Alaska Hydrate Project Overview

Methane Hydrate Production from Alaska Permafrost

NETL/DOE DE-PS26-01NT41331
Anadarko Petroleum Corporation
Maurer Technology Inc.
Noble Drilling Corporation

Methane Hydrate R&D Conference
Westminster, Colorado
September 29-30, 2003

Tom Williams, Bill Liddell, & Richard Sigal

Outline

- Project overview, status and highlights to date
- Overview of operations
  - Overview of Arctic platform
- Review future plans
- Reservoir characterization activities

Map of North Slope Showing Location of Hot Ice #1

Background

- Anadarko Petroleum Corp (APC) Became Aware of DOE Hydrate RFP through Maurer Technology
  - Created partnership between Anadarko, Maurer Technology and Noble in 2Q01
  - Maurer has excellent contacts within DOE and has worked on numerous DOE contracts
  - Noble has been working on novel advanced drilling technology
  - APC has acreage and technical expertise
- Received Phase I award in 4Q01
  - Began assessment of hydrate potential on the North Slope of Alaska
  - Began working on Core Lab and Arctic Platform designs
  - Began developing well plan for Phase II activity

Objectives

- Primary objectives
  - Drill, core and test for hydrates
  - Design, build and field test mobile core lab to measure hydrate filled sediments
  - Design and test drilling methodology to core permafrost, coal seams and hydrates with minimal damage
  - Characterize hydrate-filled sediments and reservoir at large
- Secondary objectives
  - Develop process to operate outside narrow weather window
    - Test Arctic platform
  - Test light-weight rig
  - Test ability to operate “roadless”

Phase I Deliverables

- ✓ Digital Map of well locations
- ✓ Well log correlation sections
- ✓ Seismic maps and sections showing stratigraphic and lithologic units within the gas hydrate stability zone
- ✓ Reservoir modeling report
- ✓ Well Data for control wells used for site selection
- ✓ Site Selection Plan
- ✓ Testing and analytical procedures report (Topical Report)
- ✓ Well Plan
- ✓ Phase I Report

Additional Phase I Achievements Beyond Phase I Contract Obligations

- ✓ Topical Reports from University of Oklahoma and the Drilling Research Center on Core Apparatus and Testing
- ✓ Three reports from the University of Alaska Anchorage
  - ➢ Geologic Research of Well Records
  - ➢ Water Generated During Production of Gas Hydrates
  - ➢ Permafrost Foundations/Suitability as Tundra Platform Legs
- ✓ Support of other DOE Hydrate projects including contribution to Westport's Core Handling Manual
- ✓ Hydrate Preservation in Cores, Report by George Moridis, LBNL
- ✓ USGS (Kirby et al) Report on Dissociation of Hydrates at Elevated Pressures

Additional Phase I Achievements Beyond Phase I Contract Obligations

- ✓ Arctic Platform Video
- ✓ Numerous News Articles, Presentations and Participation and Publications at Hydrate Meetings and Workshops
- ✓ Permafrost Data from Cores for Future Study
- ✓ First Ever N. Slope Coal Cores provided to the USGS for Coalbed Methane Study

Phase II Participants

- ***Maurer Technology Inc.*** – Project Coordination, Project Management, DRC Testing, and Engineering Support.
- ***Anadarko Petroleum Corporation*** – Overall Project Management for the Design, Construction, and Operation of the Arctic Drilling Platform, the Mobile Core Lab, the Field Coring Operations, Permits, Leases, and Cost Share.
- ***Noble Engineering and Development*** – Provided Personnel and Real-Time Data Collection and Transmitted Digital Data and Video to Project Participants Located Offsite and Wellsite Drilling Personnel.

Phase II Participants

- ***University of Alaska*** – Supports Studies on Geology, Tundra, and Produced Water Disposal.
- ***Lawrence Berkley National Lab (LBNL)*** – Reservoir Modeling Used for Well Test Planning and Onsite Portable X-ray Scanner and Wellsite Operator (George Moridis and Barry Friefeld).
- ***Sandia National Lab*** – Provided Downhole Mud Pressure and Temperature Recording Tool.
- ***Pacific National Lab (PNL)*** – Provided Portable Infrared Scanner.
- ***United States Geological Survey (USGS)*** – Provided Synthetic Core for Drilling Tests, Phase Behavior Model for Hydrates, Pressure Vessels for Hydrate Core Storage and Technical Advice. Modeling of Hydrate Preservation and Dissociation (Steve Kirby). Provided Personnel for Coal Core and Analysis.
- ***Schlumberger Oilfield Services*** – Provided CMR Equipment Used in Mobile Core Lab and Two Onsite Analysts; and Well-Logging Services.
- ***Paulsson Geophysical Services*** – Scheduled for Vertical Seismic Profiling.
- ***Advisory Board*** – Craig Woolard, University of Alaska, Anchorage; Steve Bartz, Schlumberger; Steve Kirby, USGS; Tim Collette, USGS; Theresa Imm, Artic Slope Regional Commission; C. Sondergeld, University of Oklahoma; Richard Miller, University of Kansas; and David Young, Baker Hughes Inteq.

Phase II Deliverables

- Drilling and Coring Report (Task 9.2)
- Well Logging Report (Task 10.0)
- Core and Fluid Analysis Report (Task 11.0)
- Well Completion Report (Task 13.0)
- Well Testing Report (Task 15.0)
- Hydrate Reservoir Characterization and Modeling Report (Tasks 17, 18, &19)
- Post Well Analysis (Task 21)
  - Engineering report
  - Lessons learned
  - Costs vs planned budget
  - Successes and failures of field program
  - Potential of future hydrate wells on the North Slope
  - UAA and UAF to study preserved core and provide summary results
- Final Report and Technology Transfer/Website

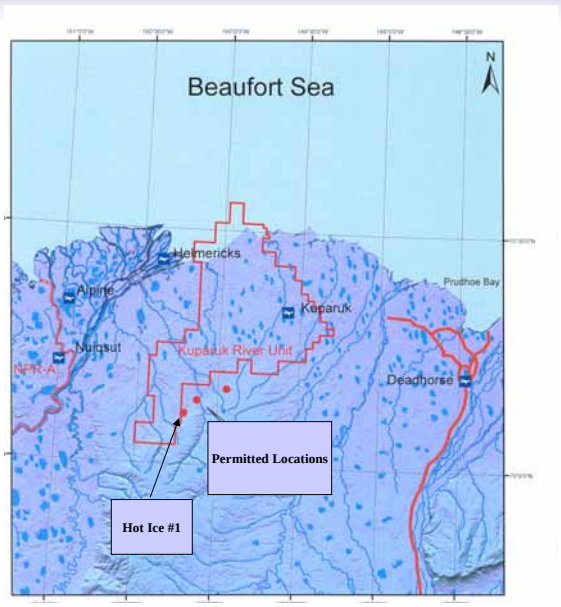
Project Highlights to Date

- Concept of early access and early surface occupation has been successfully demonstrated (or, it will be by the end of the Hot Ice project)
- Concept of low/minimal/virtually zero negative impact has been demonstrated (or, it will be by the end of the Hot Ice project)
- Working concept of the Arctic Platform has been demonstrated. Opportunities for improvement have been noted on this beta version.
- Leaving the temporary facility on location, loaded w/ equipment, has been demonstrated with minimum/no impact on surrounding wildlife and flora (plan to follow-up with a survey next summer.
- The facility was successfully operated as a “no discharge facility”

Project Highlights - Continued

- The ability to recover frozen core with minimal damage was demonstrated from the minimum footprint rig and platform The ability to drill/auger the piling holes using a rolligon was successfully demonstrated.
- No access roads were required. Ice 'trails' and ice 'work areas' were used to eliminate repetitive low impact environmental stress from low impact vehicles/rolligons and tracked vehicles.
- The ability to haul heavier loads by rolligons without negative impact was demonstrated.
- The ability to characterize the whole core on site was demonstrated.
- The ability to make Petrophysical measurements on core plugs at reservoir conditions was demonstrated.
- Development and demonstration on on-site lab.
- Live data from North slope to Houston and Washington D.C.

Operational Overview



Drilling Scope

- Use Dynatec 1500 UDR slim hole rig
- Obtain continuous 3.25” diameter core
- Monitor the drilling effort via a live data feed
- Control Fluid Temperature (-5 C)/Monitor DH Temperature
  - Utilize Sandia data logger to provide mud temperature, pressure and inclination

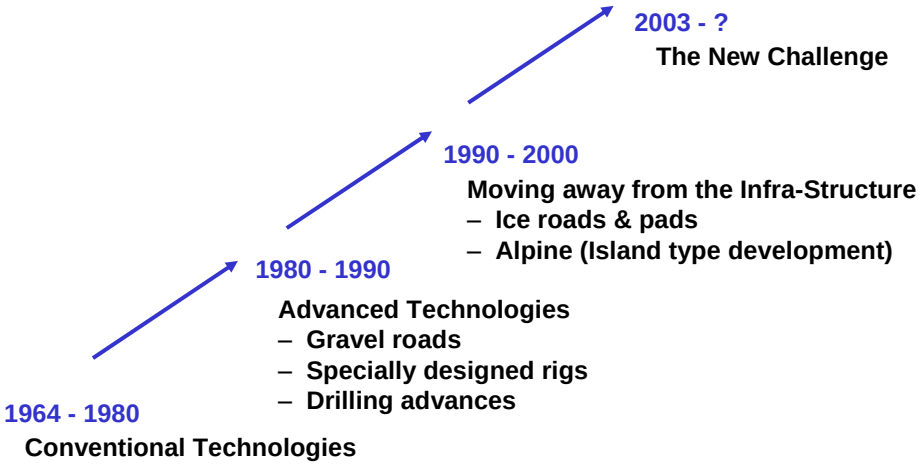
Arctic Platform Overview

- Why an Arctic Platform?
  - Flexibility for extended well test
  - Added environmental protection
  - Second well could be drilled quicker and cheaper
  - Extends testing window

Reward / Risk

- Reward
  - The Alaska North Slope is one of the remaining areas of North America where major oil and gas fields still can be found
- Risk
  - How to commercially find and develop these fields

Historic Response to Challenges

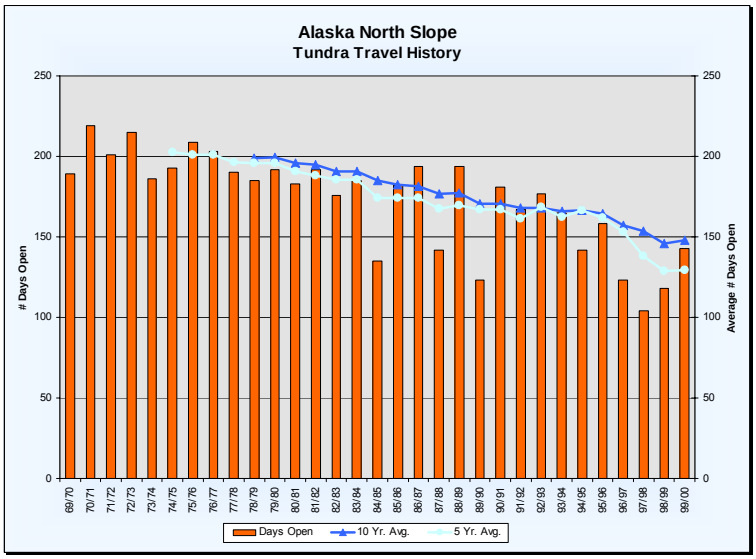


The New Challenge…

…Requires New Thinking and Innovation
(A Game Changer)

- How to expand the time window for exploration from effectively 3 -4 months to 9 months or more
- Essentially, how to drill more exploration wells per year and still be cost effective (low finding & development costs, F & D)
- How to reduce the evaluation of a discovery from 3 - 5 years to less than one year
- How to reduce development costs and remediation costs

Historical Tundra Travel Window



Drilling Location Scouting – Fall 2002

Anadarko's Arctic Platform -- Fast-track Test

- June, 2002 through August, 2002 the initial design phase was done
- August, 2002 to December, 2002 platform components were built and assembled
- Started installing platform January 20th, 2003
- Platform installed February 25th, 2003
- Spud Hot Ice #1 was on March 31st, 2003
- Suspended operations on April 21 due to weather. Plan to resume drilling and testing operations late 4Q03 or early1Q04

Platform Construction

The movie has been removed as the file is too large.

Platform Operations

Setting Support Containers

Operations Deck

Communications

Operations Deck

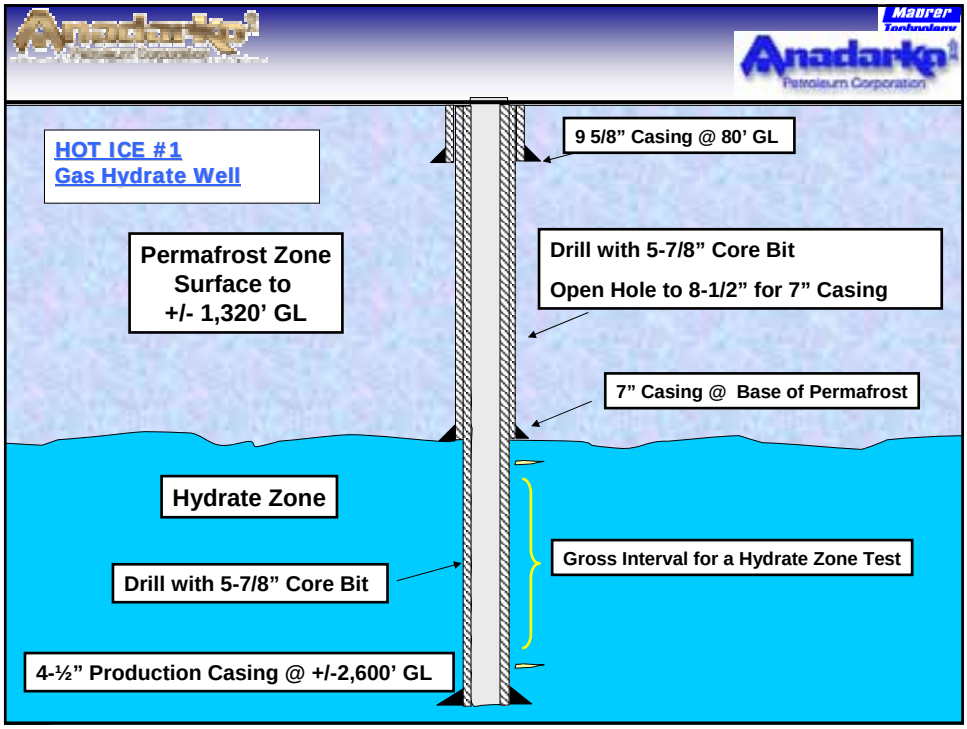
Rigging Up

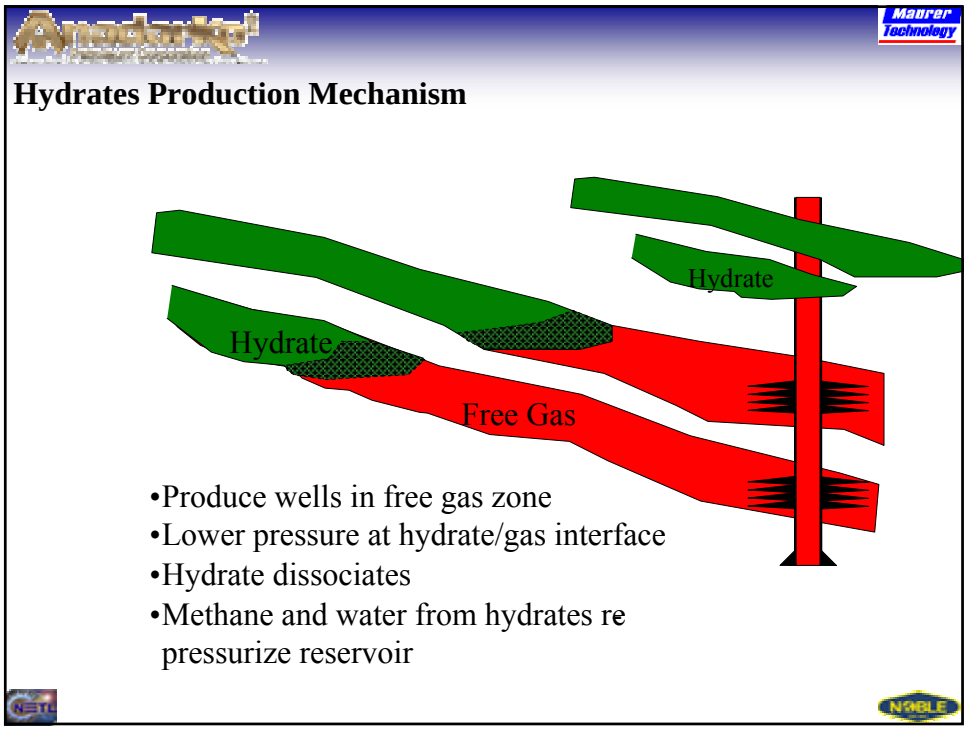
Rigging Up

Overhead View

Current Status and Jan ’04 Future Plans

- Resume Drilling Operations
  - Drill and core through the hydrate stability zone
- Completion and testing plans
  - Perform operations without any accidents or spills
  - Prove hydrates can be produced via depressurization
  - Obtain well data to calibrate reservoir simulator
- Data gathering objectives
  - Gather production rate data
  - Collect BHP data
  - Collect water and gas samples from hydrate zone
  - Conduct VSP
- 85 day schedule from mob to demob


HOT ICE #1
Gas Hydrate Well
9 5/8" Casing @ 80' GL
Permafrost Zone
Surface to
+/- 1,320' GL
Drill with 5-7/8" Core Bit
Open Hole to 8-1/2" for 7" Casing
7" Casing @ Base of Permafrost
Hydrate Zone
Gross Interval for a Hydrate Zone Test
Drill with 5-7/8" Core Bit
4-½" Production Casing @ +/-2,600' GL


Hydrates Production Mechanism
Hydrate
Hydrate
Free Gas
•Produce wells in free gas zone
•Lower pressure at hydrate/gas interface
•Hydrate dissociates
•Methane and water from hydrates re
pressurize reservoir

Sunny & -30ºF

Ground View - Healthy Tundra – Summer 03

Reservoir Characterization

Arctic Sunset – 2/14/2003

Hydrate Measurement Considerations

- Cores are unstable, i.e. they decompose into methane, water and sand.
- Core must be maintained at subzero temperatures during handling and measurement.
- Cores must simultaneously be pressurized and cooled to *in-situ* conditions for measurements.

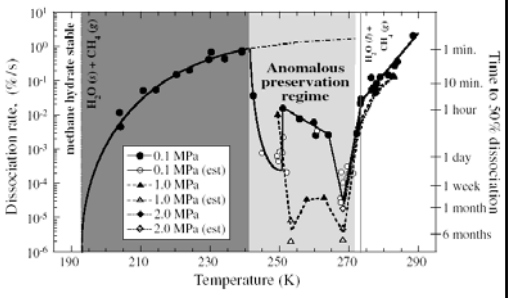
“Dissociation Rates of Methane Hydrate At Elevated Pressures And of a Quartz Sand-Methane Hydrate Mixture at 0.1 MPa”

Report of the Menlo Park USGS Research in Support of the Maurer/Anadarko/DOE Methane Hydrate Joint Industry Project Under the National Methane Hydrate Research and Development Program National Energy and Technology Program, Department of Energy

March 5, 2003

Stephen H. Kirby, Susan Circone, and Laura A. Stern
U.S. Geological Survey
345 Middlefield Rd. MS 977
Menlo Park, CA 94025

Report Prepared by Susan Circone



Hydrate Specific Exploration Problems Addressed

- Seismic velocities in hydrates for areal mapping and log evaluation
- Resistivity for log evaluation
- Hydrate saturation
- Hydrate dissociation rates
- Thermal conductivity for production modeling

Mobile Lab Measurement Capacities

Plug Testing Capabilities:

Pressure and Temperature:

- Compressional Velocity and Shear Velocity
- Dynamic elastic moduli
- Resistivity
- NMR
- Dissociation $S_{hydrate}$

Pressure:

- Pore volume compressibility
- Porosity
- Permeability

Ambient:

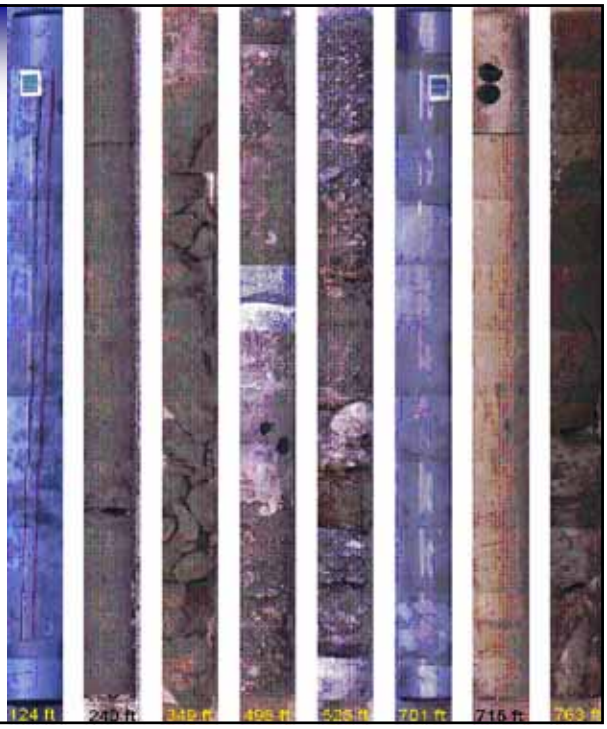
- Grain density
- Bulk densities (dry and saturated)
- Rw

On site analysis

Whole Core Measurements:

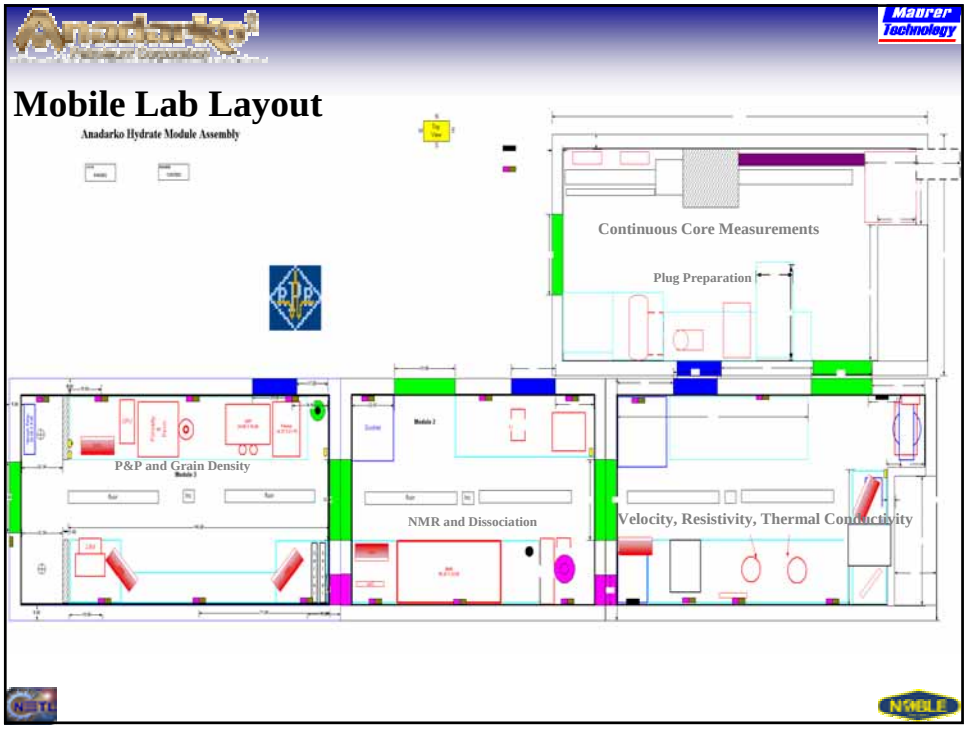
- Natural gamma ray
- Temperature scanning
- White light photography
- Compressional velocities
- Geological description
- CMR (Schlumberger)
- Portable IR Camera (Battelle Northwest Lab.)
- High Resolution Cat Scan (Lawrence Berkeley Lab)

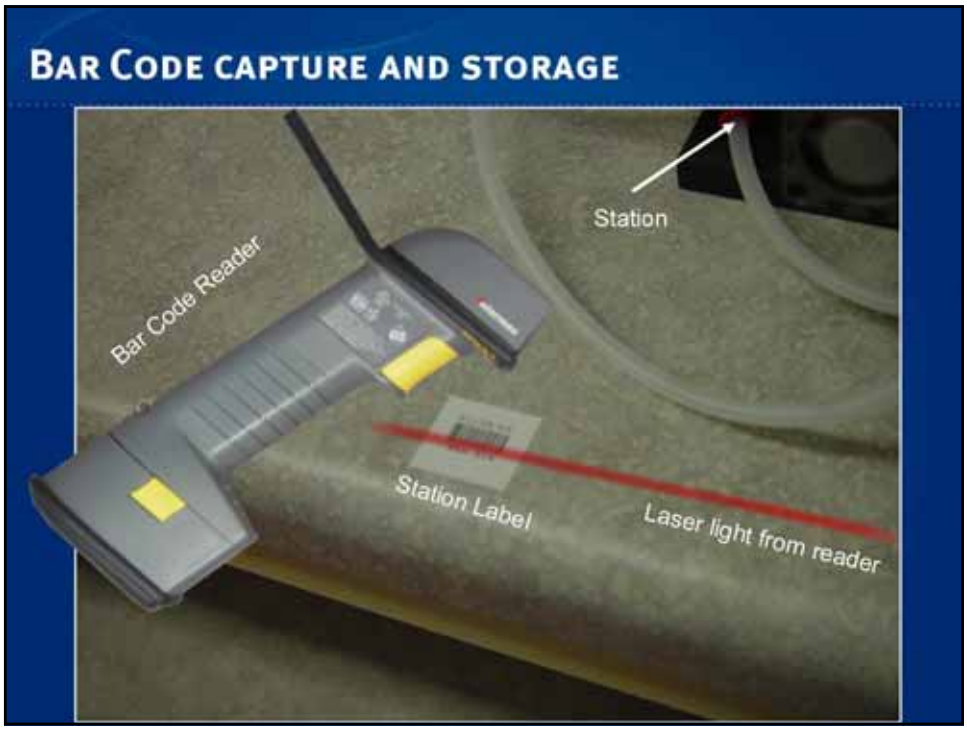
Representative Core Sections from Hot Ice #1 Well



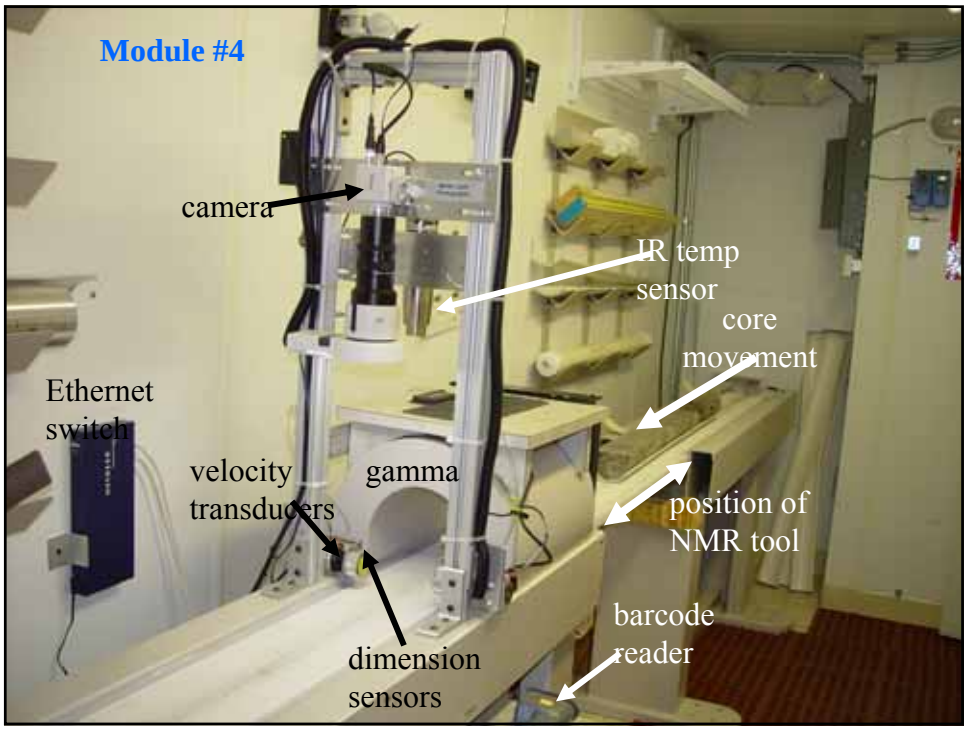
Note: Barcode, Core Plugs, and Variety of Lithology

Barry Freifeld LBNL X-Ray Scanner

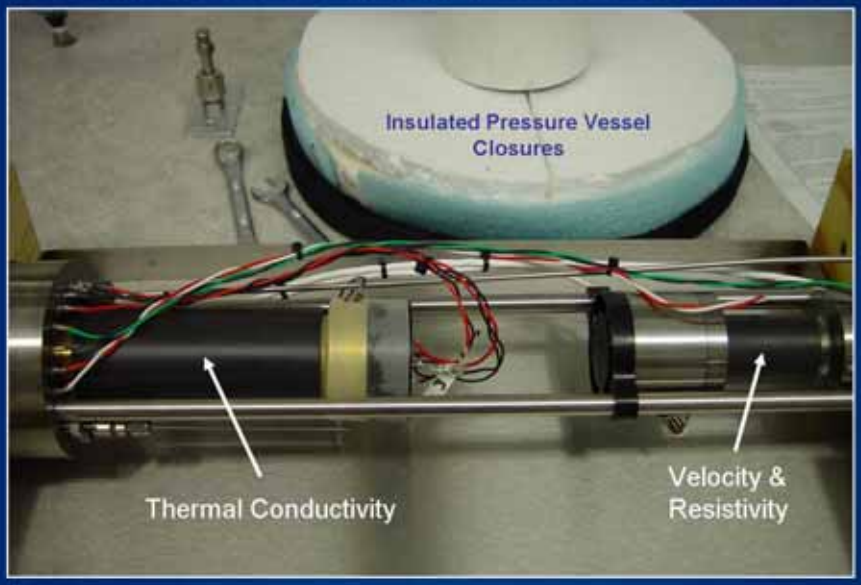

Mobile Lab Layout
Anadarko Hydrate Module Assembly
Maurer Technology
Continuous Core Measurements
Plug Preparation
P&P and Grain Density
NMR and Dissociation
Velocity, Resistivity, Thermal Conductivity
NOBLE


BAR CODE CAPTURE AND STORAGE
Station
Bar Code Reader
Station Label
Laser light from reader

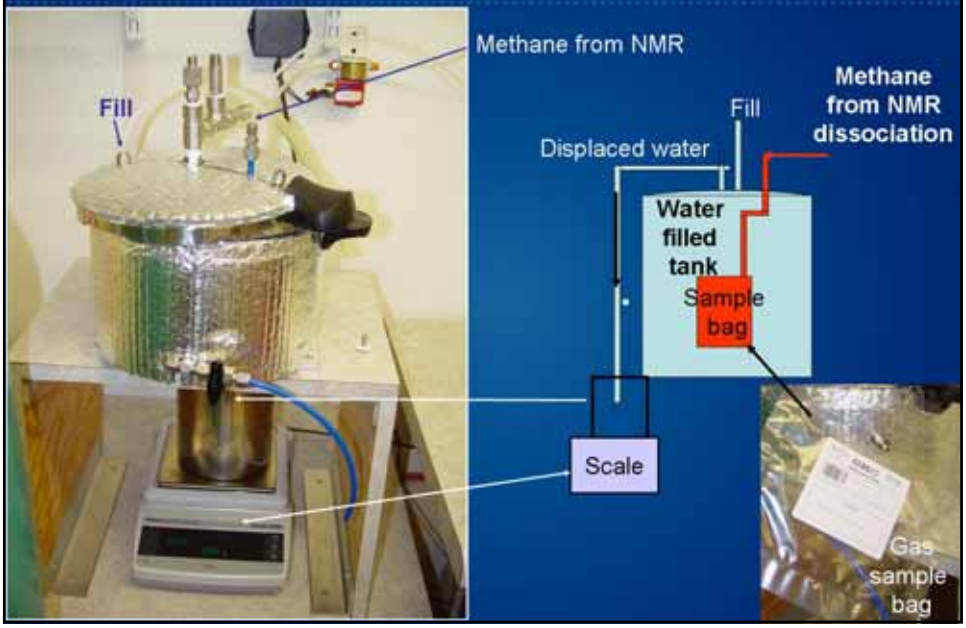

CORE PREPARATION
FELKER
Plugging
Slicing
Polishing
Cuttings

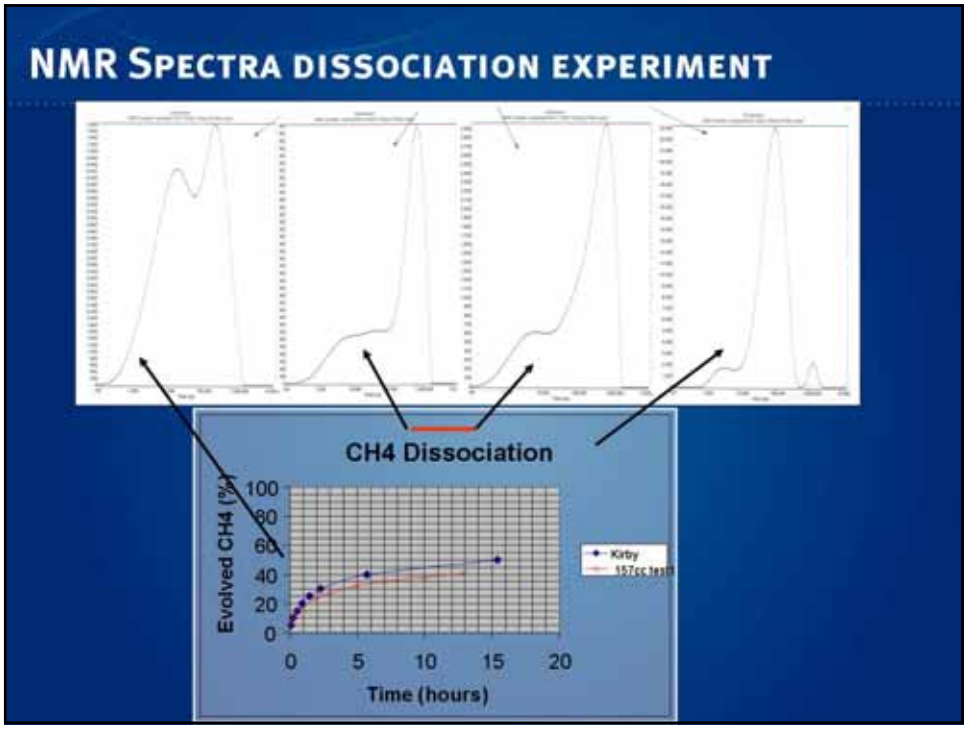

Module #4
camera
IR temp sensor
core movement
Ethernet switch
velocity transducers
gamma
position of NMR tool
barcode reader
dimension sensors

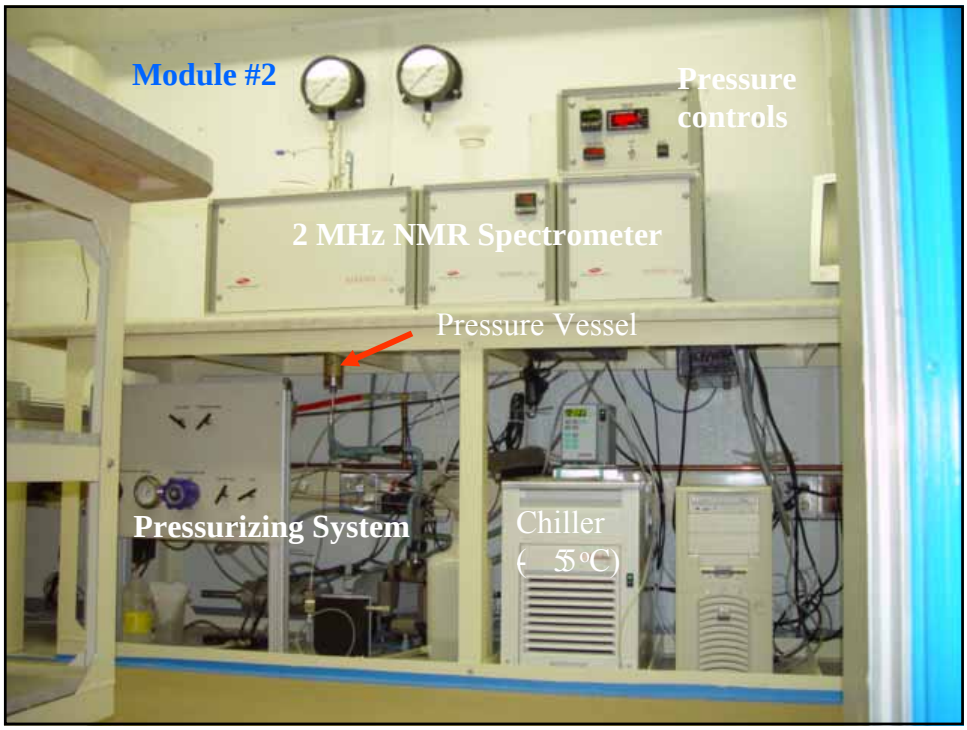
Internal Sample Measurement Systems



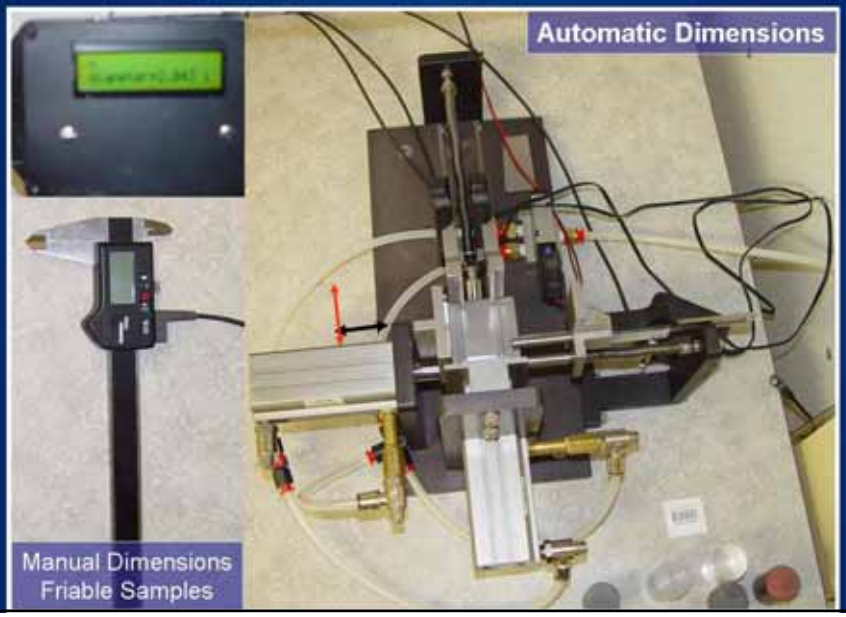
NMR Dissociation




NMR SPECTRA DISSOCIATION EXPERIMENT
CH4 Dissociation
Evolved CH4 (%)
100
80
60
40
20
0
0
5
10
15
20
Time (hours)
Kirby


Module #2
Pressure controls
2 MHz NMR Spectrometer
Pressure Vessel
Pressurizing System
Chiller
(- 5 °C)

AUTOMATED OR MANUAL CAPTURE



Data Measured on Sample 1117.6

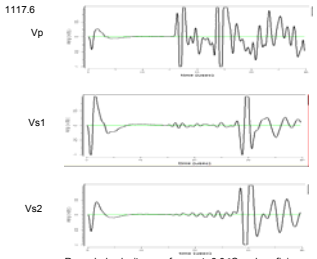
Length(mm)	26.797
Diameter(mm)	25.32
Weight(gms)	23.617
Grain_Volume(gms/cc)	8.13
grain density	2.665

Pressure(psi)	Porosity	Permeability(mD)
817.02	36.32	1620.4417
1217.82	35.33	1543.978
1827.36	34.42	1443.4373

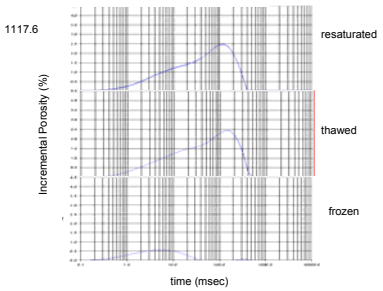
TEMPERATURE(C)=-6.83	
Pressure(psi)	Resistivity(ohm*m)
519.1	142.412
793.4	137.291
1065.2	129.588
1611.3	112.923
1888	104.589

		TEMPERATURE(C)=-6.83	
Pressure(psi)	Velocity_P(km/sec)	Velocity_S1(km/sec)	Velocity_S2(km/sec)
519.1	3.76	2.122	2.16
793.4	3.789	2.135	2.164
1065.2	3.789	2.138	2.164
1611.3	3.799	2.122	2.144
1883.1	3.809	2.113	2.135
2157.4	3.789	2.11	2.132

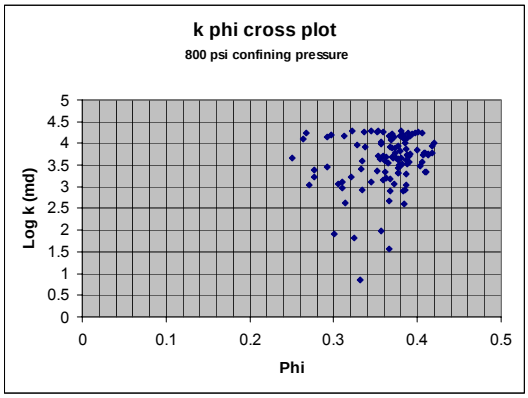
Thermal Conductivity (W/m*C)	2



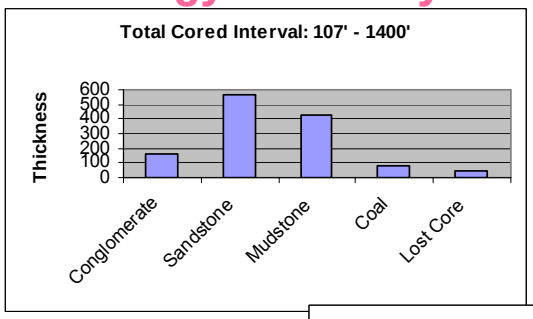
Recorded velocity waveforms at -6.0 °C and confining pressure of 2000 psi.

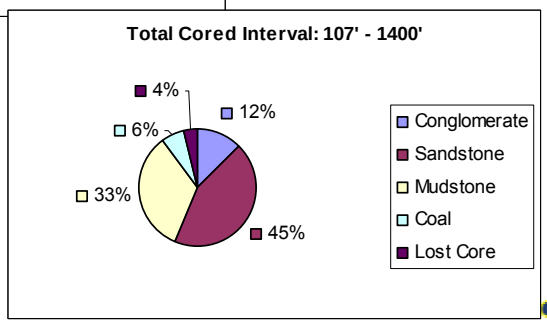


P & P Data



Lithology Summary





Mobile Core Analysis Lab Overview

Recalculation of Base of Hydrate Stability Zone

Information from the Hot Ice well and an analysis of the local geothermal gradient provided a new estimate for the base of the hydrate stability zone (BHSZ).

This re-analysis places the BHSZ at **2210 ft below the surface** at the Hot Ice location. This is **400 ft shallower** than the estimate based on regional maps from Collett et al. (1988).