the project to industry, academic, government and other interested professionals.

5.0 Experimental

No experimental work was conducted during the period of this report. However, photos and drawings of some of the experimental equipment that was used on the cruise are presented in Appendix D.

6.0 Conclusions

Pre-cruise estimates of hydrate concentrations ranged up to 20% of pore space. The sediments should be mostly silts and clays with only a few possible thin sands.

The science plan is aggressive and is designed to provide more work than can be accomplished within the time estimates of the drilling plan.

Drilling plan time estimates allow for only the bare minimum of down time and drilling delays. If additional problems are encountered, the staff on the ship will have to adjust the science plan to remain within the budget.

Only experiments that need to be conducted on core as soon as possible will be done on the ship. The balance of the required experiments will be conducted at shore-based facilities.

The plan calls for the testing and first use of the pressurized measurement vessel developed by Georgia Tech. The vessel requires the use of transfer vessels and core manipulators that were developed and tested in the lab but this will be the first use of the equipment in an actual cruise.

7.0 References

No external references were used for this report.

8.0 Appendix

Appendix A. Science Plan

Table A1. Hole Locations and Target Depths

Name	PROPOSED HOLE LOCATION	INLINE	TRACE	X	Y	LAT	LONG	2WT WB	DEPTH WB	2WT TD	DEPTH TD	DEPTH BML TD
KC3L	KC151 #3 Open	5700	20248	1643513.88000	9733112.29000	26° 49' 22.6" N	92° 59' 25.8" W	1.782	4375	2.407	6190	1815
KC1L	KC151 #1 Open	5700	20280	1644827.03010	9733112.40830	26° 49' 22.6" N	92° 59' 11.3" W	1.752	4301	2.435	6300	1999
AT2L	AT13 #2 Shell	2615	6997	901438.18940	10148521.86390	27° 56' 49.4" N	89° 17' 21.6" W	1.712	4203	2.100	5238	1035
AT1L	AT14 #1 BHP	2562	7064	904181.44430	10145035.55470	27° 56' 15.4" N	89° 16' 50.3" W	1.722	4228	2.100	5236	1008
AT1C	AT14 #1 BHP	2562	7064	904181.44430	10145035.55470	27° 56' 15.4" N	89° 16' 50.3" W	1.722	4228	2.100	5236	1008
AT2C	AT13 #2 Shell	2615	6997	901438.18940	10148521.86390	27° 56' 49.4" N	89° 17' 21.6" W	1.712	4203	2.100	5238	1035
KC3C	KC151 #3 Open	5700	20248	1643513.88000	9733112.29000	26° 49' 22.6" N	92° 59' 25.8" W	1.782	4375	2.407	6190	1815
KC1C	KC151 #1 Open	5700	20280	1644827.03010	9733112.40830	26° 49' 22.6" N	92° 59' 11.3" W	1.752	4301	2.435	6300	1999
ATM1	AT14 #1 BHP	2556	7073	904551.77030	10144646.35110	27° 56' 11.62" N	89° 16' 46.09" W		4257			159
ATM2	AT14 #5 BHP	2556	7071	904470.29280	10144646.25410	27° 56' 11.6" N	89° 16' 47.0" W	1.715	4210	1.829	4505	99

Figure A1. Drill Site Location Map

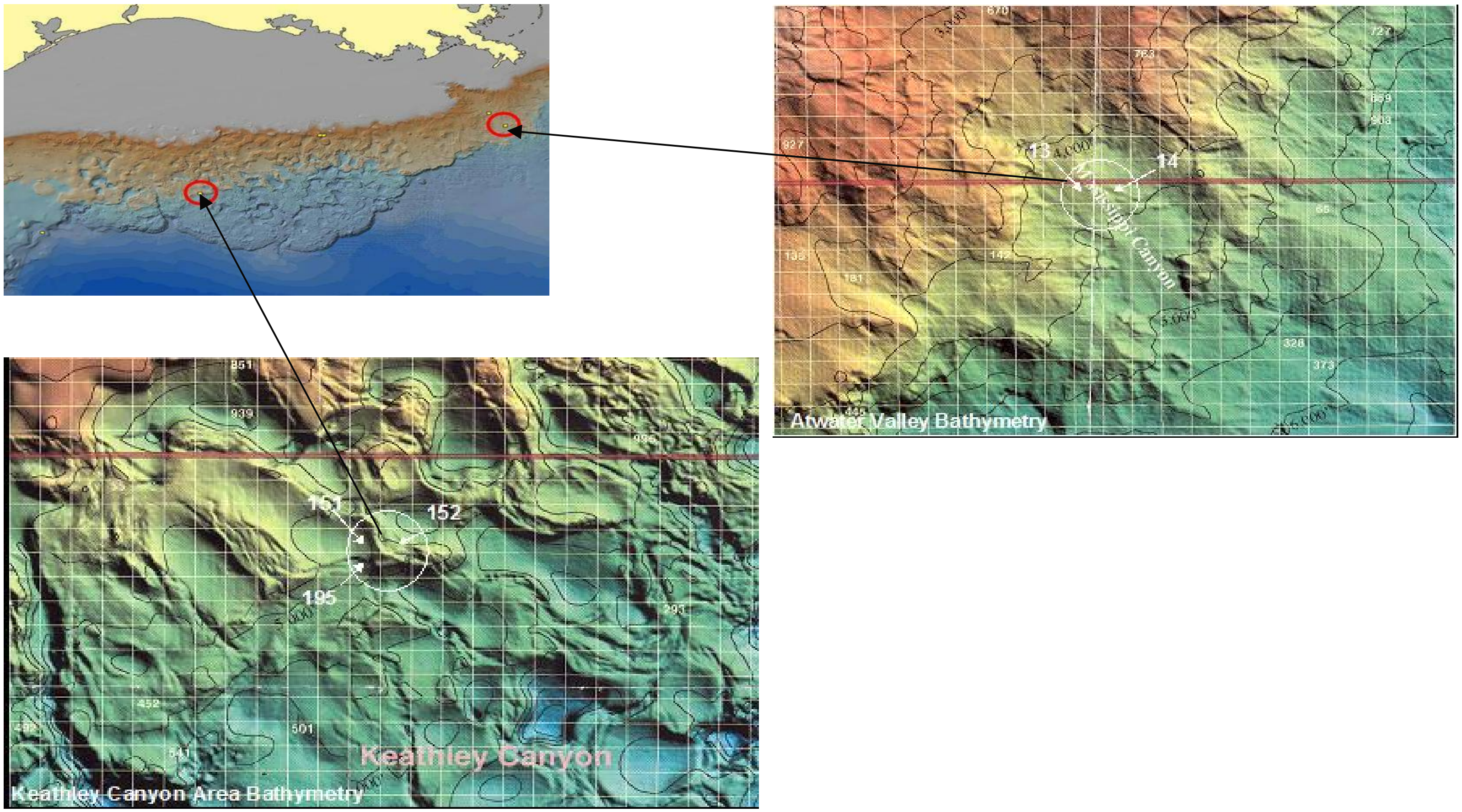


Figure A2. Atwater Valley Seismic Plot

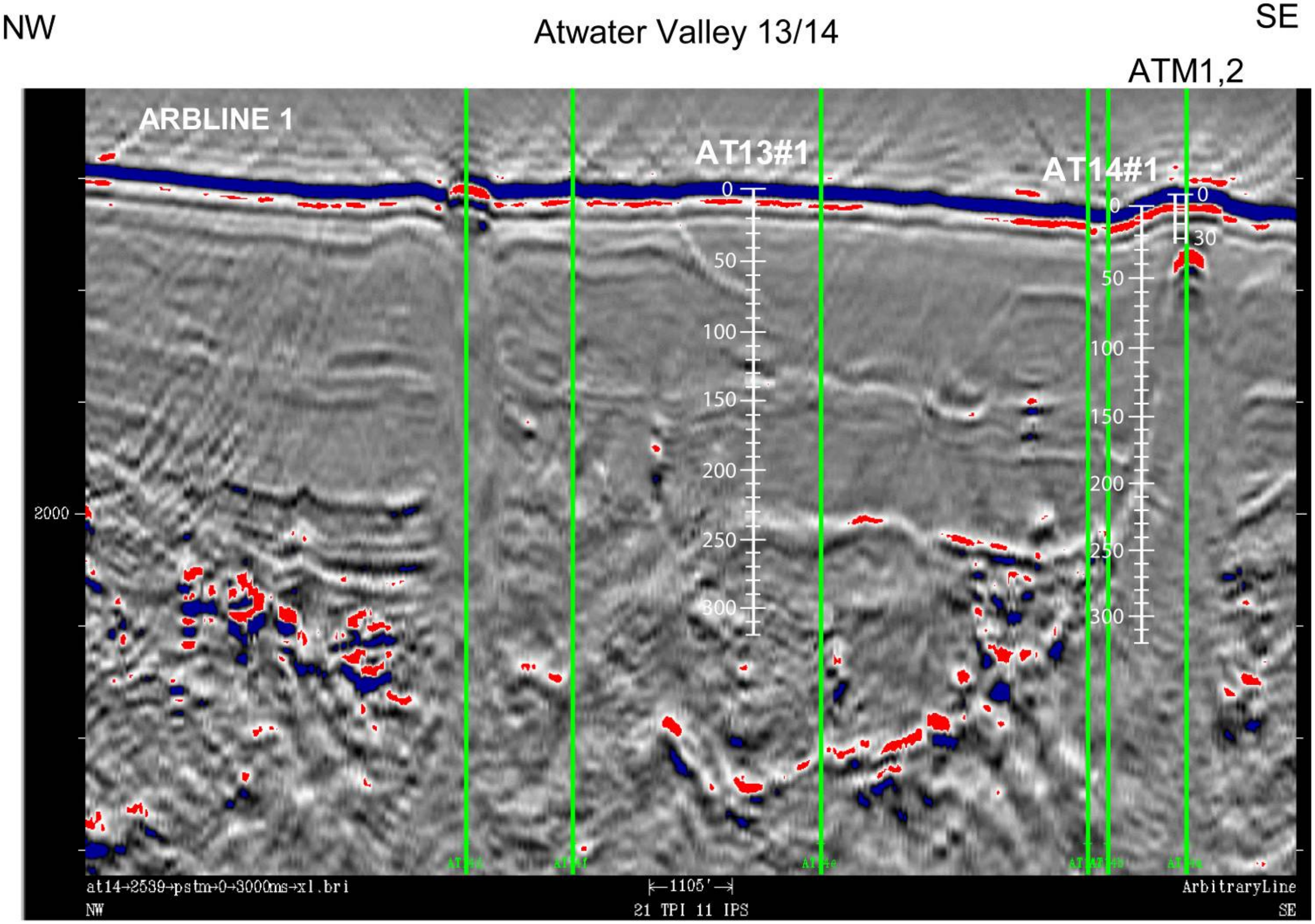


Figure A3. Keathley Canyon Seismic Plot

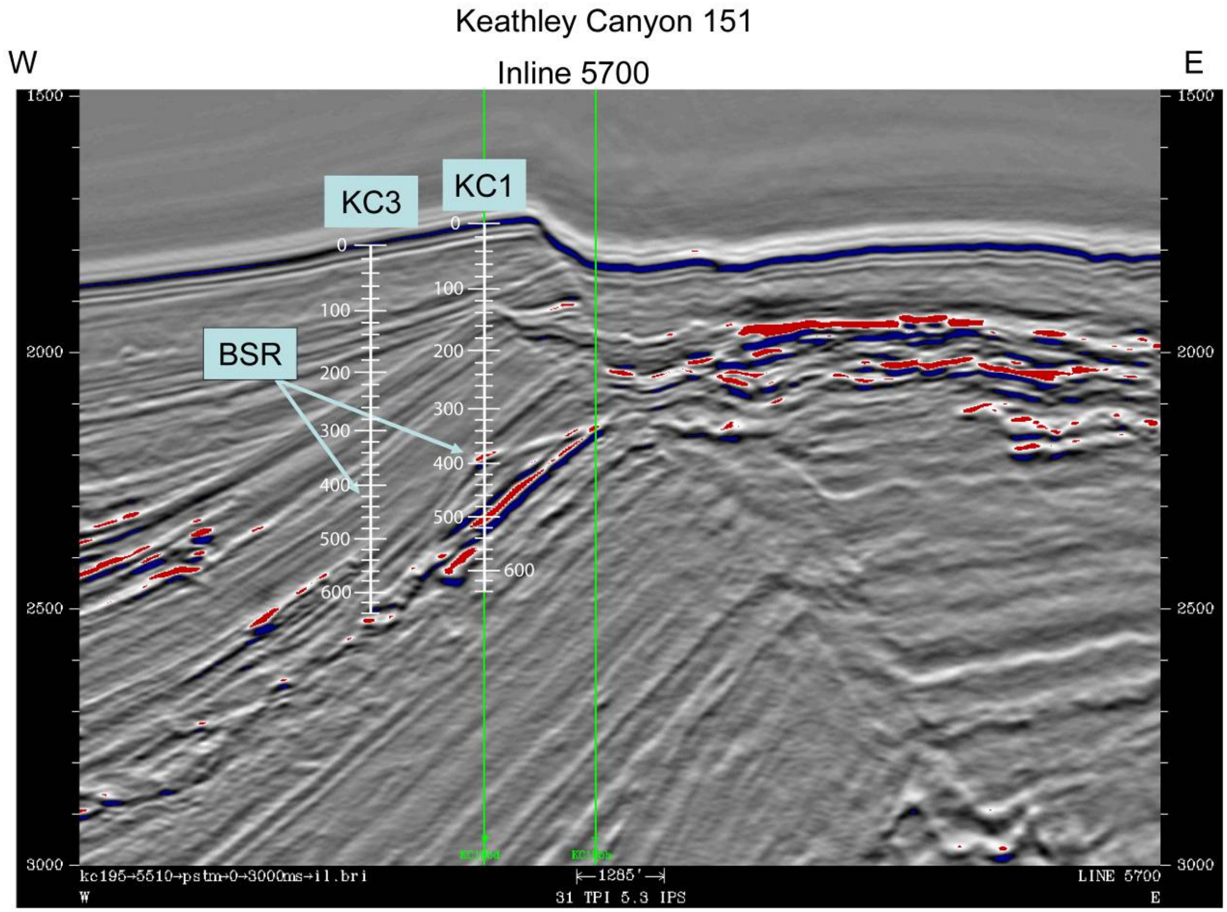


Table A2. Test Matrix

Test	Area	Specific test or value	Summary: Ship LP	Summary: Ship HP	Summary: Shore LP	Summary: Shore HP	Total
1	Mechanical	Stress-strain curves			3	1	4
2		Tensile strength			0	0	0
3		Shear Strength	1		2	1	4
4		Compressive strength			1	2	3
5		Young's moduli			2	1	3
6		Shear moduli			2	1	3
7		Bulk moduli			2	1	3
8		Poison's ratio			2	1	3
9		failure/stability envelopes			1	0	1
10		permeability			3	0	3
11		shear strength (minivane)	1		3	0	4
12		Triaxial Compression	1		1	0	2
13		Constraint modulus			1	0	1
14					0	0	0
15	Kinetics	Dissociation	1	1	1	1	4
16		Kinetic rate constants			0	0	0
17					0	0	0
18	Thermal	Thermal conductivity			4	1	5
19		Thermal diffusivity			0	0	0
20		Heat capacity			0	0	0
		IR imaging	1				
21					0	0	0
22	Seismic	P and S-wave velocities		1	1	2	4
23		acoustic impedance			1	1	2
24					0	0	0
25	Electrical	Resistivity		1	2	2	5
26		real permittivity at microwave frequencies			1	0	1
		magnetic susceptibility		1			
27					0	0	0
28	Geological	Distribution of hydrates within sediments			1	1	2
29		Pore filling			1	1	2
30		Pore Pressure		1	0	0	1

31		In-situ Temperature		1	0	0	1
32		Optical observation / analyses			1	0	1
33		Hydrate Type (Raman spectroscopy)			1	0	1
34					0	0	0
35	Formation Water	PH		1	3	0	4
36		Complete analysis			1	0	1
37		Pore water extraction		1	2	0	3
38		Electr. conductivity / ionic concentration			1	0	1
		Halogens, Ba, PO4					
39					0	0	0
40	Sediment Description	Chemical analysis			0	0	0
41		Grain size			3	0	3
42		water content			3	0	3
43		grain density			2	0	2
44		specific surface area			2	0	2
45		Density		1	2	0	3
46		Clay mineralogy			1	0	1
47		organic content			1	0	1
48	Gas analysis	C1-C5		1	2	1	4
49		C Isotope			1	1	2
50					0	0	0
51	Biological	Methanogens			0	0	0
		Clone library			0	0	0
52					0	0	0

APPENDIX B. Drilling Plan

Table B1. Drilling Time Table

		Base Case (2 KC + 2 AT + 2 mounds @ AT)		
	Activity	**Depth (m-MD)**	**Task Time (hr)**	**Cumulative Time (d)**
AT #2L	Move rig to Atwater Valley 14	0	33.0	1.4
	Position Rig on location in A.V. Establish position. RIH w/ LWD assembly	1,281	24.6	2.4
	Drill 8 1/2" hole with LWD tool string to 315m BML (~1600m MD)	1,600	16.3	3.1
	Sweep hole & POOH above mudline	1,600	3.9	3.2
	POOH to surface & L/D BHA			3.2
	RIH & set cement plugs			3.2
	POOH with cmt stinger			3.2
	M/U LWD BHA. RIH to mudline			3.2
AT #1L	Reposition Rig to next location in A.V. Set sea bed frame	1,289	4.4	3.4
	Drill 8 1/2" hole with LWD tool string to 307 m BML (~1599 m MD)	1,599	15.8	4.1
	Sweep hole & POOH back to surface. L/D LWD tools.	1,599	22.7	5.0
AT #1C	Position on Location & prep for coring; RIH to mudline; Core top 90'	1,289	18.9	5.8
	Begin drilling & spot coring (10m per 30 m) with FHPC to 183m BML	1,472	16.1	6.5
	Take 7 pressure cores	1,472	9.6	6.9
	Take 15' samples from 183- 244 m BML; Drill to TD at 1599 m MD	1,599	15.4	7.5
	In-situ temperatures	1,599	3.3	7.7
	Take 3 Piezoprobe tests	1,599	14.0	8.2
	Circ, ream cored hole, POOH to mudline, R/U wireline	1,599	5.5	8.5
	Log open hole with DSI. Pull DP above mudline	1,599	14.3	9.1
Mound Cores	Move to mound & establish position for surface cores	0	4.4	9.3
	Take 2 ea FHPC & FPC cores & in-situ temps	0	11.1	9.7
	Move to next mound & repeat 2 FHPC & 2 FPC & temps	0	13.3	10.3
	Move to next mound & repeat 2 FHPC & 2 FPC	0	0.0	10.3
AT#2C	Position on Location & prep for coring; RIH to mudline; Core top 90'	1,281	7.4	10.6
	Drill & spot core down to 244 m BML.	1,525	23.3	11.6
	Take 30' samples from 244m to 315 m BML	1,600	9.6	12.0
	Take 7 pressure cores	1,600	9.6	12.4
	In-situ temperatures	1,600	2.1	12.4
	Take piezoprobe test at TD	1,600	3.6	12.6
	Circ, ream cored hole, POOH to mudline; R/U wireline	1,600	5.5	12.8
	Log open hole with DSI & VSP. Pull DP above mudline	1,600	30.8	14.1
	POOH & L/D core assembly; Ballast Up	1,600	16.9	14.8
KC #3L	Move from AT 14 to KC 151 sites	0	36.7	16.3
	Position on Location & prep for drilling; RIH to mudline	0	25.0	17.4
	Drill 8 1/2" hole with LWD tool string to 553 m BML (~1887m MD)	1,333	28.5	18.6
	Sweep hole & POOH above mudline	1,890	3.3	18.7

KC #1L	Reposition Rig to next location in K.C. Set sea bed frame	1,311	4.4	18.9
	Drill 8 1/2" hole with LWD tool string to 609 m BML (~1920 m MD)	1,920	31.4	20.2
	Sweep hole & POOH to surface with LWD tools. L/D same.	1,920	17.7	20.9
KC #1C	Position on Location & prep for coring; RIH to mudline; Core top 90'	1,311	30.0	22.2
	Begin drilling & spot coring with FHPC to 361m BML	1,672	40.1	23.9
	Take 7 pressure cores	1,672	9.6	24.3
	Take 15' samples from 361-422 m BML (30m +/- BSR) & drill to TD at 1923 MD	1,923	31.2	25.6
	In-situ temperatures	1,923	4.2	25.7
	Take total of 3 Piezoprobe tests	1,923	14.0	26.3
	Circ, ream cored hole, POOH to mudline	1,923	11.0	26.8
	Log open hole with DSI & VSP. pull DP above mudline	1,923	33.0	28.2
KC #3C	Position on Location & prep for coring; RIH to mudline; Core top 90'	1,333	7.4	28.5
	Drill & spot core (60' per 200') to 410m BML	1,743	43.0	30.3
	Take 7 pressure cores	1,743	9.6	30.7
	Take 15' samples from 410-471m BML; Drill to TD at 1890m	1,890	26.4	31.8
	In-situ temperatures	1,890	4.6	31.9
	Take Piezoprobe tests	1,890	3.6	32.1
	Circ, ream cored hole, POOH to mudline, pull center of bit	1,890	7.7	32.4
	Log open hole with DSI	1,890	13.2	33.0
	POOH & L/D core assembly; Ballast Up	1,890	17.3	33.7
	Demobilize to Mobile	0	33.0	35.1

Table B2. Well Planning Checklist as of 21 February 2005

	Activity	Estimated Completion Date	Status
1.0	**Health, Environment, Safety**		
1.01	Safety Plan/Working Document	4-Mar-05	ongoing
1.02	Emergency Response Matrix and Plan	11-Feb-05	ongoing
1.03	Operational HAZOP	9-Feb-04	***Complete***
1.04	Risk Assessment / HAZID	19-Feb-05	Not started
1.05	Company / BU responsibility	18-Feb-05	ongoing
1.06	Reporting structure	11-Feb-05	ongoing
1.07	Environmental Impact Assessment	15-Apr-04	***Complete***
1.08	Waste Disposal	15-Mar-04	***Complete***
1.09	Rig Oil Spill Plan	15-Mar-04	***Complete***
1.10	Environmental Responsibilities	4-Feb-05	***Complete***
1.11	Emissions Reporting	19-Feb-05	***Complete***
1.12	Confirm Service Co Prequalifications	1-Apr-04	***Complete***
1.13	Contractor Safety Plans	1-Apr-04	***Complete***
1.14	Offshore Survival Training	28-Oct-04	***Complete***

1.15	Contractor MSDS sheets, rig, mud, cmt, etc	15-Mar-05	Not started
1.16	Coast Guard Emergency Evacuation Plan (EEP)	1-Feb-05	ongoing
1.17	Contractor JSA Review	1-Feb-05	ongoing
1.18	Notify ETC Management of operations	4-Mar-05	Not started

2.0 Permitting & Regulatory Compliance

2.01	NPDES permits	15-Dec-04	***Complete***
2.02	Emissions Permits	16-Feb-05	***Complete***
2.03	NPDES permit compliance	16-Feb-05	***Complete***
2.04	MMS Districting	4-Nov-03	***Complete***
2.05	Permit Checklist	1-Feb-05	ongoing
2.06	Geologic Research Permits	20-Jan-05	***Complete***
2.07	MMS Permit to drill	19-Feb-05	***Complete***
2.08	Drilling Plan	15-Jan-05	***Complete***
2.09	Publishing of Notice for CFR 251	31-Mar-04	***Complete***
2.10	Environmental Plan	15-Apr-04	***Complete***
2.11	P&A Permit	15-Mar-05	Not Started
2.12	APD	19-Feb-05	ongoing
2.13	ROV Survey	1-Jan-05	ongoing
2.14	MMS regulations	1-Feb-05	ongoing
2.15	Approvals for Installing PMS	1-Feb-05	Not Started
2.16	Obtain regs for rig and vessel movement & stationing	15-Oct-04	***Complete***
2.17	Obtain regs for helicopter movement	15-Jan-05	***Complete***
2.18	Communications Permit, radio or sat.	30-Jun-03	***Complete***
2.19	Disposal of domestic rig trash, etc. requirements	18-Feb-05	ongoing
2.20	Review Rig Contractor's Compliance action plans	1-Mar-05	Not Started
2.21	Data sharing with MMS under CFR 251 permitting rules	15-Jan-05	***Complete***
2.22	Coastal Zone Management	4-Feb-05	***Complete***
2.23	Atwater Valley EEP	15-Feb-05	***Complete***
2.24	Keathley Canyon EEP	15-Feb-05	***Complete***

3.0 Contracts & Service Orders

3.01	Bottom Survey	16-Feb-04	***Complete***
3.02	Cementing	1-Dec-03	***Complete***
3.03	Communications	1-Jul-03	***Complete***
3.04	Computers	1-Jul-03	***Complete***
3.05	Coring	18-Sep-03	***Complete***
3.06	Core Evaluation / Study	31-Oct-03	***Complete***
3.07	LWD	11-Mar-05	Ongoing
3.08	Drill Rep Assignment	4-Mar-05	Ongoing
3.09	Drilling Fluids	17-Sep-03	***Complete***
3.10	Kinley Cutter / Gripper	4-Mar-05	Ongoing

3.11	Log Processing	17-Jan-05	***Complete***
3.12	H2S & Safety services	12-Feb-04	***Complete***
3.13	Helicopter Services	1-Mar-04	***Complete***
3.14	Pipe Recovery & Fishing	11-Mar-05	Ongoing
3.15	Tubular running / Pipe Handling	10-Feb-04	***Complete***
3.16	Vessels	1-Mar-05	***Complete***
3.17	Positioning	30-Jun-03	***Complete***
3.18	ROV	1-Feb-05	***Complete***
3.19	Supply Base and Material Consultant	1-Mar-04	***Complete***
3.20	Wireline logging	11-Mar-05	Ongoing
3.21	VSP	11-Mar-05	Ongoing
3.22	VSP vessel & crane for source	1-Mar-05	Not Started
3.23	Marine Mammal Observers	4-Mar-05	Not Started
3.24	Core Handling Procedures	14-Feb-05	***Complete***
3.25	Core Handling Equipment/Personnel	1-Mar-04	***Complete***
3.26	Ice Maker	1-Mar-04	***Complete***
3.27	DP Inspection	25-Mar-05	Ongoing
3.28	Drilling Jars	4-Mar-05	Ongoing
3.29	**Purchase Orders**	**(Place Orders)**	
3.30	Kinley Cutter	25-Nov-03	***Complete***
3.31	Mud Chemicals	1-Mar-05	Ongoing
3.32	Cement Chemicals	1-Mar-05	Ongoing
3.33	Bits	4-Mar-05	ongoing
3.34	DOT approved containers for core transport	1-Mar-04	***Complete***
3.35	Additional pressure chambers for Hyace coring system	1-Dec-03	***Complete***

4.0	**Rig**		
4.01	Contract Award	1-Jul-03	***Complete***
4.02	Rig Negotiations	22-Sep-03	***Complete***
4.03	Planning Service Order	8-Oct-03	***Complete***
4.04	Project Execution Service Order	25-Mar-05	Not started
4.05	Rig Contract Amendment #2	11-Mar-05	Not started
4.06	Rig Contract Amendment	5-May-04	***Complete***
4.07	Letter Agreement for start date	1-Aug-04	***Complete***
4.08	Change of Rig Assignment	1-Feb-05	***Complete***
4.09	Equipment Requirements		
4.10	Divert, mud gas sep, safety valves, chicksans	27-Oct-03	***Complete***
4.11	Review fishing tool inventory	1-Nov-03	***Complete***
4.12	Review drill string, BHA,	1-Nov-03	***Complete***
4.13	Review bulk system	26-Sep-03	***Complete***
4.14	Hydraulics / Pump capabilities	30-Nov-03	***Complete***

4.15	Wireline lubricator	15-Dec-03	***Complete***
4.16	Rig Inspection	26-Feb-05	ongoing
4.17	Rig Orientation	1-Mar-04	Not started
4.18	Rig De-Mob	1-Apr-03	***Complete***
4.19	Mud Pumps	25-Feb-05	ongoing
4.20	Mud Pits	25-Feb-05	ongoing
4.21	Communications	15-Jan-04	***Complete***
4.22	Dry Dock	31-Jan-05	N/A
4.23	Rig Schedule	15-Mar-05	Pending
4.24	Rig Visit	21-Jan-05	ongoing
4.25	Alternative Rig	1-Feb-04	***Complete***

5.0 Project Management

5.01	Delegation of Authority	1-Mar-04	***Complete***
5.02	Preliminary Rig Visit	1-Jul-03	***Complete***
5.03	Rig Operations Visit	25-Sep-03	***Complete***
5.04	Work group meeting	30-Oct-03	***Complete***
5.05	JIP approval of program;	7-Nov-03	***Complete***
5.06	Document BP/LL for project	1-Jun-05	Ongoing
5.07	JIP participation in planning / operations	15-Feb-05	***Complete***
5.08	JIP dissection of program	24-Mar-04	***Complete***
5.09	JAPEX operational visit	29-Mar-04	***Complete***
5.10	JIP Program Meeting	17-Jun-04	***Complete***
5.11	Office Based Permitting Support	1-Apr-04	***Complete***
5.12	AFE	1-Mar-05	***Complete***
5.13	Rig Site Supervision / Personnel Assignments	1-Mar-05	ongoing
5.14	Decision Matrix	18-Mar-05	ongoing
5.15	Weather Window Evaluation	23-Jun-04	***Complete***
5.16	Service Company Evaluations	1-Jul-05	Not started
5.17	Definition of project success	1-Mar-05	ongoing
5.18	Time table for Data to be held with in JIP	1-Mar-05	Not started

6.0 Drilling Program

6.01	Location selection	3-Feb-04	***Complete***
6.02	Pore Pressure/Frac Grad Analysis	16-Jan-04	***Complete***
6.03	Shallow Hazard Assessment	16-Jan-04	***Complete***
6.04	Offset Well Review	1-Apr-04	***Complete***
6.05	Detailed Strat column	1-Aug-04	***Complete***
6.06	Finalize project program	15-Sep-04	***Complete***
6.07	Final drilling procedures	18-Mar-05	ongoing
6.08	Drilling Fluids Design	1-Feb-04	***Complete***
6.09	Hole Size	15-Nov-03	***Complete***
6.10	Prelim. Drlg Prog (Hyd, Fluids, DS, BHA, etc)	15-Nov-03	***Complete***

6.11	Abandonment Program	28-Jul-03	***Complete***
6.12	Abandonment Procedure	15-Jan-05	***Complete***
6.13	Cement and additive requirements	9-Apr-04	***Complete***
6.14	Surveying	30-Nov-03	***Complete***
6.15	Coring scope of work & required equipment	4-Feb-04	***Complete***
6.16	Pressure & Temperature	4-Feb-04	***Complete***
6.17	Peer Review of Drilling Plan	9-Feb-04	***Complete***
6.18	Engineering Documentation	1-Mar-05	ongoing
6.19	Positioning	4-Mar-05	ongoing
6.20	Well bore stability Model	1-Apr-05	ongoing
6.21	Review of Drilling Program	1-Mar-05	Not started
6.22	Formation Evaluation requirements	7-Nov-03	***Complete***

7.0 Core Handling & Analysis

7.01	Handling Area	1-Apr-04	***Complete***
7.02	Core handling strategy	4-Mar-05	ongoing
7.03	Onsite Core Analysis	1-Mar-05	ongoing
7.04	Liquid nitrogen containers, storage and supply	1-Aug-04	ongoing
7.05	Infrared camera	1-Feb-05	***Complete***
7.06	Storage chambers for FPC cores	19-Dec-03	***Complete***
7.07	Priority list of data gathering	1-Feb-05	Not started
7.08	Pressurized Core Transfer	1-Feb-05	***Complete***
7.09	Georgia Tech - GeoTek Measurements	1-Mar-05	ongoing
7.10	GeoTek Post Cruise Core Splitting	1-Jun-05	ongoing
7.11	Pressurized Subsampling	1-Oct-04	***Complete***
7.12	Core barrel temperature sensor	1-Mar-05	ongoing
7.13	Gas Chromatograph	1-Aug-04	ongoing

8.0 Core Transport

8.01	Core Transport	1-Jun-04	***Complete***
8.02	DOT approval of transport containers	1-Jun-04	***Complete***
8.03	DOT approval of modified PARR vessels	1-Mar-05	Not Started
8.04	DOT approval to transport Hyacinth core containers	1-Feb-05	***Complete***

9.0 Operations

9.01	Anadrill rig up / hydraulics / tool handling.	1-Apr-04	***Complete***
9.02	Equipment Deck Spread	15-Mar-05	ongoing
9.03	Seafloor monitoring	15-Mar-05	***Complete***
9.04	Personnel Management	1-Feb-05	***Complete***
9.05	Rig site organization / responsibilities	4-Mar-05	ongoing
9.06	Rigsite Load out List	15-Mar-05	Not started
9.07	Rig Site Reporting	15-Mar-05	ongoing
9.08	Prespud Meeting	18-Mar-05	Not started

9.09	Logistics	1-Mar-05	ongoing
9.10	Standby boat	1-Mar-05	***Complete***
9.11	Rig Move meeting	18-Mar-05	Not started
9.12	Confirm Power Requirements	26-Sep-03	***Complete***
9.13	Determination of max set down weight	1-Aug-04	***Complete***
9.14	Effect of VIV on aluminum DP and LWD performance	1-Oct-03	***Complete***
9.15	Gas detection	7-Nov-03	***Complete***
9.16	Guideline Funnel	1-Feb-04	***Complete***
9.17	Water, fuel and Logistical requirements	1-Mar-05	***Complete***
9.18	Slings & containers for transport of equipment	1-Mar-05	ongoing
9.19	Operational Contingency Plans	1-Mar-05	ongoing
9.20	Sonic Data retrieval	1-Jan-05	***Complete***
9.21	Shallow flows - oil, water, gas	23-Dec-04	***Complete***
9.22	ROV failure	1-Mar-04	ongoing
9.23	H2S Contingency plan for cores	15-Mar-04	***Complete***
9.24	Stuck pipe	23-Dec-04	***Complete***
9.25	Stuck wireline / in hole or re-entry to DP	23-Dec-04	***Complete***
9.26	Core handling	11-Mar-05	ongoing
9.27	Evacuation	23-Jan-05	***Complete***
9.28	P&A Contingency	23-Dec-04	***Complete***
9.29	Free Gas Logged on LWD	23-Dec-04	***Complete***
9.30	Oil Spill	in place	***Complete***
9.31	Weather	1-Feb-05	Not started
9.32	Logistics Coordinator	1-Sep-04	***Complete***

10.0 Logging (Wireline & LWD)

10.01	Logging Program	7-Nov-03	***Complete***
10.02	Wireline logging compensation	1-Mar-05	***Complete***
10.03	W/L logging & LWD scope of work	7-Nov-03	***Complete***
10.04	Drift sonic tool through BHA	1-Aug-04	***Complete***
10.05	NMR low flowrate test	1-Feb-05	***Complete***
10.06	VSP Program	1-Feb-05	***Complete***
10.07	VSI historical reports	4-Mar-05	Not started
10.08	VSP cost	15-Jan-05	***Complete***
10.09	Seismic source vessel	1-Feb-05	***Complete***
10.10	Marine Mammal Observers	4-Mar-05	ongoing
10.11	Quadrapole Sonic LWD	15-Dec-04	***Complete***

11.0 Seafloor Monitoring Station

11.01	Permanent Monitoring System	1-Nov-04	***Complete***
11.02	Budget for Engineering	1-Aug-04	***Complete***
11.03	Interface wireline disconnect with sensor array	1-Feb-05	***Complete***
11.04	Anchoring of array	1-Feb-05	***Complete***

11.05	Dummy run in shallow water to test system	???	Not started
11.06	Permitting for arrays on sea floor	???	Not started
11.07	Design of outer sheath	???	Not started
11.08	Contingency for malfunction of equipment	1-Feb-05	Not started
11.09	Peer assist for system installation	1-Feb-05	Not started

12.0 Other Miscellaneous Equipment

12.01	Cooler inserts for transporting the Parr vessels	20-Feb-05	***Complete***
12.02	Coolers for transporting pressurized core containers	20-Feb-05	***Complete***
12.03	Coveralls for science team & drilling team	1-May-04	***Complete***
12.04	Pneumatic drills for core handling area	1-Feb-05	***Complete***
12.05	Hydrates Team shirts/hats	1-Mar-05	Not started
12.06	Rags	1-Mar-05	***Complete***
12.07	Gloves	1-Mar-05	***Complete***
12.08	Safety Glasses	1-Feb-05	***Complete***
12.09	Boots for Science team members	1-Mar-05	***Complete***
12.10	Hard Hats	1-Mar-05	***Complete***
12.11	Cryogenic gloves	1-Mar-05	***Complete***
12.12	Face shields	1-Mar-05	***Complete***

13.0 Science Plan

13.01	Geologic / Science Program	1-Mar-05	ongoing
13.02	Temperature measurements	28-Feb-05	***Complete***
13.03	Data Management Plan	15-Mar-05	Not Started
13.04	ROV sampling	4-Mar-05	ongoing
13.05	Science Plan Spreadsheet	1-Dec-04	***Complete***
13.06	Supply List	1-Dec-04	***Complete***
13.07	Carver lab press	1-Jul-04	***Complete***
13.08	Miscellaneous supplies	1-Feb-05	***Complete***

APPENDIX C. Water Testing Plan

Figure C1. Shipboard Water Testing Flowchart

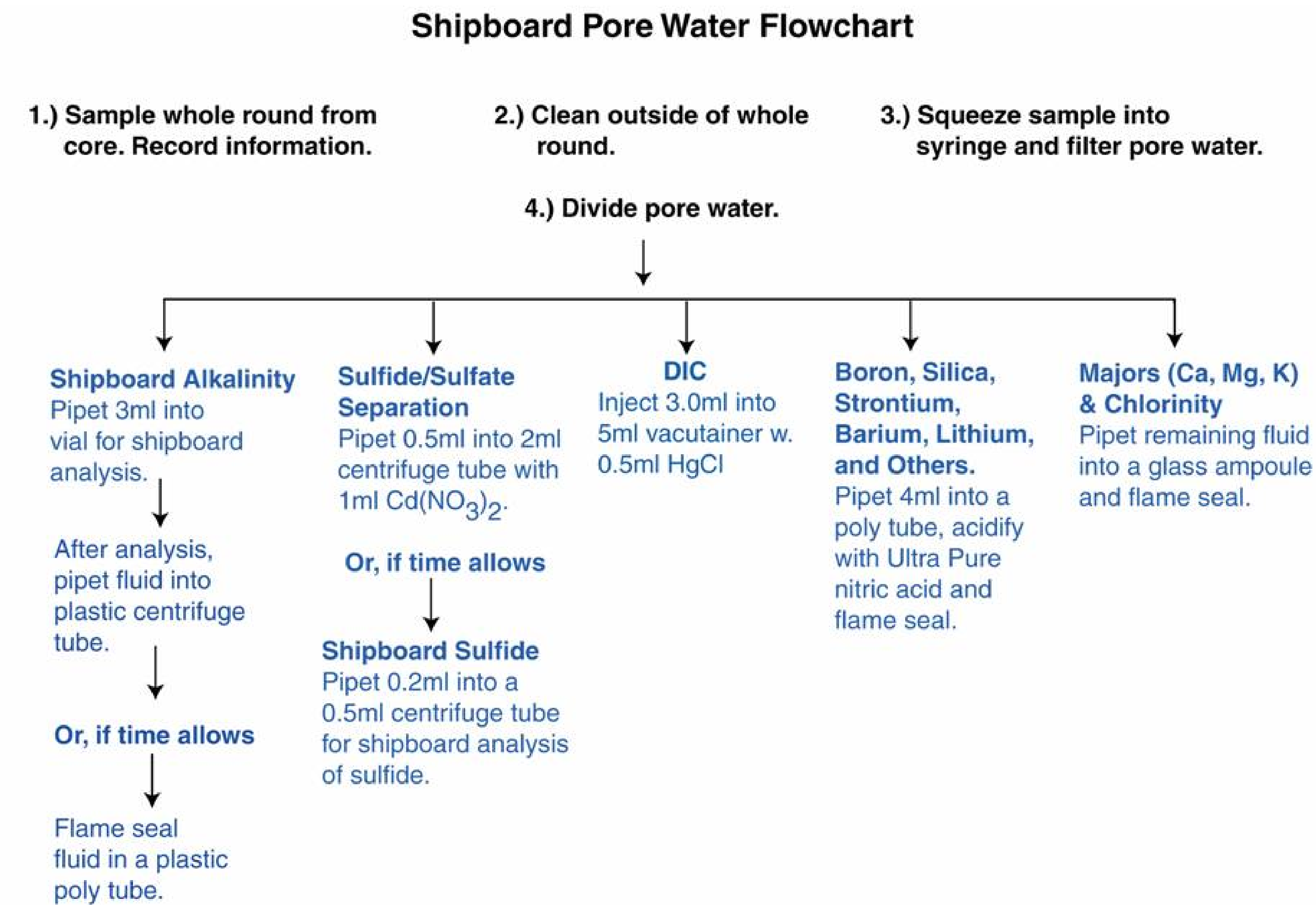
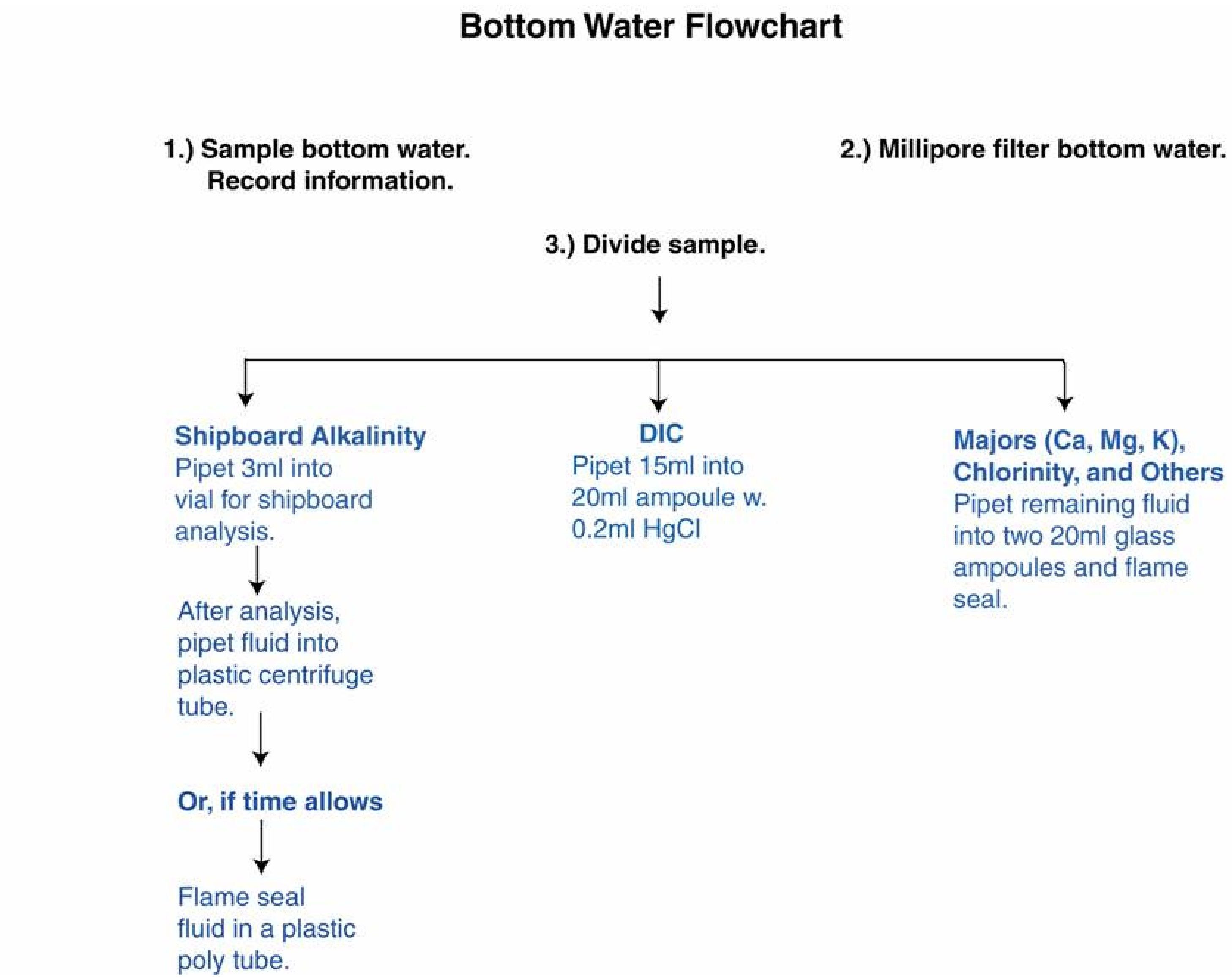


Figure C2. Bottom Water Testing Flowchart



APPENDIX D. Drawings and Photos of Experimental Equipment

Figure D1. Portable X-Ray System for Geologic Core

- **Microfocal X-ray Source**

  45–130 kV, 0.5mA

- **Cylindrical Sample**

  1.5 m × 9.5 cm

- **Core rotated on vertical axis**
- **15 cm image intensifier**
- **X-ray filter for multi-energy scanning**
- **Attenuation compensator**
- **Cabinet safe**
- **Resolution 200μm**

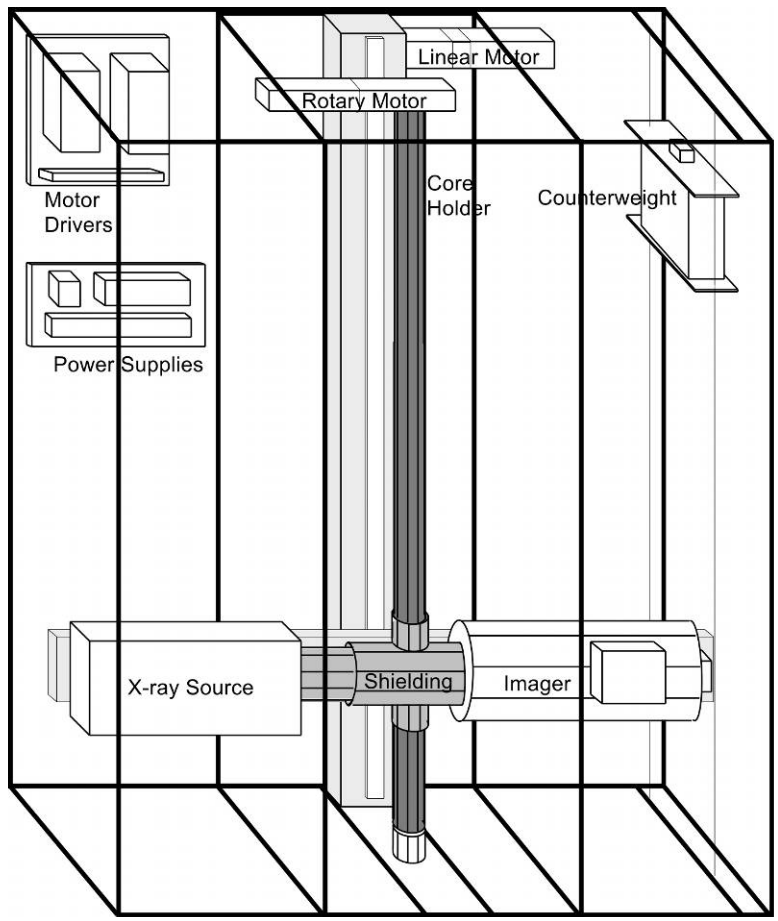


Figure D2. Pressure Coring Equipment

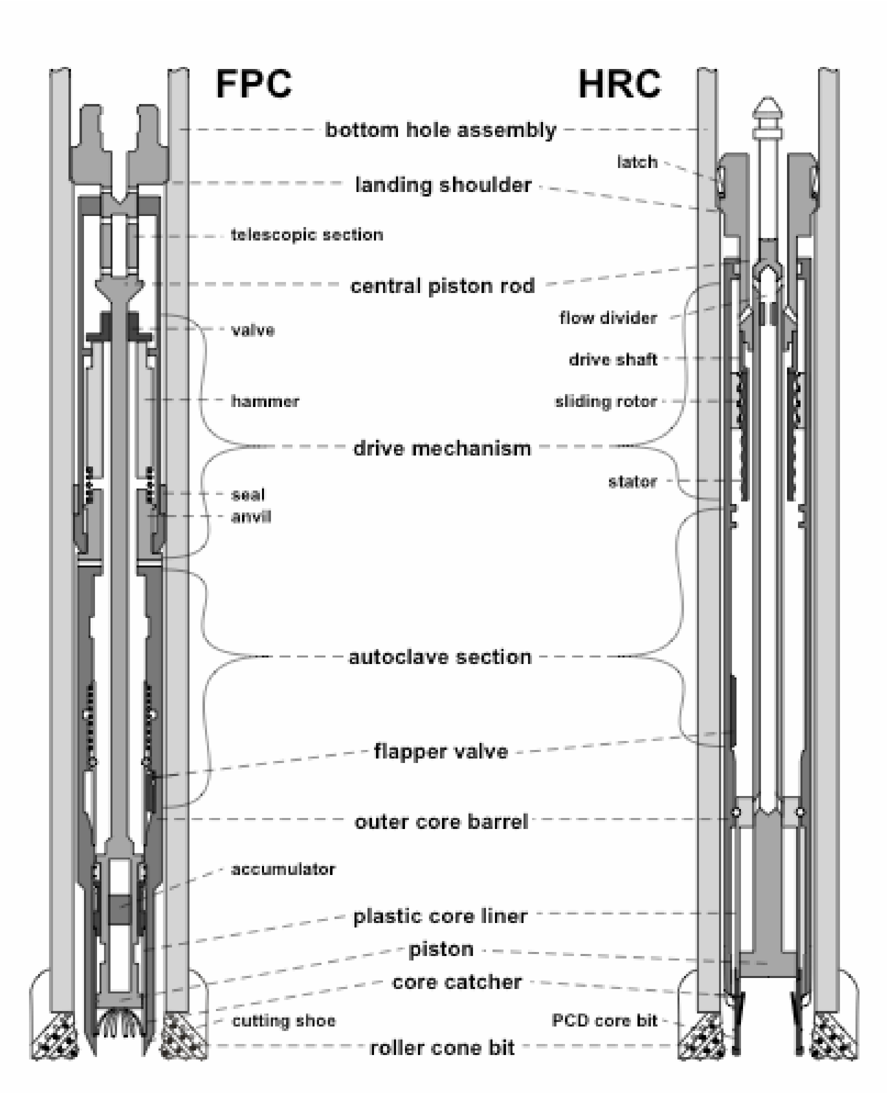
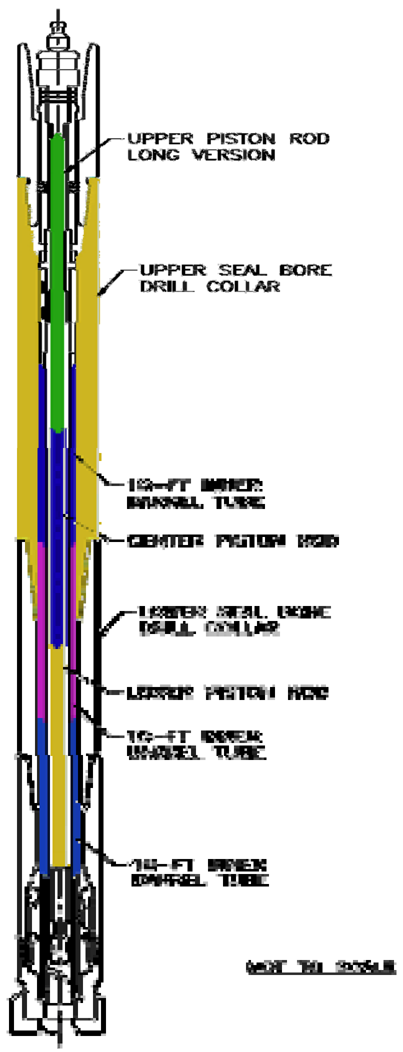


Figure D3. Conventional Coring Equipment

FHPC



FC

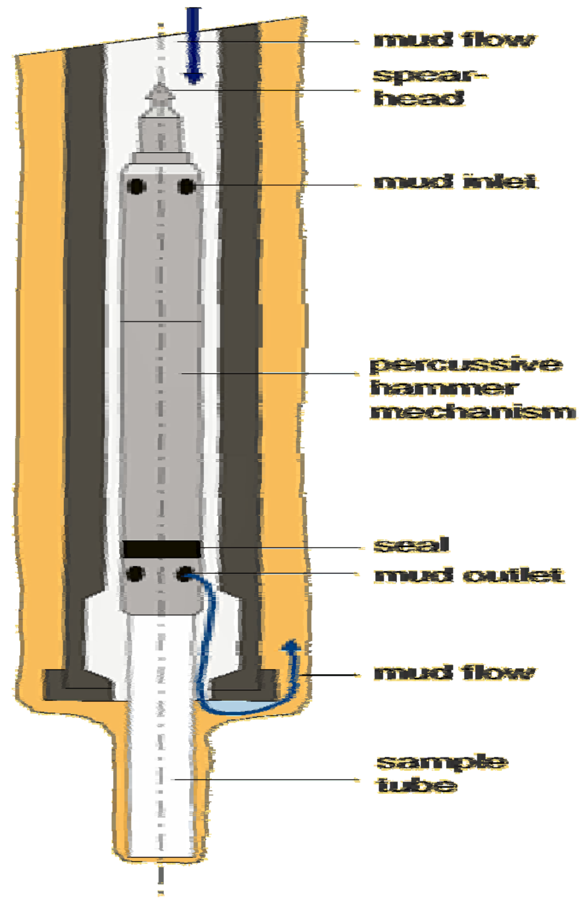


Figure D4. Core Transfer and Cutting Equipment

Pressure Core Cutting and Transfer

Pressure Core Transfer

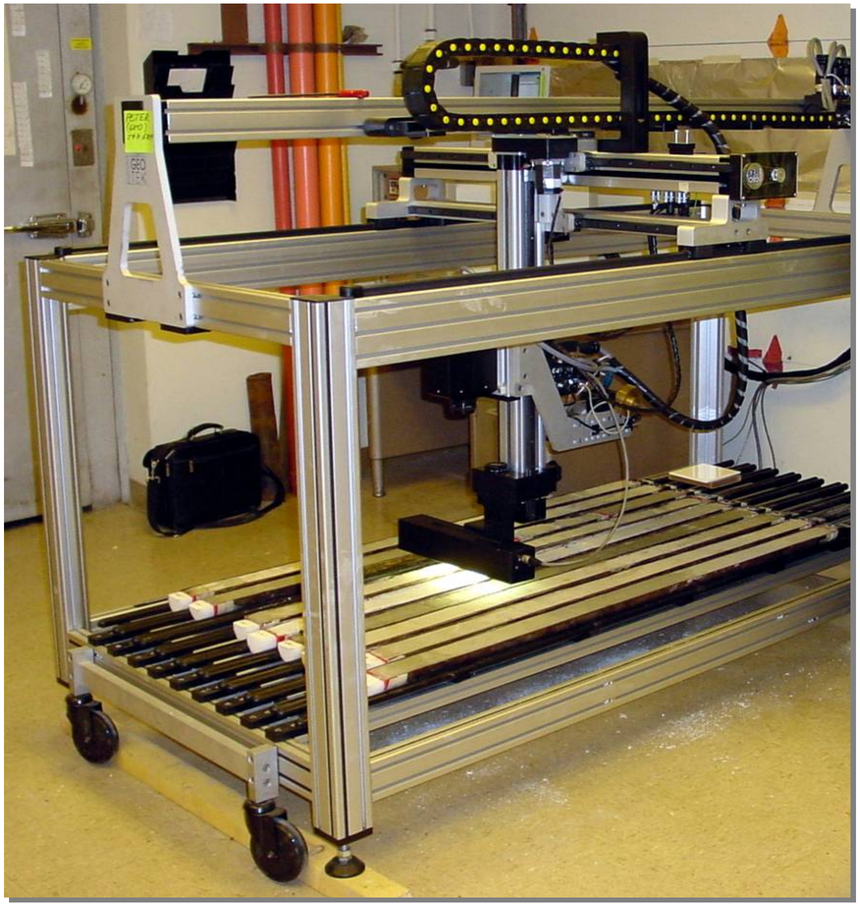
Figure D5. Multi Sensor Logger

Multi Sensor Core Logger Cold Room

Multi Sensor Core Logger

Figure D6. Gamma Ray and Core Photos

Shore-Based Scanning and Photos of Cores



Sample of Data to be Archived from post cruise Experiments

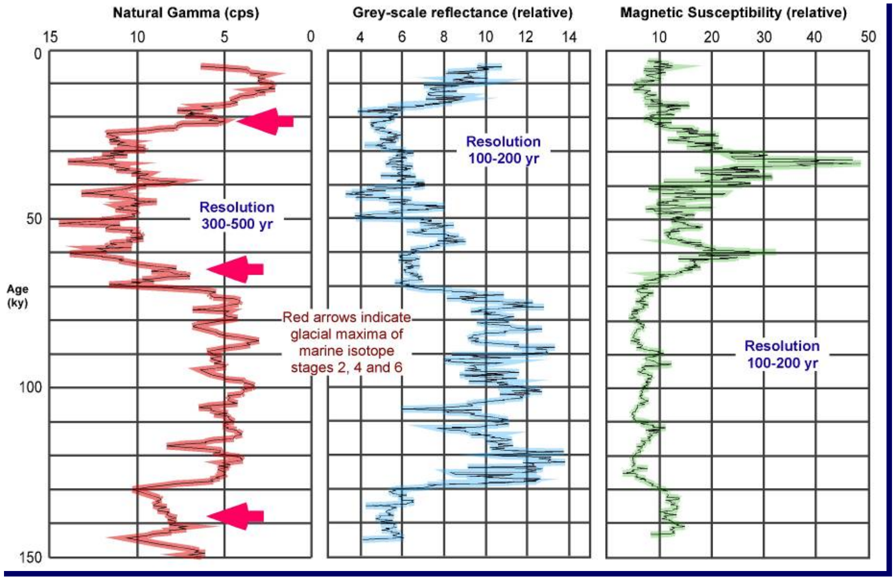


Figure D7. JIP Leg 1 – LWD Tool String

VDN

(density-neutron porosity)

Provision

(NMR porosity)

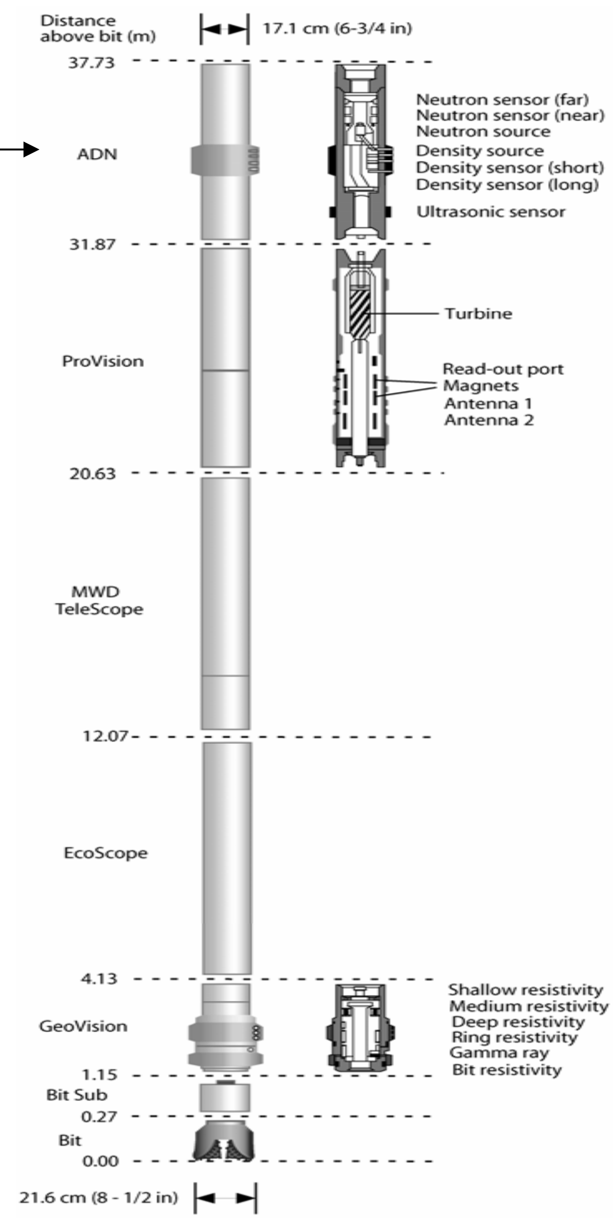
MWD

EcoScope

(resistivity, density-neutron porosity),

GeoVision

(conductivity)



sity)

Figure D8. JIP Leg 1 – Wireline Tool String

Gamma Ray

Dipole Shear Sonic Imager

(Vp and Vs)

GPIT

(inclinometer)

FormationMicro Scanner

(resistivity image)

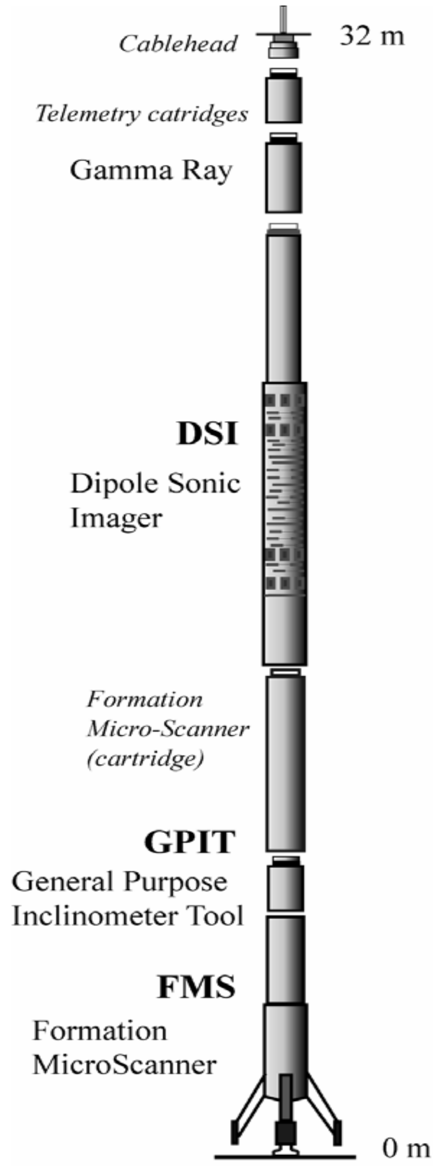


Figure D9. JIP Leg 1 – Vertical Seismic Profile (VSP) Tool String

Gamma Ray

Zero Offset Survey w/ four shuttles (2.06 m spacing)

Hole: KC 151-3   104 stations

124-334 mbsf

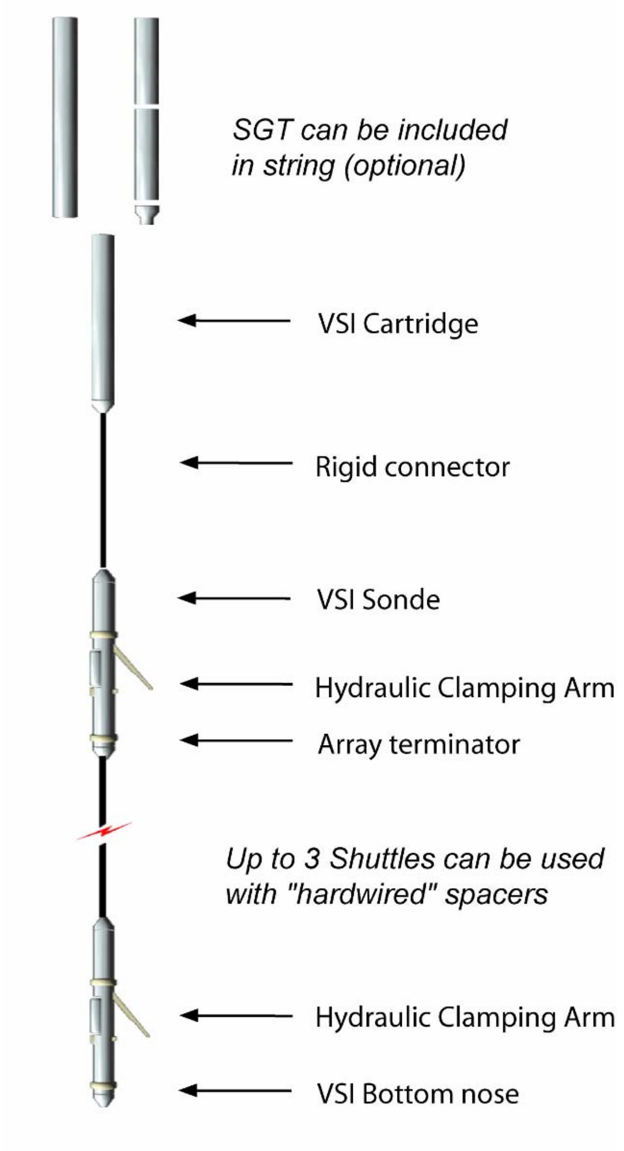


Figure D10. Gas Analyses Onboard

- **Gas chromatograph**
- **N2, O2, H2S, CO2, C1-C4**
- **Hydrocarbon composition in relation to pore water chloride and SO4 concentration**
- **Determines gas hydrate phase boundaries**
- **Real-time drilling hazards**