Oil & Natural Gas Technology

DOE Award No.: DE-FC26-01NT41330

Semi-Annual Progress Report #41330R25 (April 2013 – September 2013)

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

Principal Investigator:
Cung Vu
Chevron Energy Technology Company
1500 Louisiana Street
Houston, Texas 77005

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

October 2013

Office of Fossil Energy

DISCLAIMER

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

ABSTRACT

In 2000, Chevron began a project to learn how to characterize the natural gas hydrate deposits in the 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 April 2013 – September 2013 Project activities included:

- **Completion of the design of the improved Hybrid Pressure Coring System (PCS) that include modification options to make improvements on the prototype Hybrid PCS, previously developed by Aumann & Associates Inc. (AAI) and used by JOGMEC during their July 2012 hydrate pressure coring expedition offshore.**
- **Completion of the manufacturing of the Hybrid PCS by AAI. Factory acceptance test of the Hybrid PCS has been successfully conducted.**
- **Plan for an onshore field test has been completed. A contract with the Catoosa Test Facility has been executed and test preparation is well under way. The test is scheduled for early November 2013.**
- **Completion and delivery of a number of reports on the Instrumented Pressure Test Cell (IPTC) and the Pressure Core Characterization Tool (PCCT) and on the successful field test of the systems, conducted in January 2013, on the pressured cores collected in Japan.**

TABLE OF CONTENTS

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 in hydrate bearing sands in the GOM and on the development and testing of a pressure coring and pressure core analysis system.

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 September 2013 the members of the JIP were Chevron, Schlumberger, ConocoPhillips, Halliburton, the U.S. Bureau of Ocean Energy Management (BOEM), Total, Japan Oil, Gas and Metals National Corporation (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 September 2013.

1.6 Purpose of This Report

The purpose of this report is to document the activities of the Project during April 2013 – September 2013. *It is not possible to put everything into this Semi-Annual report, however, many of the important results are included and references to the NEL Project website:*

http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/projects/DOEProjects/CharHydGOM-41330.html/

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 Cooperative Agreement is now moving toward its conclusion. The JIP and DOE have determined that they will focus full attention on the development and testing of an integrated suite of pressure coring and pressure core analysis devices in collaboration with research and development experts in the US Department of Energy, U.S. Geological Service, Georgia Tech, Scripps Institution of Oceanography and other academic institutions as well as Aumann and Associates Inc, Geotek and other and sub-contractors. Other than drilling associated with tool testing at the Catoosa site (Hallett, OK), no other future drilling programs will be conducted in this project.

During the reporting period, significant progress was made in the development of the JIP Hybrid Pressure Coring System (PCS) and the preparation of the planned onshore test at the Catoosa site.

1. The final design of the JIP Hybrid PCS has been completed. A total of fifteen modification improvements over the previous design have been incorporated into the final design. These design improvements are based on learning gathered from available information of the JOGMEC pressure coring operation offshore Japan in 2012.

2. The JIP Hybrid PCS has been built by Aummann Associates Incorporated (AAI). A factory acceptance was successfully conducted during September 2013 at AAI's facility in Salt Lake City, Utah.

3. The onshore test at the Catoosa Test Facility near Hallett, Oklahoma is planned for early November 2013. A contract has been signed with Catoosa Test Facility for the testing services. Final preparation for the onshore test is well underway.

In addition to development of Hybrid PCS, the USGS and Georgia Tech continued to complete their work on Instrument Test Pressure Cell (ITPC) and Pressure Core Characterization Tool (PCCT) systems. Their current work is focusing on documentation and finalization of the reports on these systems.

3.0 PHASE III B (Leg III) Activities

The Cooperative Agreement is now moving toward its conclusion. The JIP and DOE have determined that they will focus full attention for the remainder of this Phase on the development and testing of an integrated suite of pressure coring and pressure core analysis devices in collaboration with research and development experts in the U.S. Department of Energy, U.S. Geological Service, Georgia Tech, Scripps Institution of Oceanography and other academic institutions as well as Aumann and Associates Inc., GeoTek and other contractors.

3.1 Instrumented Pressure Test Cell (IPTC) and Pressure Core Characterization Tool (PCCT) Development

One of the key deliverables of the JIP is the development of the tools for analysis of hydrate-bearing pressure cores. The ITPC and PCCT systems are the cumulative products of many years of research at USGS and Georgia Tech. The systems have the capability to perform a number of analyses on the pressured hydrates cores under in situ pressure conditions. The systems are capable of measuring a number of hydrate core properties:

Pre-production testing

- Temperature & pressure (inside the core)
- P-wave & S-wave velocity
- Compressibility under zero-lateral strain
- Shear strength (penetration and direct shear)
- Electrical conductivity
- Hydraulic conductivity
- Thermal conductivity
- Pore fluid sampling (without dissociation)

Production monitoring

- Most properties above
- Additional: volume contraction upon dissociation

A joint USGS and Georgia Tech operational test of the IPTC and PCCT was successfully held in January 2013 at the AIST national hydrate laboratory in Sapporo, Japan. During this reporting period, a number of presentations and reports have been prepared by USGS and Georgia Tech to document the functionality of the system. Appendix 1 is a presentation summary of the capability of IPTC and PCCT systems and some operational test results obtained in January 2013. A presentation summary describing the measurement components of the PCCT system are provided in Appendix 2. Written reports on the systems are currently being prepared.

3.2 Pressurized Hydrate Coring System

During this reporting period, the focus of the project was on the development of a prototype Hybrid Pressure Coring System (PCS) for the JIP. The objectives of the development are to produce one Hybrid PCS tool set with spare parts, to test the tool for functionality and, subsequently, to turn over the prototype tool set, operating procedure and lessons learned from the test to the DOE or DOE designee. The project work focuses on two main tasks, the development of a prototype Hybrid PCS tool and the onshore operational test of the tool. The high level project plan is summarized in Fig. 1.

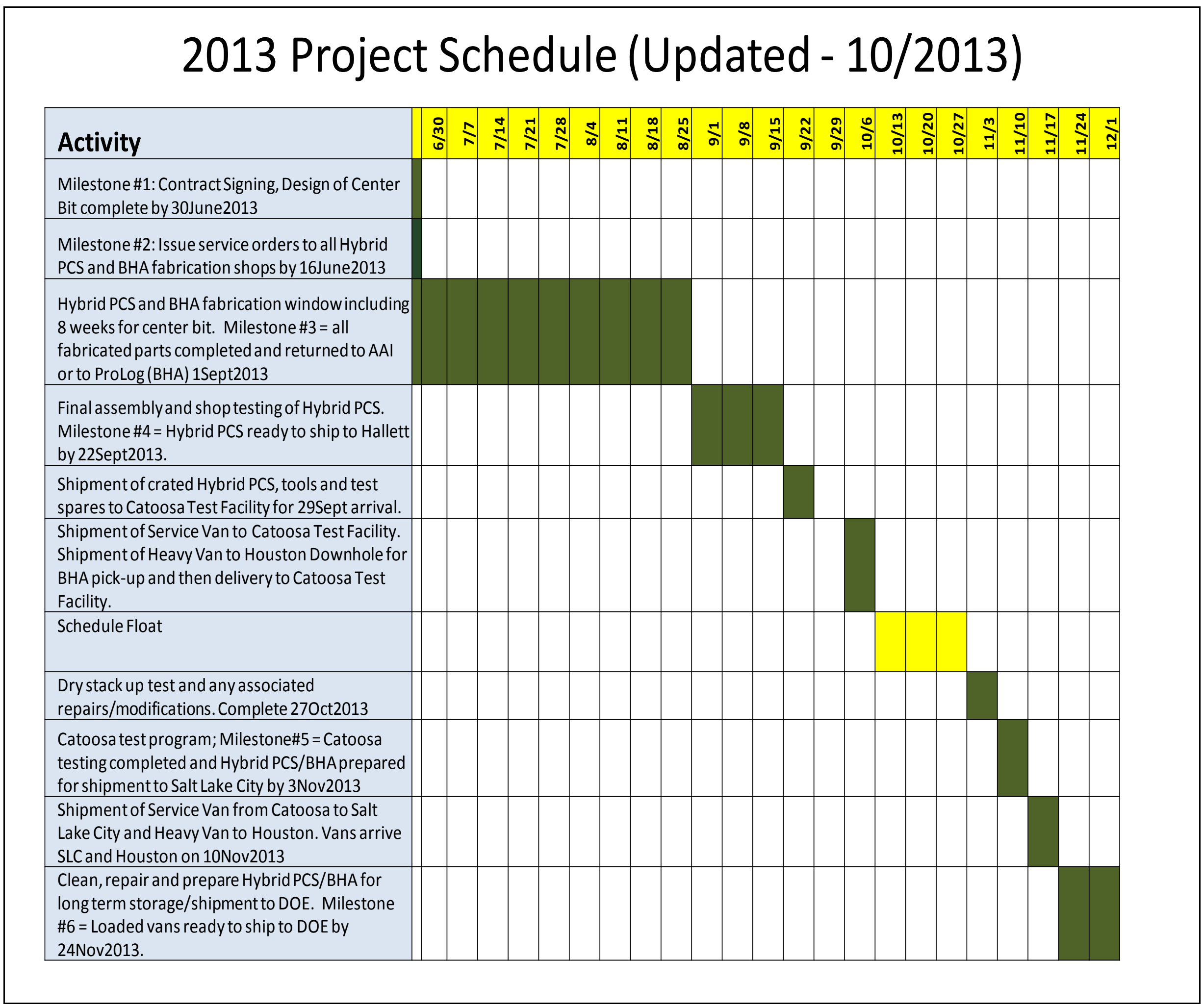


Figure 1 – Project Schedule

3.2.1 Development of the JIP prototype Hybrid PCS Tool

a) Completion of the design of the JIP Hybrid PCS Tool.

As noted in the September 2012 to April 2013 semi-annual report, JOGMEC deployed an earlier version of a prototype Hybrid PCS designed and manufactured by AAI for a hydrate pressure coring expedition in the Nankai Trough, offshore Japan, in July 2012. Based on the test experiences, fifteen design improvements have been selected incorporated into the JIP Hybrid PCS. A center bit for the cutting shoe configuration was also added to the design.

b) Manufacturing of the JIP Hybrid PCS Tool.

Sub-contracting work for the final design and manufacturing of the JIP Hybrid PCS tool was awarded to AAI on June 3, 2013. Long lead material items had been earmarked several months earlier so long lead material could be on hand now for fabrication commencement.

Design drawings were primarily completed from a recently fabricated prototype and fabrication orders were issued within 2 weeks of contract signing. Results have produced a timely completion and delivery of most manufactured parts. Minor material sourcing issues were resolved in a timely manner with appropriate chemical testing of material composition. A very small number of materials were in question and all passed the tests.

c) Factory acceptance test.

Testing of the manufactured JIP Hybrid PCS was conducted at AAI facility during the weeks of September 16th and 23rd. The results of the factory test were satisfactory.

d) Operation manual and shipment to test site.

The Operation Manual for the Hybrid PCS has been completed. Shipment of the Hybrid PCS, testing spare parts, service tools and the Operation Manual to the Catoosa Test Facility for field testing is scheduled for October18th.

3.2.2 Service and Heavy Vans

A Service Van is required to support coring operations during Hybrid PCS use at both the Catoosa Test Facility and at future offshore sites. It is primarily used to assemble and service the core barrels. The Service Van also serves as a transport container for the tool between sites. The design of the Service Van has been included in Appendix 4 of the last progress report.

A Heavy Van is required to transport the bottom hole assembly, drill collars, and other miscellaneous items between offshore test sites. Initial plans were to use the Heavy Van to transport the aforementioned items to the Catoosa Test Facility from Houston where the parts were manufactured; however, being that the Heavy Van is primarily designed for offshore transport, unconventional onshore loading equipment increased the cost and further complicated the delivery of equipment to the Catoosa Test Facility with the Heavy Van. These items will be shipped to the Catoosa Test Facility by a more conventional flatbed truck. The Heavy Van will be held at the fabrication facility until the bottom hole assembly, drill collars and other miscellaneous items are ready to be shipped to the next destination following testing. The design of the Heavy Van has been included in Appendix 4 of the last progress report.

The service order for fabrication of both the Service and Heavy Vans was placed with Pro-Log Inc. of New Iberia, Louisiana in early June of 2013. ProLog has had a long term Master Service Agreement with Chevron that dates back to the 1980s. The vans are currently under construction with a delivery of the Service Van to the Catoosa Test Facility scheduled for October 30th. The Heavy Van will remain in New Iberia during the onshore testing process and will only be used to transport the bottom hole assembly and drill collars to the next user at the conclusion of the test.

3.2.3 Onshore functionality test of the JIP prototype Hybrid PCS Tool

The onshore test objective is to test the functionality of the tool and not its durability in extreme settings. The Catoosa site (Hallett, OK) has been selected as the best available site. Planning for the test is near finalization with the onshore test currently scheduled for Nov 4th to Nov 12th 2013.

a) Selection of Catoosa test site

As reported in the last period semi-annual progress report, the Catoosa site (Hallett, OK) has been selected as the best available site, with an excellent rig and the capability to drill open holes. Detailed information on the site is provided in Appendix 3. There are lithology zones suitable for the testing of the Hybrid PCS.

b) Coring Test Interval

The site lithology has been studied. Several potential coring intervals have been identified on well logs of the wells at the Catoosa test site. Detailed geomechanical analysis showed that the compressive test of the potential coring interval is about 4 to 5 times the expected compressive of GOM hydrate with 50% hydrate saturation. The coring test interval would provide a good test of the Hybrid PCS but would not pose a risk to damage the tool itself. The geomechanical analysis was performed by Chevron geomechanical experts and was reviewed by Dr. Tim Collett (USGS), JIP Co-chief Scientist, and Dr.

Carlos Santamarina (Georgia Tech). Detailed of the coring intervals and geomechanical analysis can be found in Appendix 3.

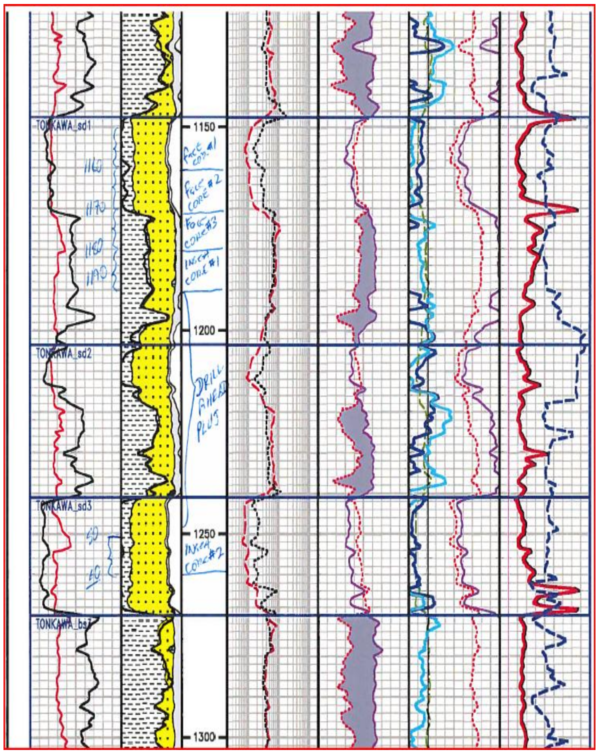
c) Contract Award of Onshore Test to CTF

Catoosa Test Facility (CTF), which operates the Catoosa test site, agreed to conduct site operations for the test of the Hybrid PCS. AAI will be conducting the coring test as a subcontractor to CTF during the testing operation. Chevron will provide the CTF with the testing program and on site administrative personnel for the test program. Chevron HSE has reviewed CTF's safe work practices and has approved CTF for the test program. Environmental questionnaires have been completed by CTF and Chevron. It was determined by DOE office that the onshore test falls under one or more of the categorical exclusions (CXes) listed in Appendix A or B of Subpart D of the DOE NEPA Implementing Procedures and would not pose adversity to the environment. An onshore test contract between CTF and Chevron was signed on September 30th, 2013.

d) Coring Test Plan

The coring test plan would involve the cutting of five cores. The coring intervals are shown in Figure 2. The details of the coring test plan are shown in Figure 3.

Cores will be taken in Tonkawa Sand #1 & Sand #3



- First Core interval may be adjusted up or down a maximum of 10 ft.
- Cores 2-4 will follow sequentially

TONKAWA SAND ONE
3 face and one insert core back to back
(nom 40 ft total)

- Drill ahead interval should be to 1240 Min (Top of Sand#3) and 1260 Max
- Last insert Core will be cut in Sand 3

TONKAWA SAND THREE
one insert core
(nom 10 ft total)

All intervals are referenced to this log and will be correlated based on actual drill performance
FURTHER CHANGES TO THE CORING INTERVALS WILL BE DONE THROUGH MANAGEMENT OF CHANGE PROCESS

Figure 2 - Coring Intervals

DAY	OPERATION	DEPTH	TIME (hr)	CUM	COMMENTS AND OBSERVATIONS
DAY 1 (Mon Nov 4)	Morning Rig up Safety meeting		0.5	0.5	
	Pick up bit, motor and orienting BHA		1.5	2	
	Rig up circulating system		1	3	
	RIH drill cement to Conductor shoe @ 748 ft		2	5	Rental bit
	Displace hole to mud		1	6	
	POOH set Scribe line RIH and orient motor		2	8	
	Sidetrack well to get 100% formation returns	900	8	16	
	Circ btms up and POOH	900	1.5	17.5	
	Rig Maint and Shutdown		0.5	18	
DAY 2 (Tues 5 Nov)	Morning Rigup/ safety mtg		0.5	0.5	
	Make up Drilling assy and RIH		2	2.5	
	Make up Drilling assy and RIH		2	4.5	
	Drill 12.25 hole	1100	7	11.5	
	POOH Lay down 4-1/2 dp Collars and BHA		2	13.5	DRILLPIPE REQUIRED ON SITE
	Rig for Marine pipe		1	14.5	
	Pick up 12 stands 5-1/2 dp	1100	3	17.5	
	Rig Maint and Shutdown		0.5	18	
DAY 3 (Wed 6 nov)	Morning Rigup/ safety mtg		0.5	0.5	
	Pick up core bbl with Face bit	1100	3	3.5	
	RIH W/R to Btm Tag Btm check tally		2	5.5	
	Circ & Cond hole rotate & Work Core bbl	1100	1	6.5	CIRCULAITON TEST WITH NO INNER BBL
	POOH to conductor shoe rig run fit tests	700	1	7.5	
	Rig up wireline		2	9.5	WIRELINE REQUIRED ON SITE
	Run Primary inner bbl		0.5	10	TOOL FIT UNDER OPERATIONAL CONDITIONS
	Circ at full coring pressure 30 min		0.5	10.5	
	Rig up and pull inner bbl		0.5	11	
	Repeat for Configuration 2		1.5	12.5	
	Repeat for Configuration 3		1.5	14	
	Repeat for Configuration 4		1.5	15.5	
	Rig Maint and Shutdown		0.5	16	
DAY 4 (Thurs 7 Nov)	Morning Rigup/ safety mtg		0.5	0.5	TEST AUTOCLAVE BALL SEAL AND N2 SET POINT TIMING
	Test 2 autoclaves with pressure in Acumulator		3	3.5	
	Rigup and Run center plug		1	4.5	CORE LAB REQUIRED ON SITE
	Ream and wash to bottom	1100	2	6.5	TEST FACE BIT DRILLING FUNCTION
	Drill 1100 to first core point	1150	2	8.5	
	Circ to Core		1	9.5	
	Rig up and pull inner plug		0.5	10	
	Pick up inner bbl with charged accumulator RIH		1	11	
	circ 30 min Cut core #1 10 ft core	1160	0.5	11.5	CUT CORE NUMBER ONE
	POOH Core #1		1	12.5	
	Cut Core #2 10 ft	1170	3	15.5	CUT CORE NUMBER TWO
	Rig Maint and Shutdown		0.5	16	
DAY 5 (Fri 8 nov)	Morning Rigup/ safety mtg		0.5	0.5	
	Cut Core #3 10 ft	1180	3	3.5	CUT CORE NUMBER THREE
	POOH with outer bbl inspect for damage and washouts	1180	2.5	6	INSPECT BBL FOR DAMAGES
	Pick up core bbl with Insert bit	1180	2.5	8.5	
	Pick up Dc and RIH to 700 ft	700	1	9.5	
	Rig up wireline	700	0.5	10	
	Test 2 inner bbl sections for fit	700	2	12	TOOL FIT UNDER OPERATIONAL CONDITIONS
	RIH with core bbl to TD	1180	0.5	12.5	
	circ 30 min Cut core #4 10 ft core	1190	1	13.5	CUT CORE NUMBER FOUR
	POOH Core #4		0.5	14	
	Run drill- ahead plug	1190	0.5	14.5	
	POOH to shoe and Shut down rig		1	15.5	
	Rig Maint and Shutdown		0.5	16	
DAY 6 Mon 11 Nov	Morning Rigup/ safety mtg	1180	0.5	0.5	
	RIH		2	2.5	TEST INSERT BIT DRILLING FUNCTION
	Drill	1250	3	5.5	
	Run and pull drill- ahead plug	1250	0.5	6	
	Pick up inner bbl with charged accumulator RIH		1	7	
	Cut core #5 10 ft core	1260	1	8	CUT CORE NUMBER FIVE
	Break core circ rig WL and pull core	1260	1	9	
	Circ Btms up and POOH laying down		3	12	RELEASE WEATHERFORD
	Rigout equipment		3.5	15.5	RELEASE CORE LAB
	Release Rig		0.5	16	
DAY 7 Tues 12 Nov	Morning Rigup/ safety mtg		0.5	0.5	
	Clean and service tools		4	4.5	RETURN ALL RENTALS
	Pack Service unit and Heavy Lift		2	6.5	RETURN RENTAL PIPE
	Load Service van, Heavy lift van, backload Drillpipe		1	7.5	RELEASE AAI
	Operations Terminated 1530 Mon 10 Nov				

Figure 3 – Coring Test Plan

e) Examination of the Cores

Chevron coring experts, Dr. Tim Collett (USGS) and Dr. Carlos Santamarina (Georgia tech) will be onsite to observe the coring operation and test. The cores obtained in the coring test will be examined onsite to assess the functionality of the Hybrid PCS. Pressures of the cores will be measured and recorded. The cores will then be de-pressurized to atmospheric condition, visually examined and photographed. The cores will then be cut and transported to Georgia Tech. The team led by Dr. Santamarina will perform further examination of the cores at Georgia Tech to provide further assessment of the coring functionality of the Hybrid PCS.

f) Post Coring Test

The Hybrid PCS equipment will be refurbished and shipped to a site designated by the DOE project managers for subsequent operation use or storage for future use.

4.0 Conclusions

Much progress has been made during the current reporting period. Documentation of the Instrumented Pressure Test Cell (IPTC) and the Pressure Core Characterization Tool (PCCT) by the scientific team from USGS and Georgia Tech are ongoing with the completion of many parts. The development of the JIP Hybrid PCS is near completion. The tool has been manufactured and factory acceptance test has been completed. The planning for the onshore test of the JIP Hybrid PCS is well under way. In the current plan, the test is currently planned to be conducted at Catoosa test site (Hallett, OK) to be scheduled from Nov 4 to Nov 12, 2013.

5.0 References

No external references were used for this report.

APPENDIX 1

Tools for Analysis of Hydrate-Bearing Pressure Cores

Carolyn Ruppel
(USGS—Woods Hole)

J. Carlos Santamarina
(Georgia Tech)

Evolution of the Pressure Core Characterization Tools (PCCT)

Between 1995 (ODP Leg 164) and early 2000s (e.g., IODP Exp. 204): Pressure core tools advanced rapidly (JNOC corer, Hyacinth, Fugro)

By 2003:

—No way to interrogate multiple physical properties of hydrate-bearing sediments recovered in pressure cores, but could X-ray the cores with Geotek instrumentation

—Becoming clear that depressurizing the cores destroyed sediment structure and made it impossible to obtain meaningful physical measurements

2004: We proposed (to the DOE/Chevron JIP) building an instrument that could receive a pressure core and measure its seismic, strength, and electrical properties. Met Geotek in Atlanta to discuss plans.

2005:

–First deployment of the **Instrumented Pressure Testing Chamber** (IPTC) on DOE/Chevron JIP Phase I pressure cores from Gulf of Mexico

–Proposed and were funded for development of **effective stress cell** by Joint Oceanographic Institutions (IODP) and DOE/Chevron JIP

Evolution of the PCCT (2)

2007: Carolyn moved from Georgia Tech to USGS

2007-08: Georgia Tech analyzed pressure cores from NGHP (India) & UBGH 1 (Korea)

2009: IPTC informally transferred to USGS Gas Hydrates Project in Woods Hole

2010: Georgia Tech proposed development of suite of other tools (e.g., shear cell, bio cell) to interrogate cores and of the manipulator and cutter to move and trim pressure core.

2011: With DOE/Chevron JIP support, Georgia Tech commenced building the new tools and the manipulator and cutter, and the USGS automated and updated aspects of the IPTC and revised sensors to handle coarse-grained sediments.

2012: Technology transfer within JIP—AIST built its own IPTC

2013: Georgia Tech and the USGS deployed the full suite of Pressure Core Characterization Tools (PCCT) in Sapporo in collaboration with JAMSTEC and AIST.

Chevron JIP-sponsored activities

USGS

5 personnel total

IPTC refinements:
- Electronics
- High pressure manifolds
- New sensor development
- Digital data acquisition
- Operations manual
- Containerized shipping

Georgia Tech

4 personnel total (5 in Sapporo)

PCCT developments:
- Manipulator
- Cutter (2 types)
- Shear stress cell
- Effective stress cell
- Biological cell
- Controlled depressurization cell

USGS and Georgia Tech

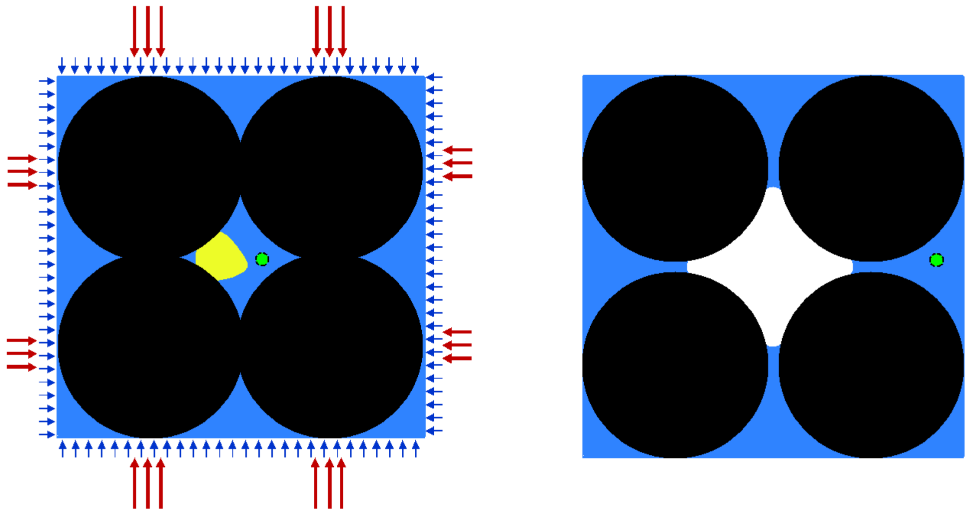
Several exchanges and a dry-run in Atlanta
Sapporo collaboration

Pressure Core Characterization Tools

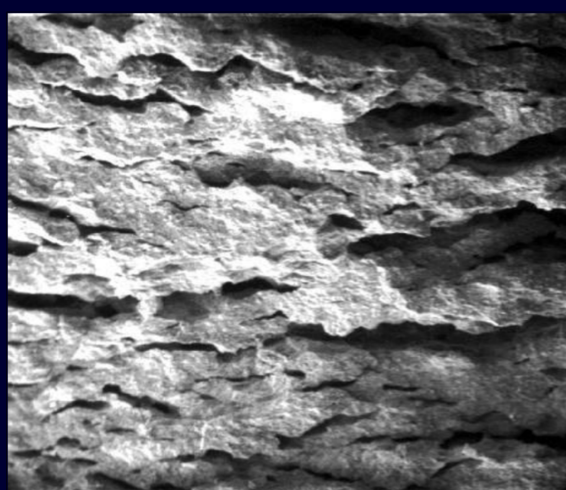
PCCTs

We got it !!!

… what do we do with it?
… valid parameters for simulators?



Standard Core: Massive Destructuration



Pressure Core

Pressure Core Characterization Tools PCCTs

Portable manipulator (MAN)
Core cutting tools (SAW and GUI)

Instrumented pressure testing chamber (IPTC)
Effective stress cell with flexible wall confinement (ESC)
Controlled de-pressurization (CDP)
Direct shear chamber (DSP)
Bio-sampling and reactor chambers (BIO)

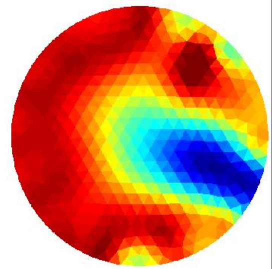
General specifications:

Nominal core length: 1m
Core/liner diameter: ID=57 mm; OD=63 mm
Devices capable of undertaking 35MPa (5000 psi)
Operation <21MPa (<3000psi)
Portable + Modular Design

Instrumentation → Properties

Pre-production testing

Temperature & pressure (inside the core)
P-wave & S-wave velocity
Compressibility under zero-lateral strain
Shear strength (penetration and direct shear)
Electrical conductivity
Hydraulic conductivity
Thermal conductivity
Pore fluid sampling (without dissociation)



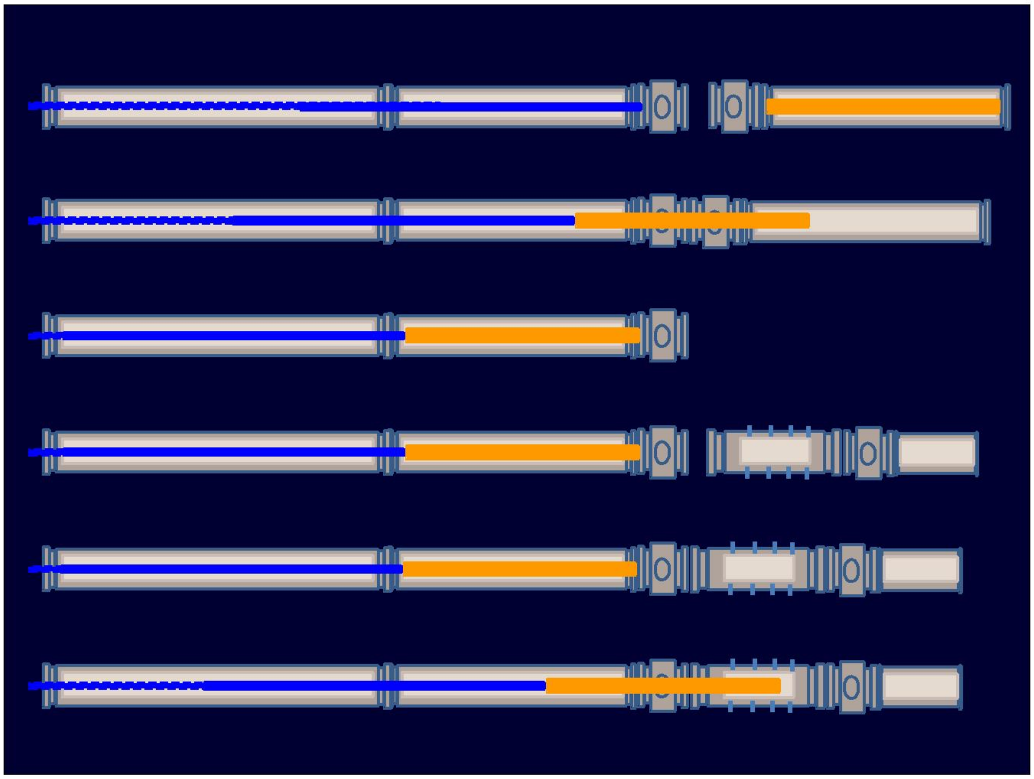
Production monitoring

Most properties above
Additional:
volume contraction upon dissociation

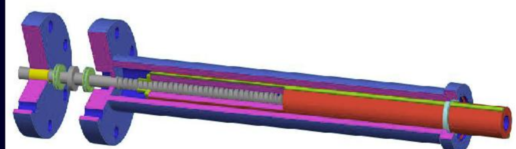
Post-dissociation properties

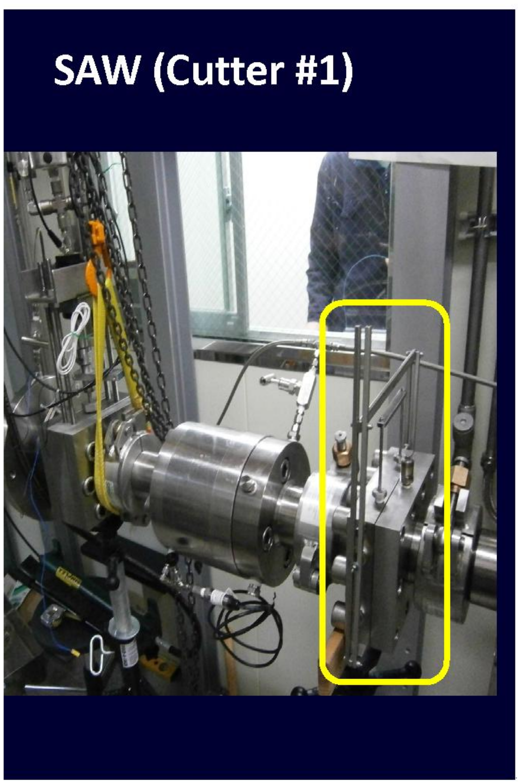
All above

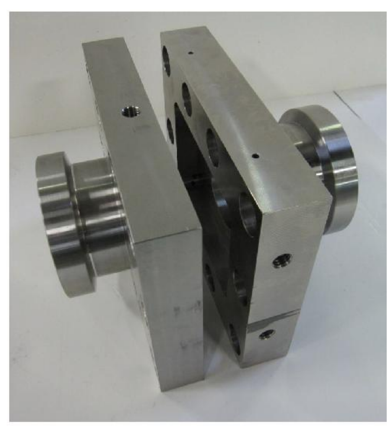
Operation



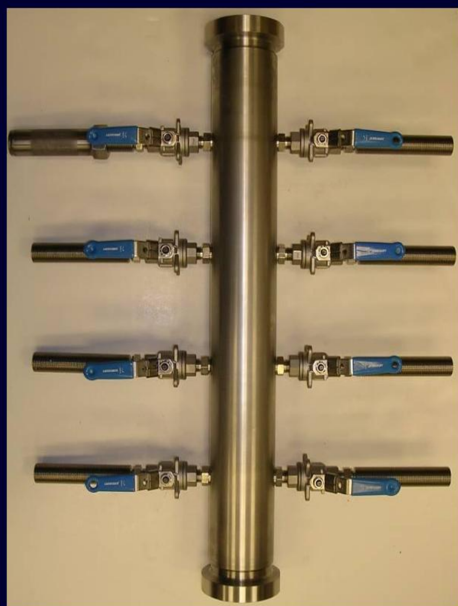

Manipulator MAN

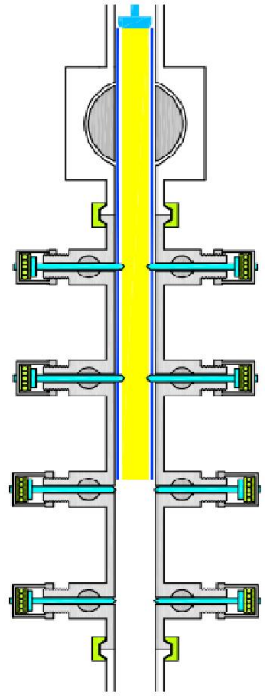


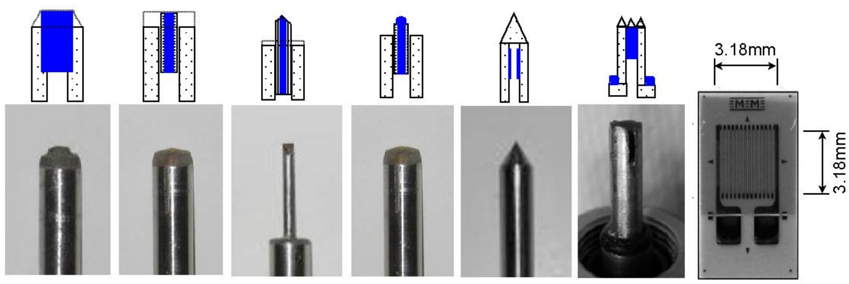

SAW (Cutter #1)



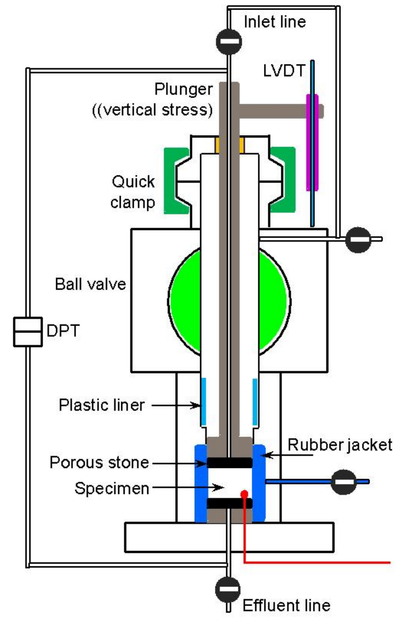
IPTC



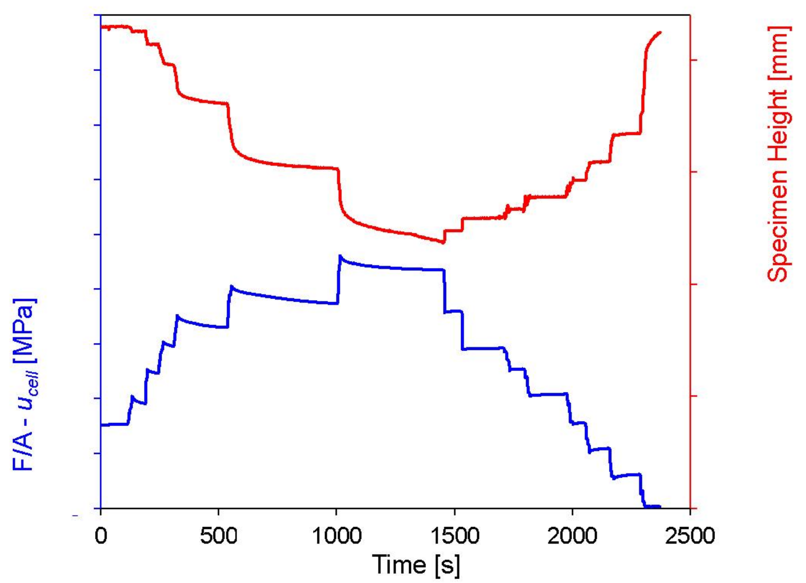




ESC Effective Stress Chamber

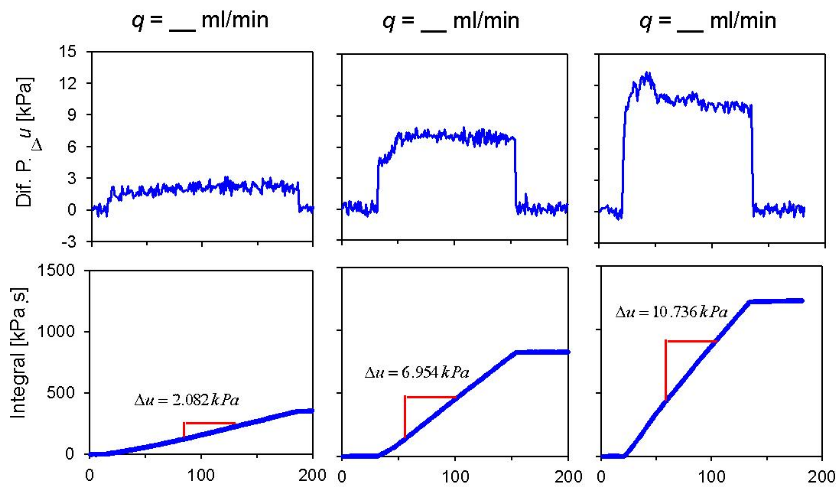


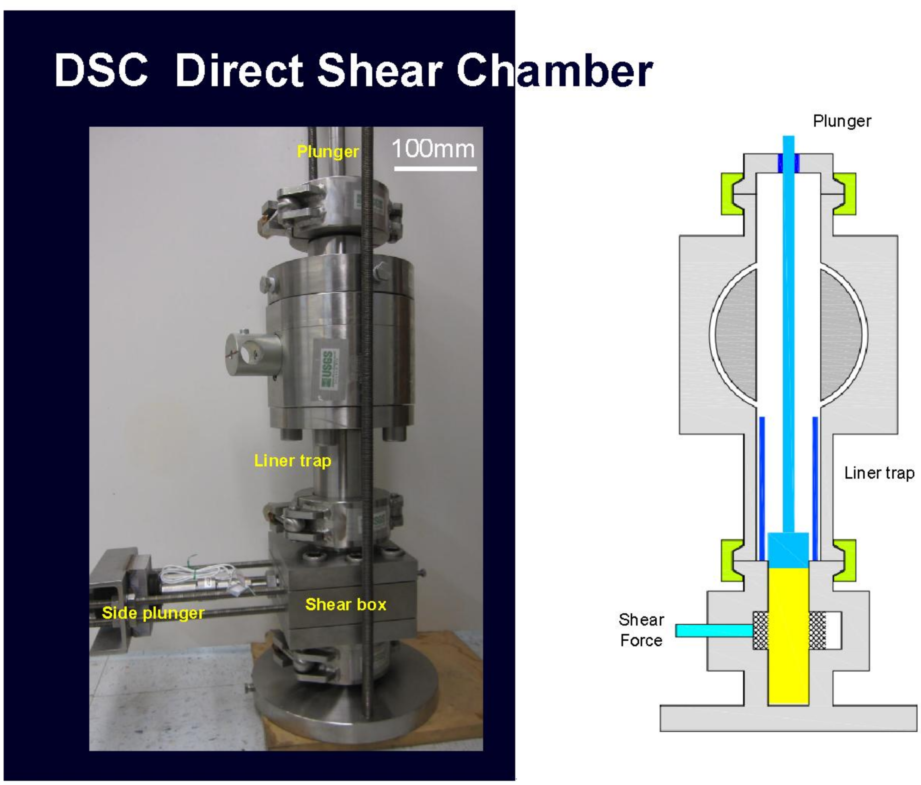
Loading and Unloading



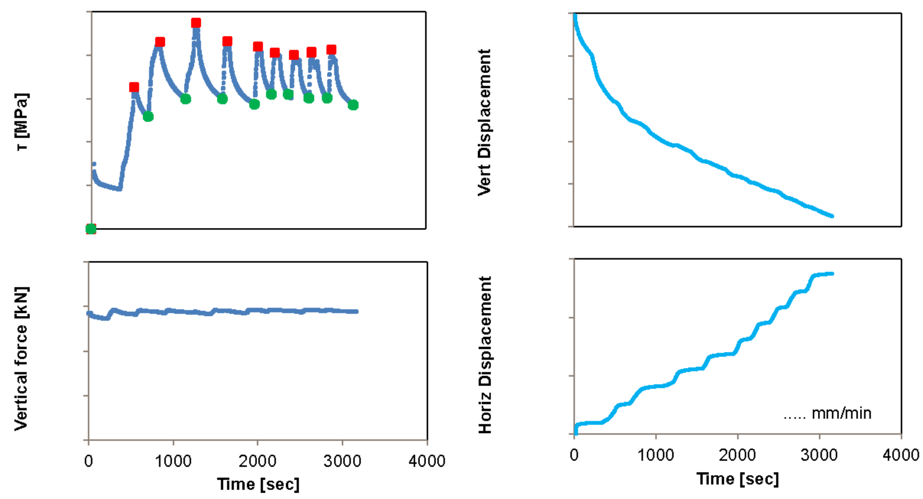
Typical data - Processing

$$k = \frac{q}{iA} \xrightarrow{i=\frac{\Delta u}{\gamma L}} k = \frac{\gamma L}{A}\frac{q}{\Delta u}$$

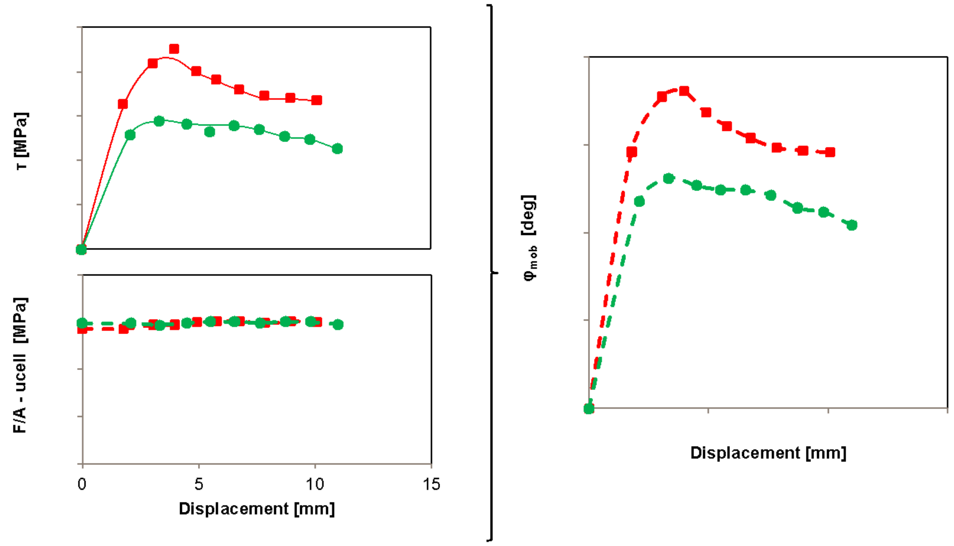




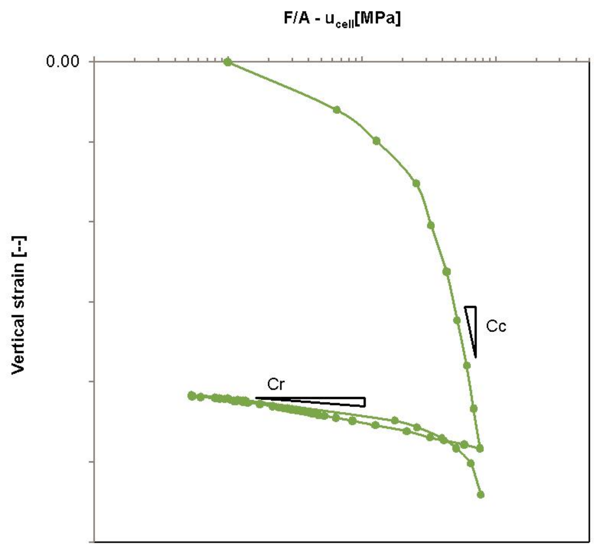
Shear Load

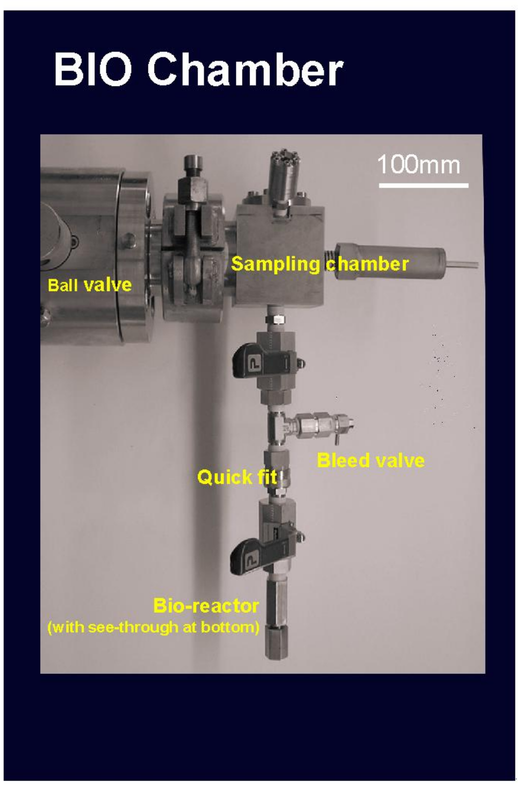


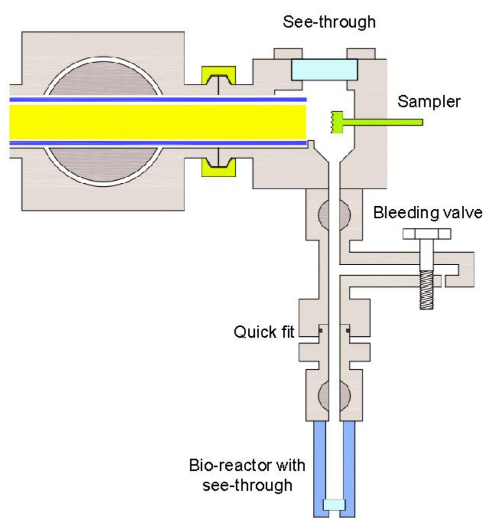
Shear Strength



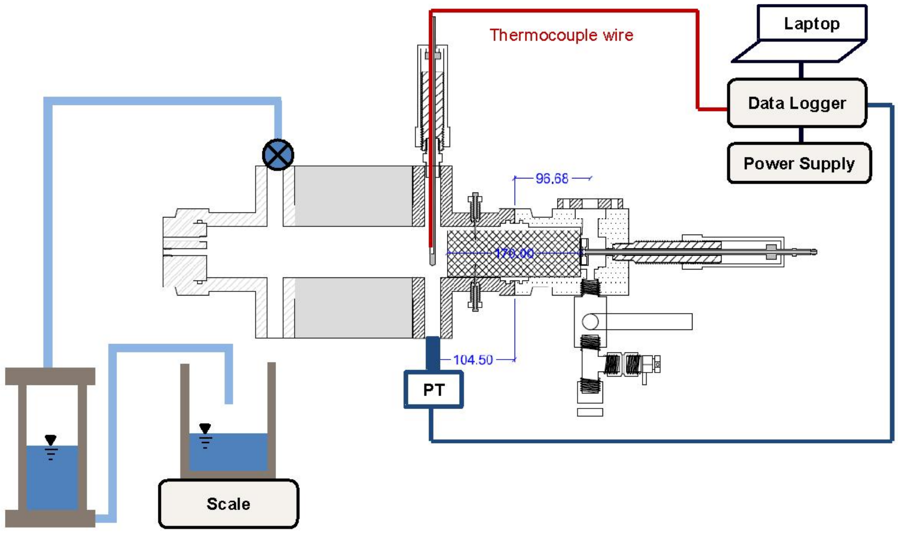
Post-dissociation compressibility







Experimental Configuration



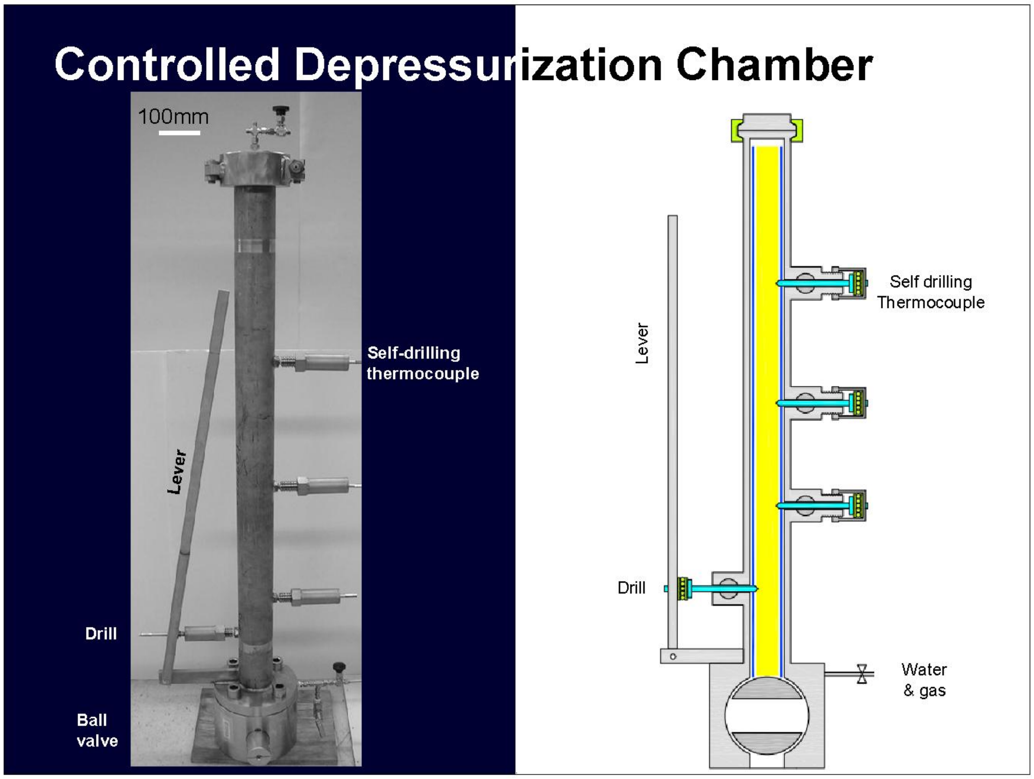
- Specimen length: 17 cm
- Note lack of collocation between temperature sensor and specimen

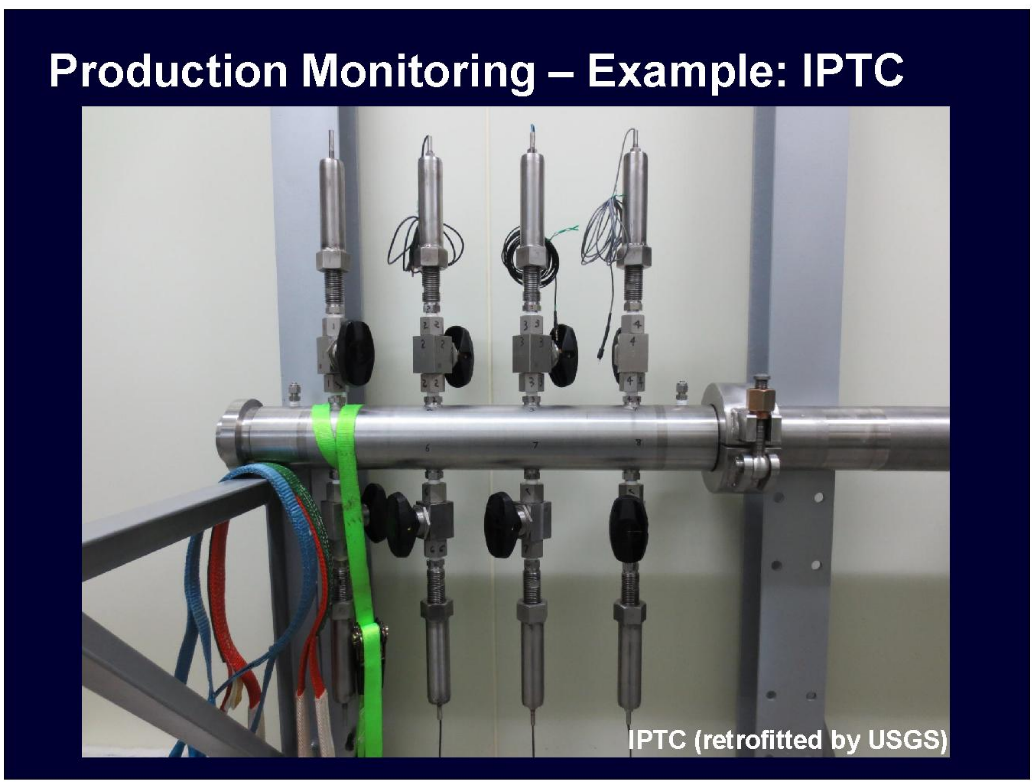
2 days

11 days

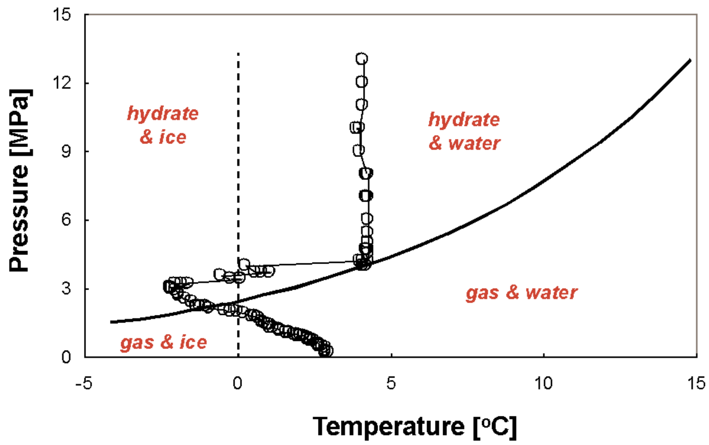
24 days

32 days

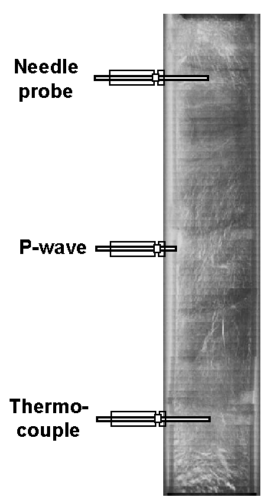

Controlled Depressurization Chamber
100mm
Self-drilling thermocouple
Lever
Drill
Ball valve
Self drilling Thermocouple
Lever
Drill
Water & gas

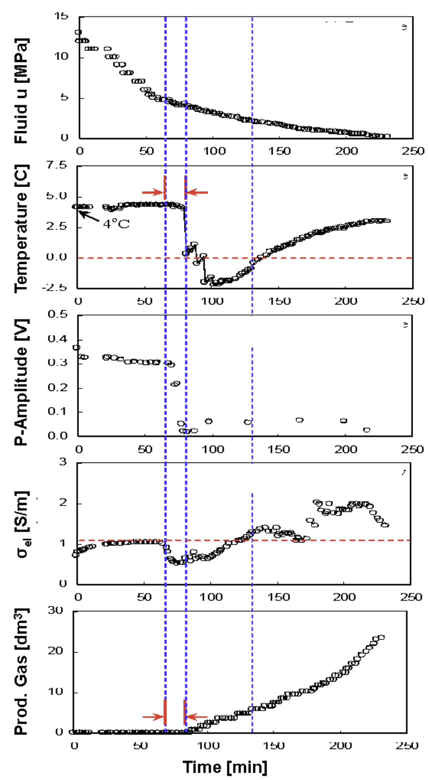

Production Monitoring – Example: IPTC
IPTC (retrofitted by USGS)

Production Monitoring

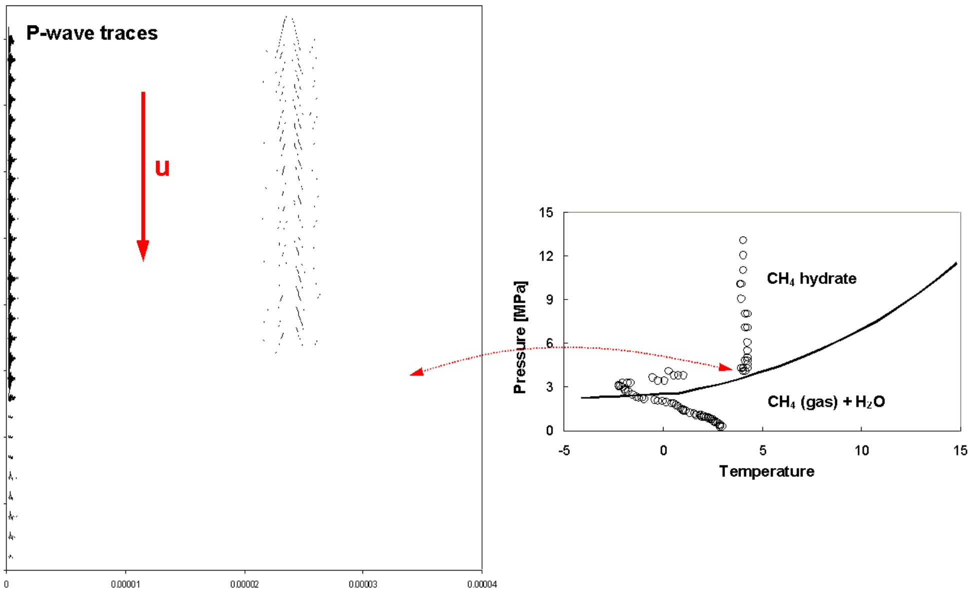


Production Monitoring



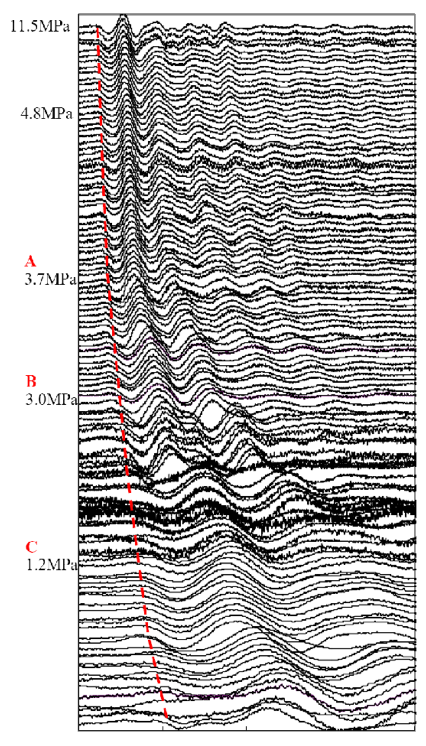


Production Monitoring: P-Waves



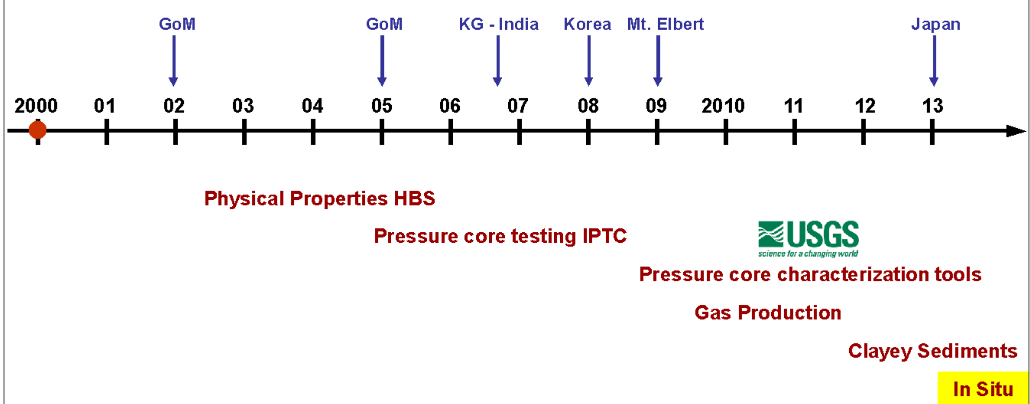
Production Monitoring:

S-waves



Summary

Study of Hydrate Bearing Sediments



Sediment Characterization - Strategy

Index properties

Reconstituted specimens at proper σ'
without hydrate
with hydrate

→ any core

Pressure cores within stability field
without σ' control
reloaded to in-situ σ'

→ production studies

In-situ tests

→ pressure cores

PCCTs – Examples of Lessons Learned

Pre-Arrival: map of operations area, test plan for each core, and adequate 'utilities' (e.g., electrical, compressed air, etc.)

Safety: Do not rush analyses. Anyone has the right to halt operations for perceived safety reasons. Overhead hoist system is necessary to prevent injury when moving heavy devices.

General: Fill and drain ports. Maintain a large reservoir of seawater. Clean devices and parts after each operation.

Device specific: IPTC operator and electronics person should face each other. PCCT devices need to be proximal to the manipulator. Inspect cutter blade and manipulator ball valve after each use.

APPENDIX 2

Components of Pressure Core Characterization Tools

for the analysis of:

hydrate-bearing sediments
gas-charged sediments
gas shales
coal

Pressure Core Characterization Tools PCCTs

Portable manipulator (MAN)
Core cutting tools (SAW and GUI)

Instrumented pressure testing chamber (IPTC)
Effective stress cell with flexible wall confinement (ESC)
Controlled de-pressurization (CDP)
Direct shear chamber (DSP)
Bio-sampling and reactor chambers (BIO)

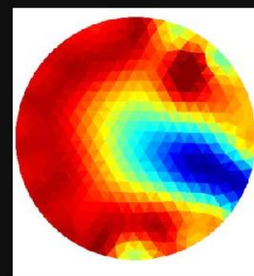
General specifications:

Nominal core length: 1m
Core/liner diameter: ID=57 mm; OD=63 mm
Devices capable of undertaking 35MPa (5000 psi)
Operation <21MPa (<3000psi)
Portable + Modular Design

Instrumentation → Properties

Pre-production testing

Temperature & pressure (inside the core)
P-wave & S-wave velocity
Compressibility under zero-lateral strain
Shear strength (penetration and direct shear)
Electrical conductivity
Hydraulic conductivity
Thermal conductivity
Pore fluid sampling (without dissociation)



Production monitoring

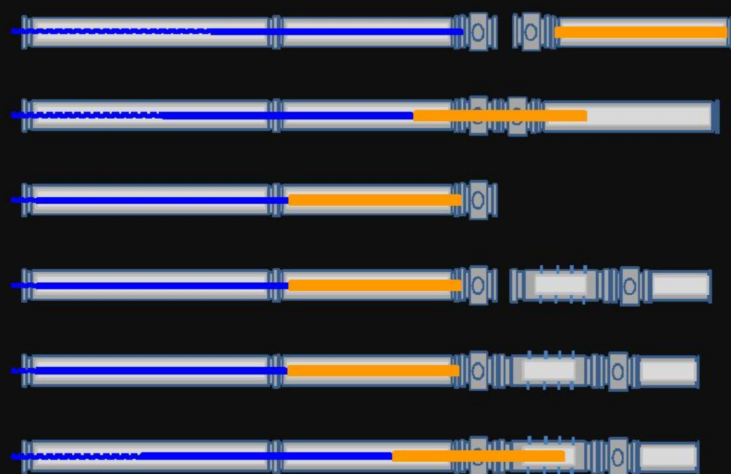
Most properties above
Additional:
volume contraction upon dissociation

Post-dissociation properties

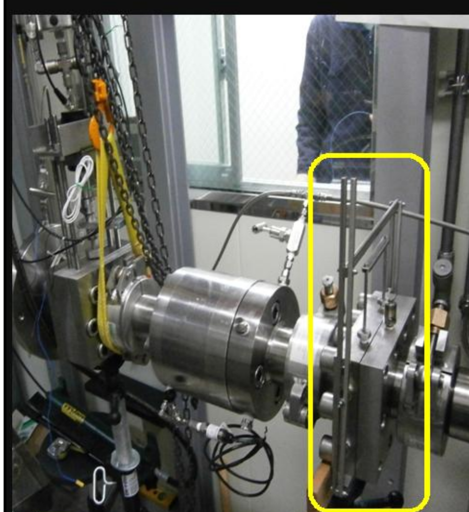
All above

Manipulator MAN

click on image to play movie



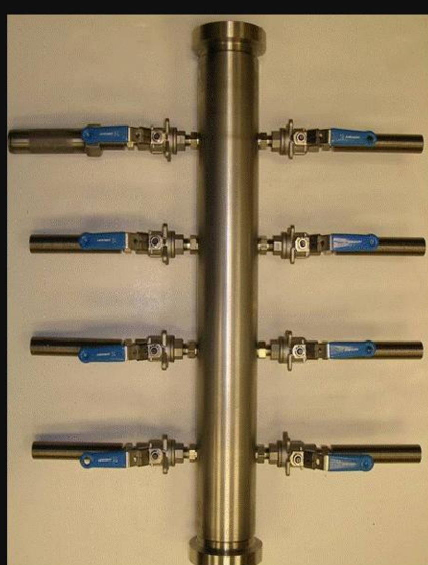
Cutters CUTs

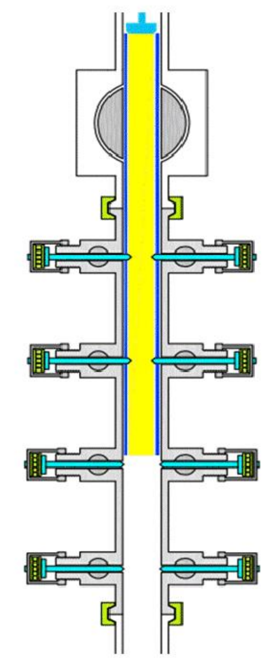


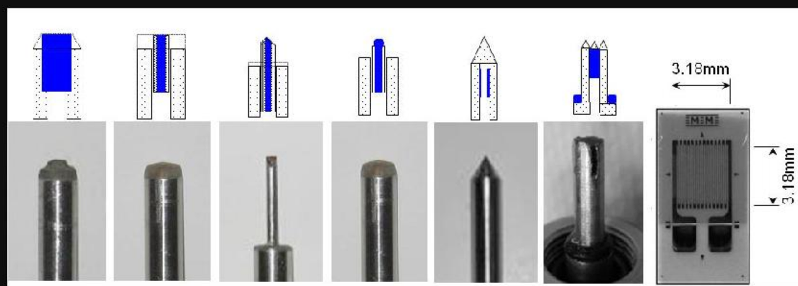
Cutters CUTs

click on image to play movie

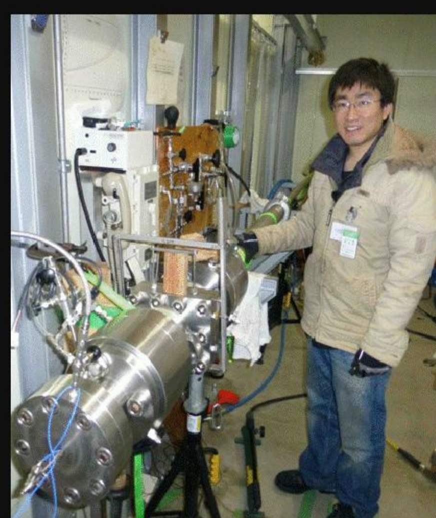
IPTC







ESC Effective Stress Chamber



ESC Effective Stress Chamber

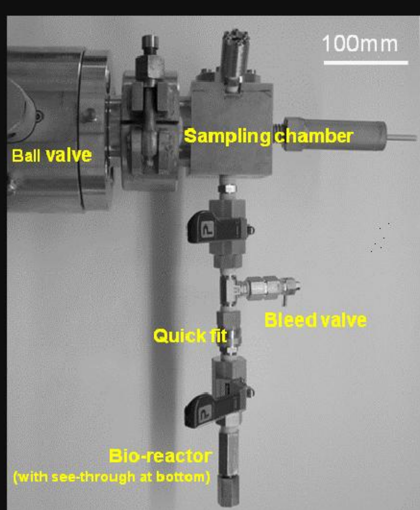
click on image to play movie

DSC Direct Shear Chamber

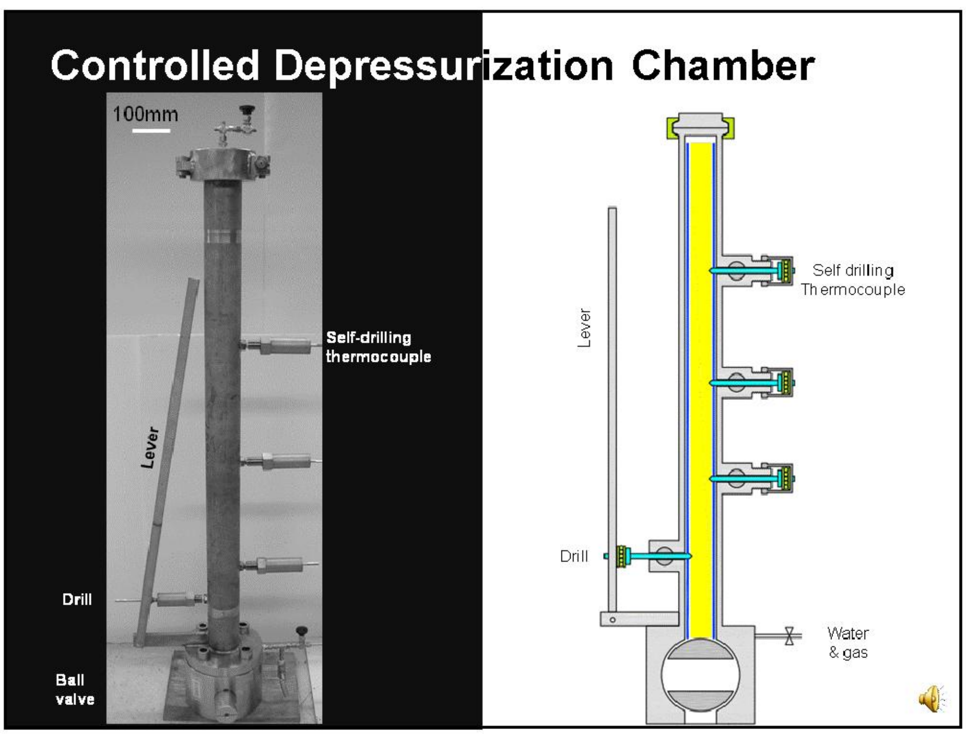
DSC Direct Shear Chamber

click on image to play movie

BIO Chamber



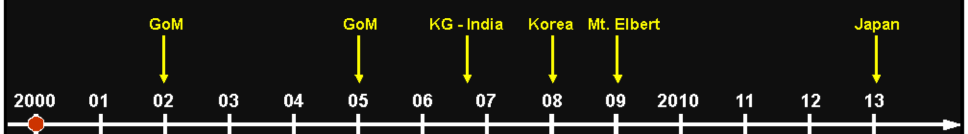

BIO Chamber
click on image to play movie


Controlled Depressurization Chamber
100mm
Self-drilling thermocouple
Lever
Drill
Ball valve
Self drilling Thermocouple
Lever
Drill
Water & gas

Controlled Depressurization Chamber

click on image to play movie

Study of Hydrate Bearing Sediments



Physical Properties HBS

Pressure core testing IPTC

Pressure core characterization tools

Gas Production

Clayey Sediments

In Situ

Sediment Characterization - Strategy

Index properties

Reconstituted specimens at proper σ'
without hydrate
with hydrate

any core

Pressure cores within stability field
without σ' control
reloaded to in-situ σ'

production studies

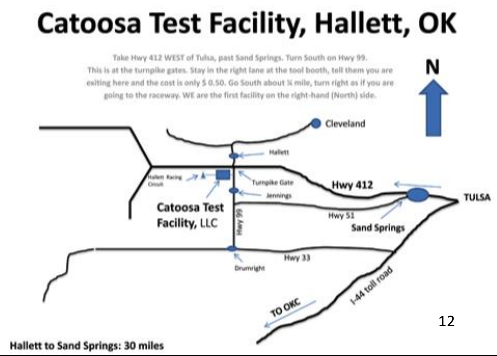
pressure cores

In-situ tests

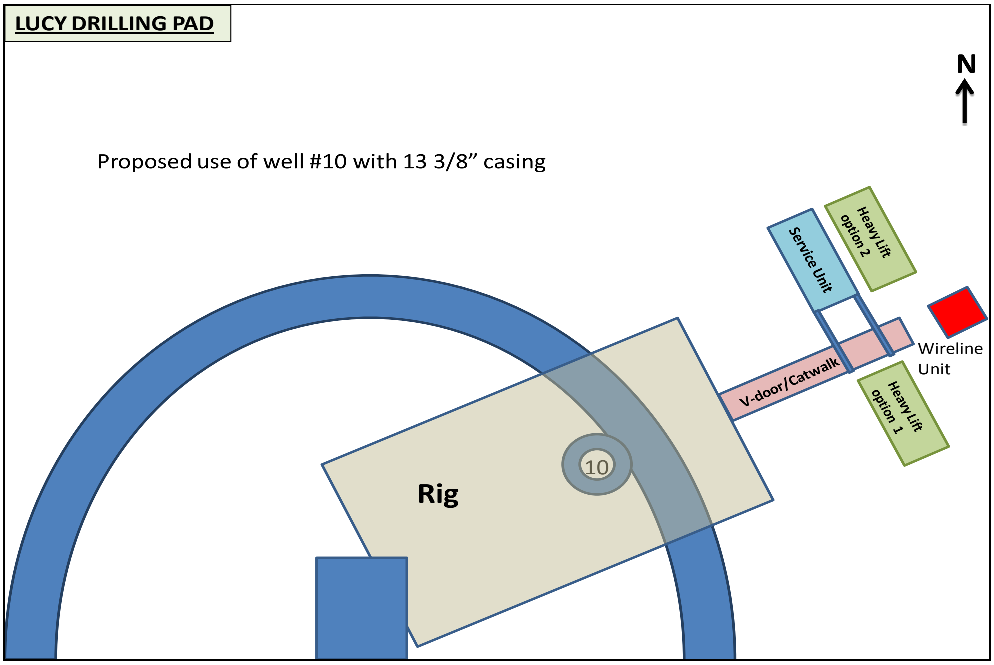
APPENDIX 3

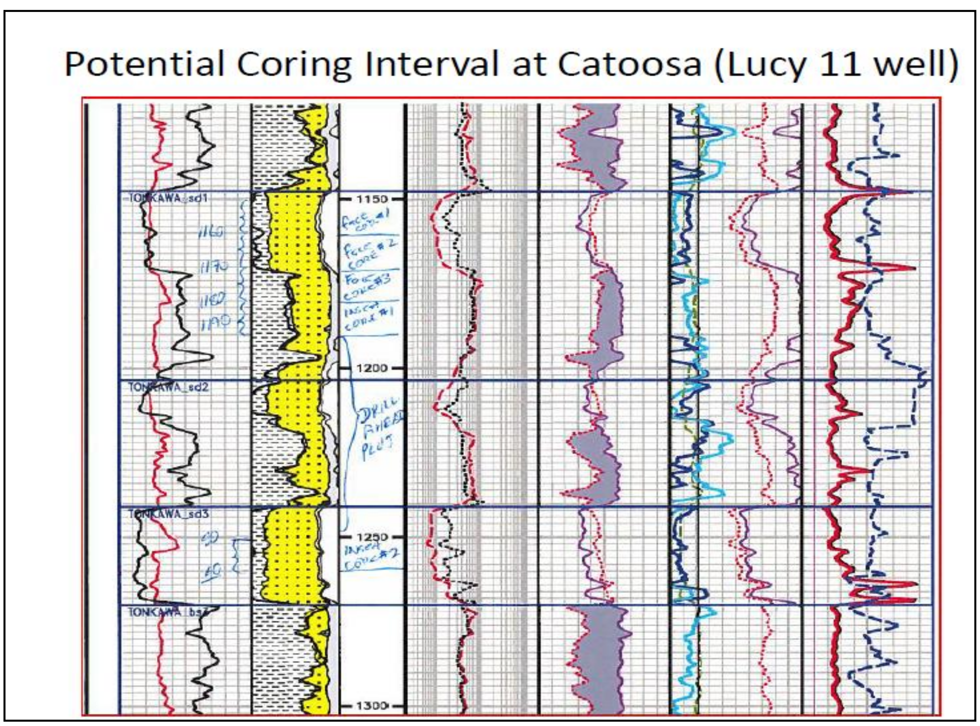
Catoosa Testing Facility, Hallet, OK

- Former Amoco and GRI site at Catoosa, recently purchased by private individuals and relocated to nearby Hallet for better variety of geologic formations.
- Wellbore data (logs, cores) at the new site are being examined along with other near-by industry wells to get best picture of subsurface conditions in order to optimize the onshore drilling test.
- Rig 11 is optimal for the test, a top drive rig with 107 ft double mast derrick, situated on a pivoting rail system. This allows the rig to pivot with pipe in the derrick from one wellbore to another very quickly with no down time.
- The data acquisition unit for Rig 11 uses the Sperry-Sun Drilling Services' Integrated System for Information Technology and Engineering (INSITE™), which allows for real-time data that can be viewed from the rig or data acquisition room.
- Large 120 foot by 90 foot warehouse and office complex with 4 self-contained offices, an electronics lab, a large conference room and a huge full service machine shop, equipped with a 5 ton overhead crane open to customer use.

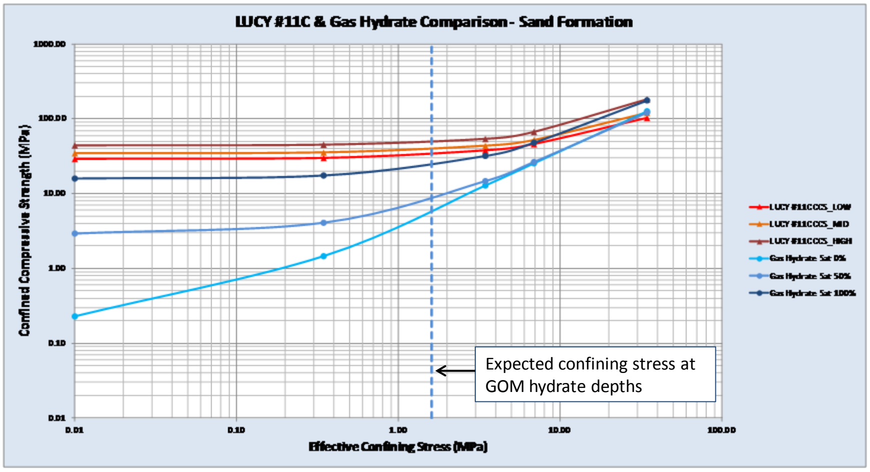


Rig 11 Site Map CTF


LUCY DRILLING PAD
N
Proposed use of well #10 with 13 3/8" casing
Heavy Lift option 2
Service Unit
Wireline Unit
V-door/Catwalk
Heavy Lift option 1
10
Rig


Potential Coring Interval at Catoosa (Lucy 11 well)
TONKAWA_sd1
TONKAWA_sd2
TONKAWA_sd3
1150
1200
1250
1300

COMPRESSIVE STRENGTH COMPARISON
Potential Catoosa Coring Intervals vs. Hydrates



17