Oil & Natural Gas Technology

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

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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 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 2011 – March 2012 Project activities included:
• **Completion of the drilling assessment of the Leg III expedition's proposed program for very long duration open hole deployment of a prototype high pressure hydrate corer at sites with extreme water depths, depth below mudline, high hydrate saturations and unconsolidated sediments. Resulting recommendations included adoption of an industry-style coring operation and organizational structure, where cores are retrieved on the rig by experienced offshore coring contractors, then transported ashore for lab analysis. Adoption of industry-style coring processes would enable the Leg III expedition to meet Chevron's world class offshore safety standards, including regulations placing tight limits on the numbers of personnel and equipment allowed on the rig in order to maximize safety. The large science team and their analytical equipment would be located onshore in a secure location and the pressurized hydrate cores would be transported from the rig to the onshore lab site in climate controlled containers.**

- **In order to maximize safety the use of a Chevron-controlled 6th generation drill ship was also recommended. Chevron control from top to bottom of the expedition would avoid any potential interface issues that might arise from coordinating a complex multi-well deepwater hydrate pressure coring, wireline logging and wireline MDT program using a prototype high pressure hydrate corer on a third party rig.**

- **The top priority of the proposed Leg III expedition is to safely recover and analyze pressure cores from reservoirs of coarse grained sediments with high hydrate saturations. By definition the prototype high pressure hydrate corer would carry a significant risk of failure in the field. Onshore testing would help reduce some of the risk, but onshore tests would not be able to duplicate the severe operating environment the prototype would be operating in. Because recovery of pressure cores was the top priority of the expedition and because of the inherent high risk of failure of the prototype pressure corer and pressure core analytical equipment, the drilling assessment recommended a staged approach to the Leg III expedition: conducting a number of short duration, one well expeditions with sufficient time between them to correct any major problems encountered by the prototype pressure corer, pressure core analytical equipment, etc. rather than attempting to undertake the proposed single, long expedition to collect cores from multiple wells at multiple sites. If the prototype pressure corer catastrophically failed at the first site, the remainder of the expedition would in all likelihood need to be canceled, with significant economic penalties.**

- **The drilling assessment also ruled out the Project's proposed use of large diameter drilling casing for the coring operation rather than using traditional drill pipe. The proposed drilling casing has a large internal diameter with minimal upsets compared to drill pipe (making it ideal for the large diameter wireline hydrate pressure corer and its latching system), but the extreme water depths, depth below mudline and very long duration open hole operations in unconsolidated sediments drove the assessment team to**

requiring use of proven drill pipes and their higher inherent safety factors. Since the current pressure corer designed and built by the project is too large in diameter to fit in conventional drilling pipe, the project team is now working to develop alternative designs consistent with the goal of coring an analyzing under pressure deeply-buried, gas hydrate-bearing sands and associated seals at such as those of the Leg II sites

- **The increased cost of the above enhancements and a probabilistic cost analysis of potential expedition outcomes that incorporated basic failure modes related to the use of prototype high pressure hydrate coring equipment, extreme water depths, depth below mudline, high hydrate saturations and very long duration open hole operations in unconsolidated sediments resulted in significant increases in the expedition cost estimates.**

- **In the same timeframe as the above assessment, the project was informed by the DOE that no funding would be available for the next fiscal year and that future year funding was likely to have large ranges of uncertainty.**

- **Due to the combination of the above factors, the project tempo was changed to a 'monitoring and minimum spend' mode to conserve what funds remained, while still progressing critical path studies.**

- **Prior funded work on modification of the IPTC and construction of the PCCT are proceeding and are on track for completion on time and on budget.**

More information is available on the Project website: http://gomhydratejip.ucsd.edu/

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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.

Based on 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. Chevron generated a research proposal which was submitted to DOE in April 2001 under a competitive DOE funding opportunity announcement (FOA). That application was selected for award by DOE under the FOA and Chevron was awarded a cooperative agreement for research based on the proposal.

The title of the project is **"Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities".**

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 hydrate data collection wells to improve the technologies required to characterize gas hydrate deposits in the deepwater GOM using seismic, core and logging data. **Phase III** of the project began in September of 2007 and will focus on obtaining logs and if possible cores of hydrate bearing sands in the GOM.

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 2012, the members of the JIP were Chevron, Schlumberger, ConocoPhillips, Halliburton, the U.S. Bureau of Ocean Energy Management (BOEM), Total, JOGMEC, Reliance Industries Limited, The Korean National Oil Company (KNOC), and Statoil.

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 cooperative agreement between DOE and Chevron in place. Semi-Annual and Topical Reports have been written that cover the activity of the Project through March 2012.

1.6 Purpose of This Report

The purpose of this report is to document the activities of the Project during October 2011 – March 2012. *It is not possible to put everything into this Semi-Annual report, however, many of the important results are included and references to the Project website, http://gomhydratejip.ucsd.edu/, are used to point the reader to more detailed information concerning various aspects of the project.* The discussion of the work performed during this report period is organized by task and subtask for easy reference to the technical proposal and the DOE contract documents.

2.0 Executive Summary

The drilling assessment of the Leg III expedition's proposed program for very long duration open hole deployment of a prototype high pressure hydrate corer at sites with extreme water depths, depth below mudline, high hydrate saturations and unconsolidated sediments has been completed. Resulting recommendations included:

1. Adopting an industry-style coring operation and organizational structure (called the "Block" organization because of its use of well-defined blocks of activities that connect to other blocks with a minimum of interfaces). Under such a system cores are retrieved on the rig (Drill Operations Block) by experienced offshore coring contractors and then turned over to logistics experts (Core Storage and Transport Block) for transport from the rig to the lab site for analysis at a secure onshore facility (Onshore Analysis Block).

    a. Industry-standard coring processes would enable the Leg III expedition to meet Chevron's world class offshore safety standards, which include regulations tightly restricting the numbers of personnel and equipment allowed on the rig in order to maximize safety.

    b. The large science team and their analytical equipment would be located onshore in a secure location and the pressurized hydrate cores would be transported from the rig to the onshore lab site in climate controlled containers.

2. In order to maximize safety the use of a Chevron-controlled 6th generation drill ship was also recommended. Chevron control from top to bottom of the expedition would avoid any potential interface issues that might arise from coordinating a complex multi-well deepwater hydrate pressure coring, wireline logging and wireline MDT program using a prototype high pressure hydrate corer on a third party rig.

    a. Chevron currently employs six of these advanced drill ships, some of which from time to time temporarily discontinue main drilling operations in order to recover, inspect and maintain their Blow Out Preventers (BOPs). Such inspection and maintenance periods can last from one to two weeks, during which time the drill ship would be able to conduct riserless drilling, such as the Leg III expedition would require.

3. The top priority of the proposed Leg III expedition is to safely recover and analyze pressure cores from reservoirs of coarse grained sediments with high hydrate saturations. By definition the prototype high pressure hydrate corer would carry a significant risk of failure in the field.

a. Onshore testing would help reduce some of the risk, but onshore tests would not be able to duplicate the severe operating environment the prototype would be operating in.

4. Because recovery of pressure cores is the top priority of the expedition and because of the inherent high risk of failure of the prototype pressure corer and pressure core analytical equipment, the drilling assessment recommended a staged approach to the Leg III expedition: conducting a number of short duration, one well expeditions with sufficient time between them to correct any major problems encountered by the prototype pressure corer, pressure core analytical equipment, etc. The project team's proposal to conduct a lengthy expedition collecting cores from multiple wells at multiple sites was considered potentially too risky because if the prototype pressure corer catastrophically failed at the first site, the remainder of the expedition would in all likelihood need to be canceled, with significant economic penalties.

5. The drilling assessment also ruled out the program team's proposed use of large diameter drilling casing for the coring operation rather than using traditional drill pipe. The proposed drilling casing has a large internal diameter with minimal upsets compared to drill pipe (making it ideal for the large diameter wireline hydrate pressure corer and its latching system), but Leg III's extreme water depths, depth below mudline and very long duration open hole operations in unconsolidated sediments led the assessment team to

requiring use of proven drill pipes with their greater operational experience and higher inherent safety factors. Since the current pressure corer that was designed and built by the project team is too large in diameter to fit in conventional drilling pipe, the team is now working to develop alternative designs consistent with the goal of safely coring and analyzing under pressure deeply-buried, gas hydrate-bearing sands and associated seals at locations such as the Leg II sites.

6. The increased cost of the above enhancements and a probabilistic cost analysis of potential expedition outcomes that incorporated basic failure modes related to the use of prototype high pressure hydrate coring equipment, extreme water depths, depth below mudline, high hydrate saturations and very long duration open hole operations in unconsolidated sediments resulted in significant increases in the expedition cost estimates.

7. In the same timeframe as the above assessment, the project was informed by the DOE that no funding would be available for FY 2012 and that future year funding was likely to have large ranges of uncertainty.

8. Due to the combination of the above factors, the project tempo was prudently changed to a ‘monitoring and minimum spend’ mode in order to conserve those funds that remained, while still progressing critical path studies.

9. Prior funded work on modification of the IPTC and construction of the PCCT are proceeding and are on track for completion on time and on budget.

3.0 Phase III A (Leg II) Activities

Phase IIIA activities during this period consisted mainly of the co-Chief Scientists Ray Boswell (DOE) and Tim Collett (USGS) working with the science team and other researchers to write, peer review and submit for publication the final science reports of the Leg II expedition in a special edition of the Journal of Marine and Petroleum Geology (JMPG) entitled **Special Issue: Scientific Results of the Gulf of Mexico Gas Hydrate Joint Industry Project Leg II Drilling Expedition**. The Journal of Marine and Petroleum Geology has notified the project that the publication release date will be June 2012 (Issue #34). These papers will also be available through Science Direct.

As previously reported the original and fully processed GOM JIP Leg II well log database was loaded onto the Lamont-Doherty Earth Observatory (LDEO) web site: http://brg.ldeo.columbia.edu/ghp/. The web site also includes original and processed data in the same formats as GOM JIP Leg I. Additional Leg II data will be added whenever available. A NETL Fire in the Ice (FITI) newsletter announcement of the availability of access to this data by researchers worldwide has resulted in a number of research proposals from professors and students.

4.0 PHASE III B (Leg III) Activities

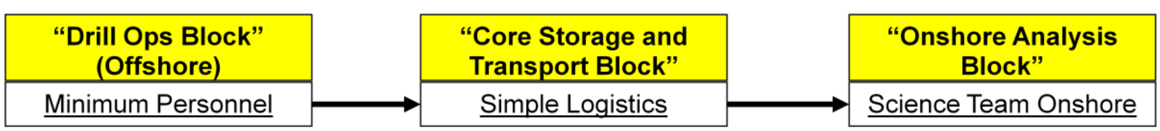
Phase III B work was scaled back to reduce the spend rate at the start of this reporting period due to a combination of factors which are discussed below.

4.1 Completion of Drilling Assessment

The drilling assessment of the Leg III expedition's proposed program for very long duration open hole deployment of a prototype high pressure hydrate corer at sites with extreme water depths, depth below mudline, high hydrate saturations and unconsolidated sediments was completed. Recommendations:

4.1.1 Block Organization

One recommendation was adopting industry-style coring operation and organizational structures. For ease of reference in this report these structures have together been called the "Block" organization because of the use of well-defined blocks of activities that connect to other blocks with a minimum of interfaces. Under such a system cores are retrieved on the rig (Drill Ops Block) by experienced offshore coring contractors and then turned over to logistics experts (Core Storage and Transport Block) for transport from the rig to the lab site for analysis at a secure onshore facility (Onshore Analysis Block).



The offshore team would consist of experienced oil industry coring contractors and company coring experts. Simple gamma scans would be conducted on each sealed pressurized core as it was retrieved on deck to verify that good core was in the pressure container, after which the core autoclave would be removed from the pressure corer and placed in climate controlled reefer boxes with measures taken to control temperature and maintain pressure of each autoclave. No other science equipment or personnel would be on board with the exception of three science team geologists to provide advice to the coring team during coring, wireline logging and potential wireline MDT deployments. Studies conducted by Georgia Tech concluded that there would be no deleterious geomechanical effects on the quality of the cores due to the time delay between core retrieval and onshore analysis.

Transport of the reefer containers containing the autoclaves would be done by Gulf of Mexico logistics companies that routinely handle oil company hydrocarbon core shipments from the rigs to onshore laboratories.

The full science team and all equipment would be staged onshore at a site selected for safe operations and ample housing, logistical, operational and safety support.

To support this new organizational system it would be necessary to build 16 autoclaves for the HPTC. Autoclaves would be re-used at each well. As with similar pressurized hydrate core transport containers, the autoclaves would of course need to be appropriately designed, tested and certified to meet all applicable standards.

4.1.2 Chevron-controlled 6th Generation Rig

In order to maximize safety the use of a Chevron-controlled 6th generation drill ship was also recommended. Chevron control from top to bottom of the expedition would avoid any potential interface issues that might arise from coordinating a complex multi-well deepwater hydrate pressure coring, wireline logging and wireline MDT program using a prototype high pressure hydrate corer on a third party rig.

Chevron currently employs six of these advanced drill ships, some of which from time to time temporarily discontinue main drilling operations in order to recover, inspect and maintain their Blow Out Preventers (BOPs). Such inspection and maintenance periods can last from one to two weeks, during which time the drill ship would be able to conduct riserless drilling, such as the Leg III expedition would require.

4.1.3 Single-well Campaigns

The top priority of the proposed Leg III expedition is to safely recover and analyze pressure cores from reservoirs of coarse grained sediments with high hydrate saturations. By definition the prototype high pressure hydrate corer would carry a significant risk of failure in the field. Onshore testing would help reduce some of the risk, but onshore tests would not be able to duplicate the severe operating environment the prototype would be operating in.

Because recovery of pressure cores is the top priority of the expedition and because of the inherent high risk of failure of the prototype pressure corer and pressure core analytical equipment, the drilling assessment recommended a staged approach to the Leg III expedition: conducting a number of short duration, one well expeditions with sufficient time between them to correct any major problems encountered by the prototype pressure corer, pressure core analytical equipment, etc. Note that this recommendation takes full advantage of the Chevron controlled 6th generation rig recommendation.

The project team's proposed lengthy single expedition to collect cores from multiple wells at multiple sites. If the prototype pressure corer catastrophically failed at the first site, the remainder of the expedition would in all likelihood need to be canceled, with significant economic penalties.

4.1.4 Drill Pipe Requirement

The drilling assessment also ruled out the program team's proposed use of large diameter drilling casing for the coring operation and recommended using traditional drill pipe. The proposed drilling casing has a large internal diameter with minimal upsets compared to drill pipe (making it ideal for the large diameter wireline hydrate pressure corer and its latching system), but Leg III's extreme water depths, depth below mudline and very long duration open hole operations in unconsolidated sediments led the assessment team to requiring use of proven drill pipes with their greater operational experience and higher inherent safety factors.

Since the current pressure corer that was designed and built by the project team is too large in diameter to fit in conventional drilling pipe, the team is now working to develop alternative designs consistent with the goal of safely coring and analyzing under pressure deeply-buried, gas hydrate-bearing sands and associated seals at locations such as the Leg II sites.

In November one of the JIP Participants (JOGMEC) generously invited several Project team representatives to observe the onshore test of their new hydrate pressure corer. As a result of the Project team's presence during the testing, many valuable lessons were learned.

A series of meetings were held in early March to collect perspectives from experts, discuss and make an initial list of design and operational requirements, etc. These meetings were attended by DOE, USGS, Aumann & Associates, Geotek, JOGMEC and Chevron. Their purpose was to share experience, establish common understandings, discuss design and operational issues and parameters and list key points for consideration.

Work on this critical item will accelerate in the next reporting period.

4.1.5 Increased Cost of Expedition

The increased cost of the above enhancements and a probabilistic cost analysis of potential expedition outcomes that incorporated basic failure modes related to the use of prototype high pressure hydrate coring equipment, extreme water depths, depth below mudline, high hydrate saturations and very long duration open hole operations in unconsolidated sediments resulted in significant increases in the expedition cost estimates.

4.2 No DOE Funding in FY2012

In the same timeframe as the above assessment, the project was informed by the DOE that no funding would be available for the FY2012 and that in future years the amount and availability of funding could have large ranges of uncertainty.

4.3 Change in Project Tempo to "Monitoring and Minimum Spend"

Due to the combination of the above factors, the project tempo was prudently changed to a 'monitoring and minimum spend' mode in order to conserve those funds that remain, while still progressing critical path studies and managing already-funded work. The project's decision to minimize project spend will help conserve existing funds in order to help contribute to the anticipated high cost of the Leg III coring expedition.

4.4 IPTC and PCCT Status

Prior funded work on modification of the IPTC and construction of the PCCT are proceeding and are on track for completion on time and on budget. Upgrading of the USGS/Georgia Tech IPTC and development of a suite of Pressure Core Characterization Tools continued during this reporting period, with all components nearing completion at the end of this reporting period. Fit-up tests are planned for the next reporting period, along with a later series of laboratory tests and training on the full IPTC/PCCT system.

PCCT components: include:

- Portable manipulator (MAN)
- Core cutting tool (CUT)
- Effective stress cell (ESC)
- Controlled de-pressurization (CDP)
- Direct shear chamber (DSP)
- Bio-sampling and reactor chambers (BIO)

PCCT Specifications:

- Maximum core length (portable manipulator): 1m
- Core/liner diameter: ID=57 mm; OD=63 mm
- All devices are designed and tested for a maximum pressure of 35MPa (5000 psi).
- All devices are intended to be operated at 21MPa max (3000psi)

4.5 Other Activities

In order to sustain science team momentum new research or data collection project proposals were solicited and considered, such as collection of 4C OBS data at the Leg II sites. After review the project regrettably decided that none of the proposals would meet the necessary low cost/high benefit ratio in the current minimum spend environment.

5.0 Conclusions

Completion of the drilling assessment resulted in recommendations included adoption of an industry-style coring operation, use of a Chevron-controlled 6th generation drill ship, conducting a number of short duration, one well expeditions, and using traditional drill pipe instead of large diameter drilling casing. The project's HPTC corer is too large in diameter to fit in conventional drill pipe, so a team has been formed to generate, review and recommend an alternative to enable pressure cores to be successfully taken from Leg II drilling sites.

The increased cost of the above enhancements and a probabilistic cost analysis produced significant increases in the expedition cost estimates.

In the same timeframe as the above assessment, the project was informed by the DOE that no funding would be available for FY2012 and that future year funding could be highly variable.

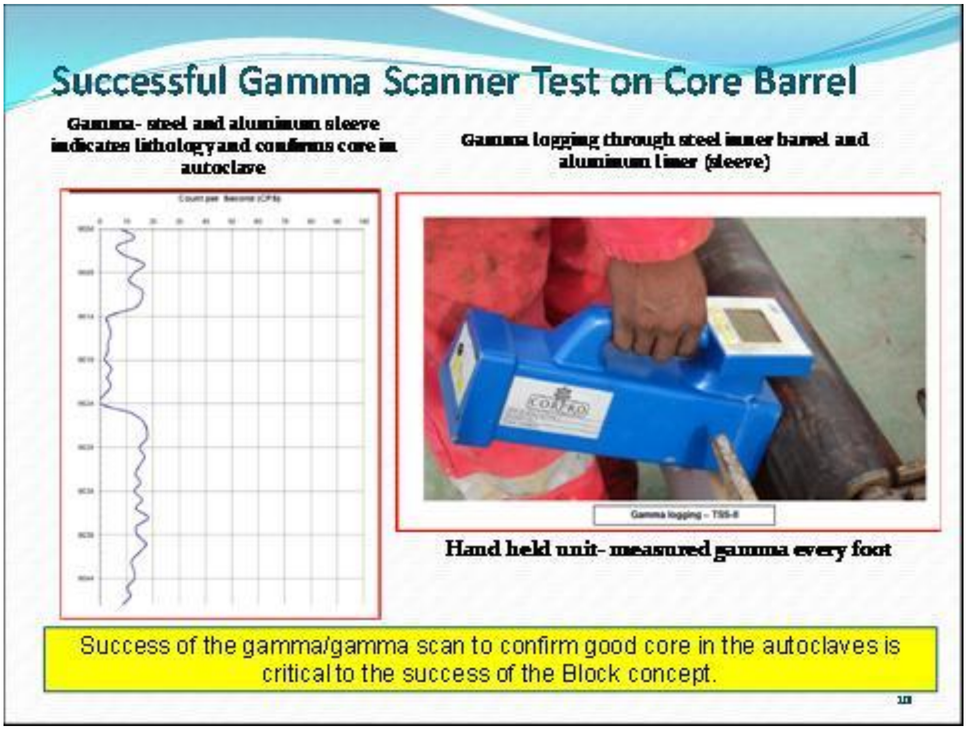
Due to the combination of the above factors, the project tempo was changed to a 'monitoring and minimum spend' mode to conserve what funds remained, while still progressing critical path studies. Prior funded work on modification of the IPTC and construction of the PCCT are proceeding and are on track for completion on time and on budget. A team has been formed to generate, review and recommend an alternative to enable pressure cores to be successfully taken from Leg II drilling sites.

6.0 References

No external references were used for this report.

7.0 Figures

Figure 1: Successful preliminary gamma test on core barrel



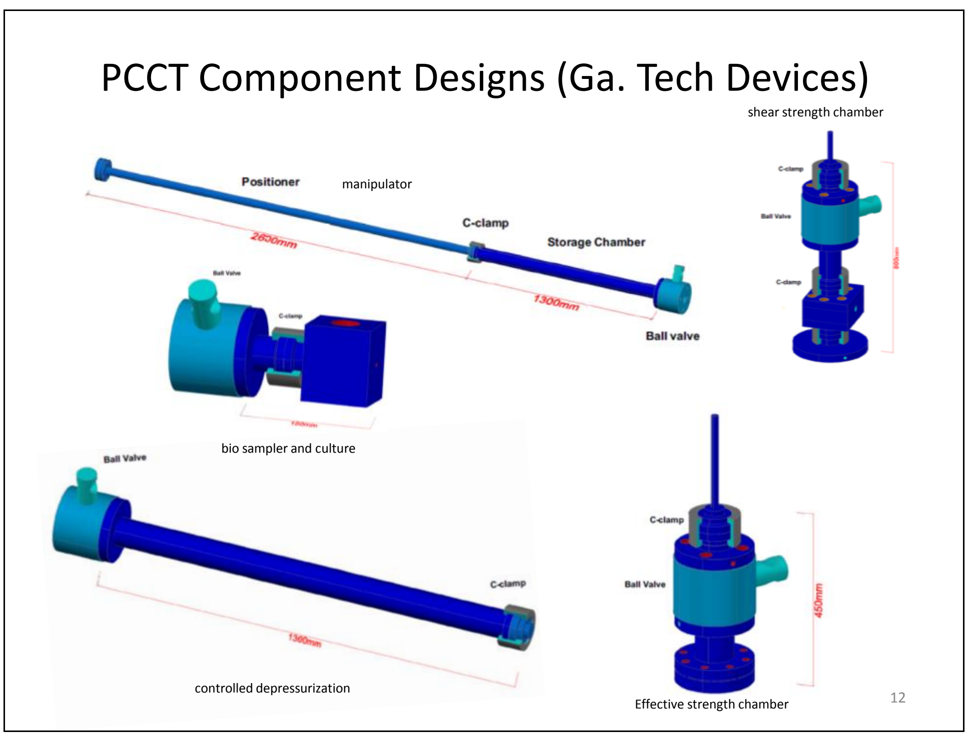
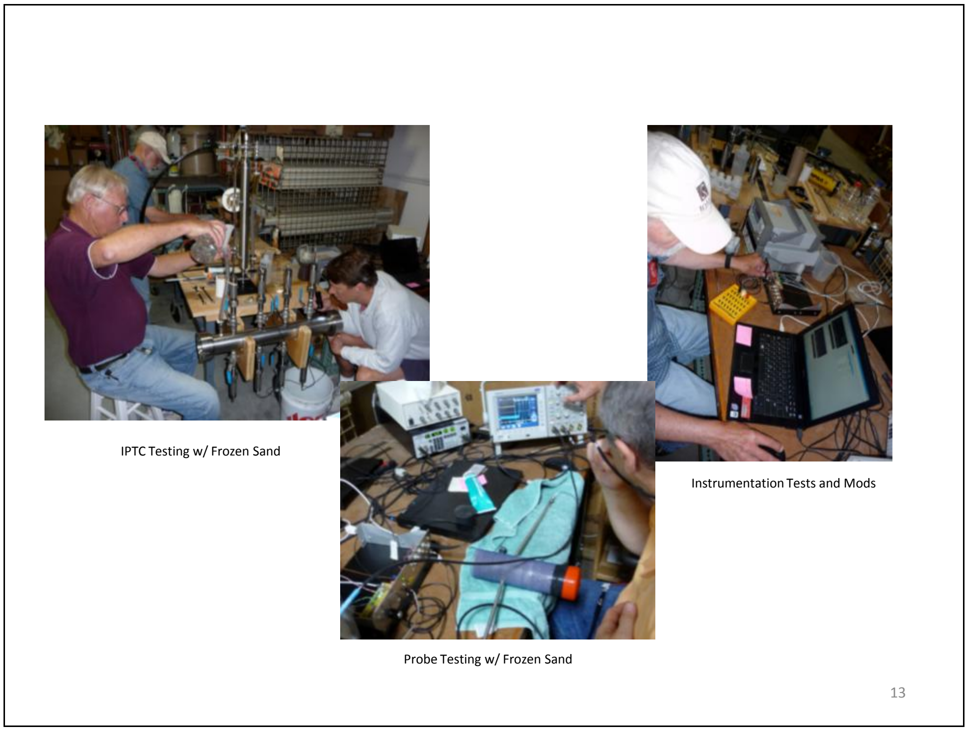


Figure 2: Georgia Tech Pressure Core Characterization Tool (PTTC) Designs

Figure 3: USGS work on IPTC modifications



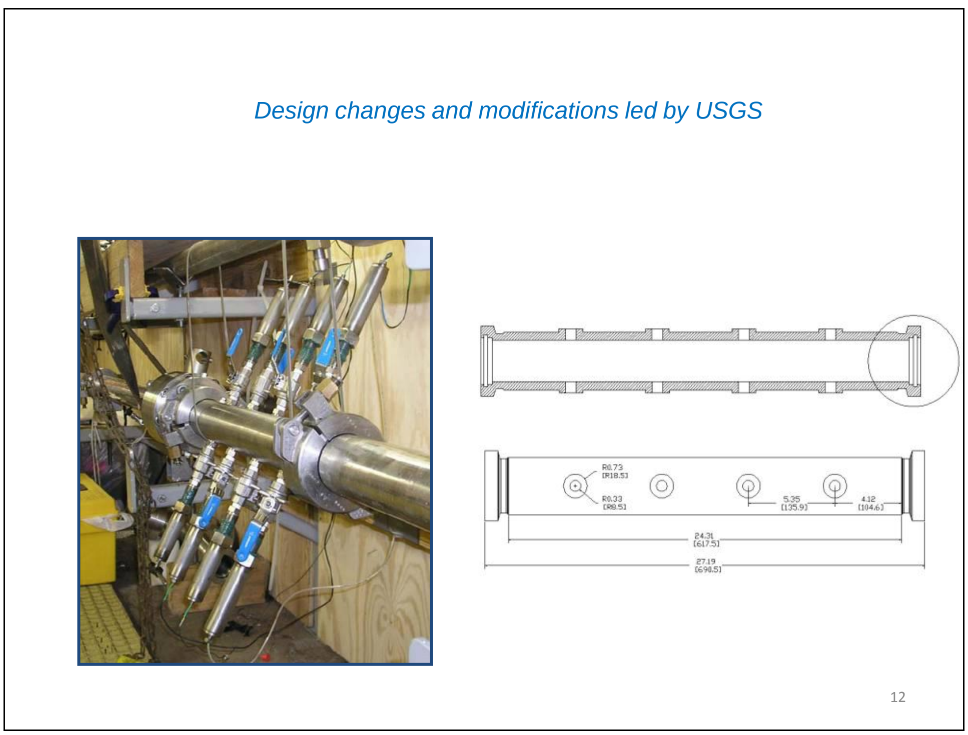


Figure 4: USGS IPTC Current configuration and proposed modifications.

8.0 Appendix A – Project Timeline

2012 Plan

Monitor

	2012				2013				2014			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Pressure Corer Development Program												
JIP HPTC Log-Term Storage / Warehousing	tbd											
Monitor JOGMEC HPTC Status (repair, redesign, shop testing)	XXX											
Possible JOGMEC HPTC test offshore Japan?			?	(possible chance to see if the HPTC works in the field)								
Program for new JIP Pressure Corer	tbd (Depends on choice of pressure corer. If HPTC works does JIP buy duplicate)											
JIP Pressure Corer - Inventory & DOE Turnover												
IPTC/PCCT Laboratory Tools Program												
Fabrication / Certification	X X X											
Calibration / Testing	X	X										
Possible IPTC/PCCT Field Test Observation (Japan)?			?									
JIP Deployment												
JIP Demob / Refurbish												
JIP Inventory and DOE Turnover												
PCATS Deployment												
Possible PCATS Field Test Observation (Japan)?			?									
JIP Deployment												
Leg III Offshore Drilling Program												
Drilling Assessment Study												
Drill Rig Tender (to determine 3rd party rate)												
Drilling Permit Applications												
Pre-spud Safety Meeting												
Leg III Expedition (~10 days incl mob/demob)												
Science Program												
Program Development and Management												
Science Team Meeting - Finalize Science Plan												
Science Team Deployment												
Post-cruise Studies												
Reporting												
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Leg III Initial Results Publication												
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