Oil and Natural Gas Technology

DOE-BPXA Cooperative Agreement Award Number DE-FC-01NT41332

2Q2007 Quarterly Progress Report

Nineteenth Quarterly Report: April 2007 – June 2007

Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay – Kuparuk River Area on the North Slope of Alaska

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

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Office of Fossil Energy

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PROJECT ABSTRACT

Methane hydrate may contain significant offshore and onshore arctic gas resources. The appraisal phases of this study are designed to help determine whether or not gas hydrate can become a technically and economically recoverable gas resource. The Phase 1-2 reservoir characterization, development scenario modeling, and associated studies indicated that 0-12 TCF gas may be technically recoverable from 33 TCF gas-in-place (GIP) Eileen trend gas hydrate beneath industry infrastructure within the Milne Point Unit (MPU), Prudhoe Bay Unit (PBU), and Kuparuk River Unit (KRU) areas on the Alaska North Slope (ANS). Modeled production methods involve subsurface depressurization and/or thermal stimulation of pore-filling gas hydrate into gas and water components.

Phase 2 studies included rate forecasts and hypothetical well scheduling, methods typically employed to evaluate the development potential of conventional large gas accumulations. This work helped quantify: 1. Potential to technically produce gas from the 33 TCF GIP Eileen trend gas hydrate resource using conventional petroleum technologies and 2. Range of 0-12 TCF possible recoverable resource based on potential future development schemes. Phase 2 studies culminated in recommendations to acquire Phase 3a stratigraphic test static data including 400-600 feet core, extensive wireline logs, and MDT wireline tests within the Mount Elbert intra-hydrate MPU prospect interpreted from the Milne 3D seismic survey. Phase 3b studies, if approved, would acquire additional static data and include production testing, likely from a gravel pad within production infrastructure.

Phase 2 production forecast and regional schematic modeling studies included downside, reference, and upside cases. Reference case forecasts with type-well depressurization-induced production rates of 0.4-2.0 MMSCF/D predict that 2.5 TCF of gas might be produced in 20 years, with 10 TCF ultimate recovery after 100 years; it is important to note that typical industry forecasts would not exceed 50 years. Downside cases envision research pilot failure and economic or technical infeasibility. Upside cases identify additional potential if Phase 3 data acquisition would confirm reference case or upside modeling results of pressure-induced, thermally enhanced, or chemically stimulated gas hydrate dissociation into producible gas. Phase 3a field studies initiated in early 2007 and acquired data to help mitigate uncertainty in potential gas hydrate productivity. Successful Phase 3a MountElbert-01 stratigraphic test drilling and data acquisition was completed between February 3-19, 2007. Initial Phase 3b production test planning is underway with Phase 3a data evaluation, but a Phase 3b long-term production test is not currently approved by BP.

ACKNOWLEDGEMENTS

This cooperative DOE-BPXA research project has helped facilitate and maintain industry interest in the resource potential of shallow natural gas hydrate accumulations. This research could help determine whether or not methane hydrate may become an additional unconventional gas resource and DOE and BPXA support of these studies is gratefully acknowledged.

Efforts of DOE National Energy Technology Lab staff Brad Tomer, Ray Boswell, Richard Baker, Edith Allison, Tom Mroz, Kelly Rose, Eilis Rosenbaum, and others have enabled continuation of this and associated research projects. Scott Digert and others at BPXA continue to promote the importance of this cooperative research within industry. BPXA staff support and stratigraphic test well planning efforts of Micaela Weeks, Larry Vendl, Dennis Urban, Dan Kara, Paul Hanson, and others led to successful Phase 3a well operations and data acquisition. The State of Alaska Department of Natural Resources through the efforts and leadership of Dr. Mark Myers, Bob Swenson, Paul Decker, and others has consistently recognized the contribution of this research toward identifying a possible additional unconventional gas resource and actively supported the Methane Hydrate Act of 2005 to enable continued funding of these studies.

The USGS has led ANS gas hydrate research for nearly 3 decades. Dr. Tim Collett coordinates USGS partnership in this Alaska gas hydrate research and potential future development. Seismic studies accomplished by Tanya Inks at Interpretation Services and by USGS scientists Tim Collett, Myung Lee, Warren Agena, and David Taylor identified multiple MPU gas hydrate prospects. Support by USGS staff Bill Winters, Bill Waite, and Tom Lorenson and Oregon State University staff Marta Torres and Rick Colwell is gratefully acknowledged. Steve Hancock at APA (RPS Energy) and Peter Weinheber at Schlumberger helped design the Phase 3a wireline testing program. Scott Wilson at Ryder Scott has progressed reservoir models from initial studies by the University of Calgary (Dr. Pooladi-Darvish) and the University of Alaska Fairbanks (UAF). The Canadian Modeling Group (CMG) STARS program was adapted to an industry-standard production model of gas hydrate-bearing reservoir behavior and has helped assess the regional development potential of Alaska North Slope gas hydrate (if proven as a resource). Dr. Shirish Patil and Dr. Abhijit Dandekar have helped redevelop the UAF School of Mining and Engineering into an arctic regions gas hydrate research center. The University of Arizona reservoir characterization studies led by Dr. Bob Casavant with Dr. Karl Glass, Ken Mallon, Dr. Roy Johnson, and Dr. Mary Poulton have described the structural and stratigraphic architecture of Eileen trend ANS Sagavanirktok formation gas hydrate-bearing reservoir sands.

Current related studies of gas hydrate resource potential are too numerous to mention here. National Labs studies include Dr. Pete McGrail, CO_2 Injection, and Dr. Mark White, reservoir modeling, at Pacific Northwest National Lab and Dr. George Moridis, reservoir modeling, at Lawrence Berkeley National Lab. The Colorado School of Mines under the leadership of Dr. Dendy Sloan continues to progress laboratory and associated studies of gas hydrate. The significant efforts of international gas hydrate research projects such as those supported by the Directorate General of Hydrocarbons by the government of India and by the Japan Oil, Gas, and Metals National Corporation (JOGMEC) with the government of Japan are contributing significantly to a better understanding of the resource potential of natural methane hydrate. JOGMEC and the government of Canada support of the 2002 and current Mallik project gas hydrate studies in Northwest Territories, Canada are gratefully acknowledged. This cooperative DOE-BPXA research project builds upon the accomplishments of many prior government, academic, and industry studies.

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2.0 PROJECT INTRODUCTION

The cooperative research between BP Exploration (Alaska), Inc. (BPXA) and the U.S. Department of Energy (DOE) is helping to characterize and assess Alaska North Slope (ANS) methane hydrate resource and is helping to identify technical and commercial factors that could enable government and industry to understand the future development potential of this possible unconventional energy resource. Results of Phase 1-2 reservoir characterization, reservoir modeling, regional schematic modeling, and associated studies culminated in approval to proceed into a 2007 Phase 3a stratigraphic test to acquire data designed to help mitigate potential recoverable resource uncertainty. Future Phase 3b production testing is a key goal of the Federal Research and Development program and may follow, but this is under evaluation. Collaborative research partners include U.S. Geological Survey (USGS), Arctic Slope Regional Corporation Energy Services, Ryder Scott Company, APA RPS Engineering, University of Arizona, University of Alaska Fairbanks, Oregon State University, Pacific Northwest National Lab, Lawrence Berkeley National Lab (LBNL), and others.

Methane hydrate may contain a significant portion of world gas resources within offshore and onshore arctic regions petroleum systems. In the United States, accumulations of gas hydrate occur within pressure-temperature stability regions in both offshore and also onshore near-permafrost regions. USGS probabilistic estimates indicate that clathrate hydrate may contain a mean of 590 TCF in-place ANS gas resources (Figure 1). Over 33 TCF in-place potential gas hydrate resources are interpreted within shallow sand reservoirs beneath ANS production infrastructure within the Eileen trend (Figure 2). Gas hydrate accumulations require the presence of all petroleum system components (source, migration, trap, seal, charge, and reservoir). Future exploitation of gas hydrate would require developing feasible, safe, and environmentally-benign production technology, initially within areas of industry infrastructure. The ANS onshore area within the Eileen trend favorably combines these factors. The information and technology being developed in this onshore ANS program will be an important component to assessing the possible productivity of the potentially much larger marine hydrate resource. The resource potential of gas hydrate remains unproven, but if proven, could increase ANS gas resources and could lead to greater U.S. energy independence.

In 1972, the existence of natural methane hydrate within ANS shallow sand reservoirs was confirmed by data acquired in the Northwest Eileen State-02 well. Although up to 100 TCF in-place gas may be trapped within the gas hydrate-bearing formations beneath existing ANS infrastructure, it has been primarily known as a shallow gas drilling hazard to the hundreds of well penetrations targeting deeper oil-bearing formations and has drawn little resource attention due to no ANS gas export infrastructure and unknown potential productivity. Characterization of ANS

gas hydrate-bearing reservoirs and improved modeling of potential gas hydrate dissociation processes led to increasing interest to study gas hydrate resource and production feasibility.

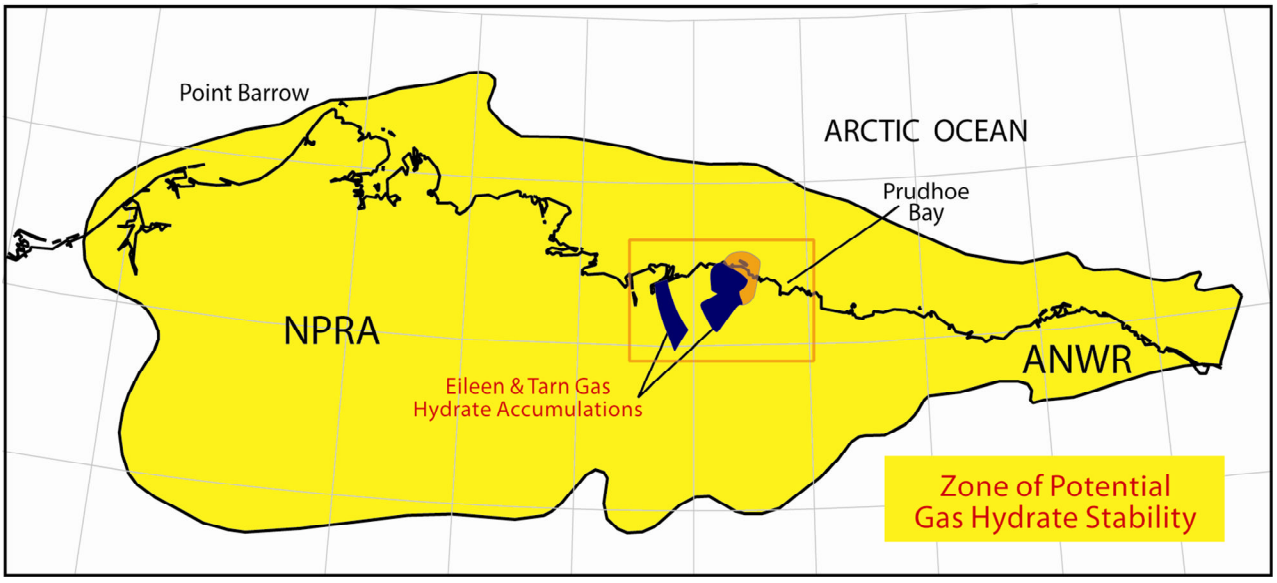

Figure 1: ANS gas hydrate stability zone with Eileen and Tarn gas hydrate trends (Collett, 1993).

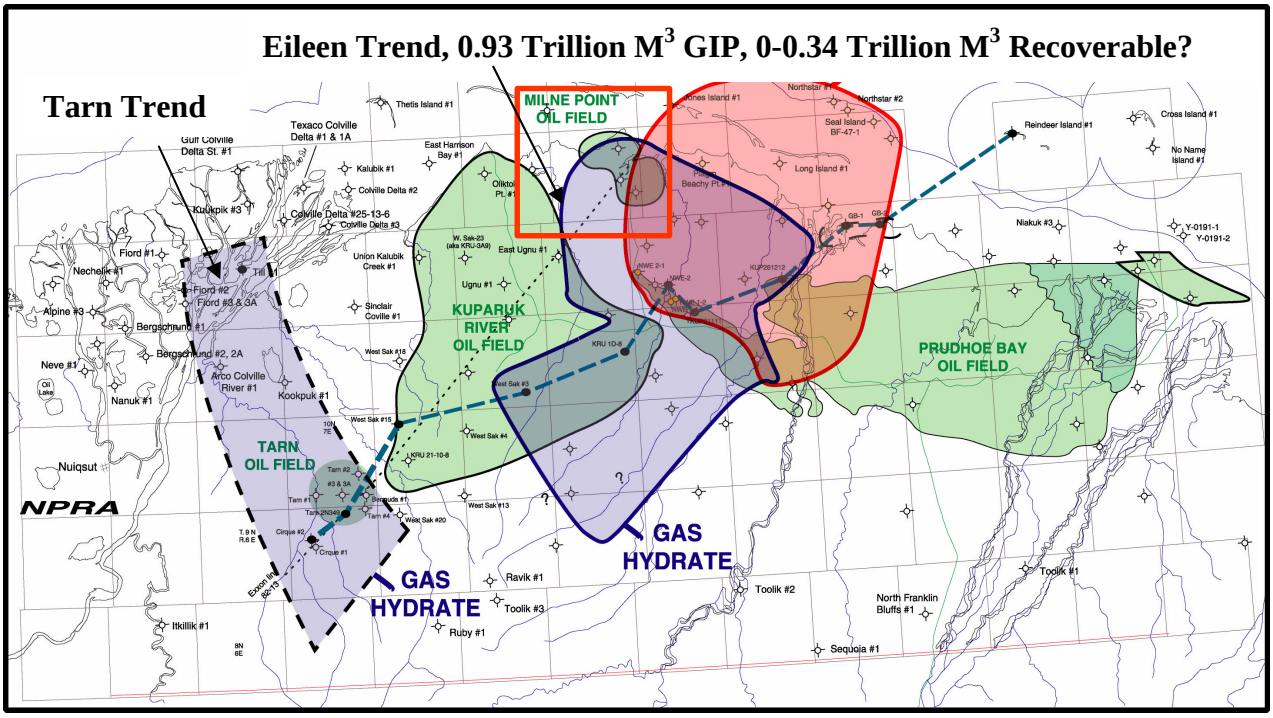

Figure 2: Eileen and Tarn Gas Hydrate Trends and ANS Field Infrastructure (modified after Collett, 1998) and including potential Eileen trend gas-in-place (GIP).

As part of a multi-year effort to encourage these feasibility studies, the DOE also supports significant laboratory and numerical modeling efforts focused on the small scale behaviors of gas hydrate. Concurrently, the USGS has assessed the potential in-place resource potential and participated in field operations with DOE and others to acquire data within many naturally

occurring gas hydrate accumulations throughout the world. There remain significant challenges in quantifying the fraction of these in-place resources that might eventually become a technically-feasible or possibly a commercial natural gas reserve. This study estimates this potential ANS prize within the Eileen trend and recommends additional research, data acquisition, and field operations.

A "chicken and egg" problem has hindered unproven resource research and development in the past; an "unconventional" resource commonly requires a few positive examples before it can generate stand-alone interest from industry. This was true for tight gas resources in the 1950-1960's, Coal-Bed-Methane plays in the 1970-1980's and the shale gas resources in the 1990-2000's. In each case, the resource was thought to be technically infeasible and uneconomic until the combination of market, technology (new or newly applied), and positive field experience helped motivate widespread adoption of unconventional recovery techniques in an effort to prove whether or not the resource could be technically and commercially produced. In an attempt to bridge this gap, Phase 2 gas hydrate reservoir modeling efforts were coupled with a series of possible regional schematic models to quantify a suite of potential recoverable reserve outcomes.

These regional schematic modeling scenarios indicated that 0-12 TCF gas may be technically recoverable from 33 TCF in-place Eileen trend gas hydrate beneath ANS industry infrastructure within the Milne Point Unit (MPU), Prudhoe Bay Unit (PBU), and Kuparuk River Unit (KRU) areas. Production forecast and regional schematic modeling studies included downside, reference, and upside cases. Reference case forecasts with type-well depressurization-induced production rates of 0.4-2.0 MMSCF/D predict that 2.5 TCF of gas might be produced in 20 years, with 10 TCF ultimate recovery after 100 years (typical industry forecasts would not exceed 50 years). The downside case envisions research pilot failure and economic or technical infeasibility. Upside cases identify additional potential recoverable resource. Additional static data acquisition and possible future production testing could help validate whether or not these reference and upside model results might occur in a future potential development using depressurization-induced, thermally enhanced, and/or chemically stimulated dissociation of gas hydrate into producible gas. Modeled production methods involve subsurface depressurization and/or thermal stimulation of pore-filling gas hydrate into gas and water components. Phase 2 studies included rate forecasts and hypothetical well scheduling, methods typically employed to evaluate potential conventional large gas development projects. This work helped quantify: 1. Potential to technically produce gas from the 33 TCF GIP Eileen trend gas hydrate resource using conventional petroleum technologies and 2. Range of 0-12 TCF possible recoverable resource based on potential future development schemes. Phase 2 studies culminated in recommendations to acquire Phase 3a stratigraphic test static data including 400-600 feet core, extensive wireline logs, and MDT wireline tests within the Mount Elbert intra-hydrate MPU prospect interpreted from the Milne 3D seismic survey (Figure 3). Phase 3a field studies led to successful acquisition of critical data to help mitigate uncertainty in potential gas hydrate productivity. Successful Phase 3a MountElbert-01 stratigraphic test drilling and data acquisition was completed between February 3-19, 2007. Although potential Phase 3b production test planning is underway with Phase 3a data evaluation, a Phase 3b production test is not currently approved by BP. Phase 3b studies, if approved, would acquire additional data and include production testing, likely from a gravel pad within production infrastructure.

3.0 EXECUTIVE SUMMARY

This Quarterly report encompasses project work from April 1, 2007 through end-June 2007. This research program is designed to determine whether the currently unproven gas hydrate resource may become a new unconventional gas reserve Major research objectives accomplished during this reporting period included planning, evaluating, reporting, and cost auditing of data acquired in the February 2007 Phase 3a stratigraphic test well and tracking costs for this well. Acquired data included 430 feet core (100 feet gas hydrate-bearing), extensive wireline logs, and wireline production tests and samples using the Modular Dynamics Testing (MDT) downhole tool. Significant pre-well planning, inclusion of world hydrate experts, and onsite vigilance were key elements to safely drilling and acquiring this data on an ANS Milne Point Unit exploration ice pad. Chilled oil-based drilling fluid mitigated operational safety concerns and enhanced core and data acquisition by maintaining gas hydrate and borehole stability during openhole drilling and operations.

4.0 QUARTERLY RESULTS

The project accomplishments during the reporting time period from April 2007 through end-June 2007 included planning, evaluating, reporting, and cost auditing of data acquired in the February 2007 Phase 3a stratigraphic test well (Project Task 8.0). The 1Q07 Technical Progress report completed June 27, 2007 provides a detailed review of Stratigraphic Test well drilling and data acquisition.

4.1 Data Analyses Planning

- Work with Isotech Labs to locate MDT gas samples and analyses
- Prepared and sent MountElbert core samples to ConocoPhillips at Bartlesville Lab
- Prepared and sent MountElbert core samples to at Oregon State University
- Prepared and sent MountElbert core samples to University of Alaska Fairbanks for future lab testing experimental analyses
- Checked and maintained condition of core storage refrigerated unit located at ASRC Yard
    - Purchased and installed 8 freezers and transferred MountElbert library and sample set cores into freezers during and after modifications of refrigerated unit (Figure 3)
    - Prepared plan to add lighting, electricity, core layout space, and man-door to unit
        - Plan implemented by ASRC electrical and construction staff by mid-May 2007 (Figure 4)
    - Held preliminary discussions with State of Alaska Geological Materials Center for feasibility of post-project transfer of MountElbert core samples, freezers, and refer unit to their Eagle River facility; elected to keep unit at more secure, locked, and gated ASRC Fabrication Shop Yard site for duration of project activities
- Wrote procedure and safety protocols and transferred core samples from fully charged liquid nitrogen Dewar to drained Dewar for dry-shipping for laboratory studies
- Wrote procedure and safety protocols and transferred core samples from methane-pressure vessels to liquid nitrogen Dewar per directions from core analysis team and in consideration of shipping restrictions regarding pressure vessels
    - Selected, inventoried, and transferred core samples for shipping in-series and analyses at LBNL, NRC, PNNL, CSM, USGS
    - Shipped samples in Dewar to LBNL for initial CTscan and shipping in-series
- Met with Schlumberger for log data finalization and special studies discussions

- Prepared contract for Fekete reservoir modeling studies to enable Fekete / University of Calgary participation in Reservoir Model Comparison studies
- Opened dialog with BP and ConocoPhillips for core sedimentologic description support
- Determined disposition of MDT samples with Matt Allen, Schlumberger OilPhase
- Provided input to MountElbert-01 SCAL with OMNI and USGS
- Reviewed LBNL core CTscans and evaluated LBNL recommendations for sample distribution for selected additional studies at various laboratories

Figure 3: 6 of 8 Freezers installed for core storage in refrigerated unit prior to temporary disconnection of unit for installation of man-door, electrical outlets. and lighting (May 16, 2007).

4.2 Data Analyses Evaluation

- Participated via teleconference in Reservoir Modeling meeting at USGS
  - Prepared and sent summary notes from meeting to team
  - Helped coordinate working discussions with Schlumberger to validate algorithms to convert MDT data into qualitative flow rates
  - Reiterated value of qualitative or order-of-magnitude data, not actual rate data
  - Provided input to early indications of potential factors affecting rate data, such as tool and/or wellbore storage effects due to very small gas volumes produced

- Facilitated discussions with Schlumberger to confirm that no direct readout of produced gas or water volumes is available from the MountElbert-01 MDT tests other than pump strokes
    - Schlumberger working on algorithm to convert to qualitative rate data
    - Qualitative gas rate analyses possibly due to gas compression and/or tool storage
- Coordinated core viewing, sampling, high-level description visit for Dave Houseknect, USGS, May 21-22 (Figures 5-6)
- Correlated core gamma to wireline log field prints in preparation for core analyses

Figure 4: ASRC electrical and construction staff modifying core storage refrigerated unit for lighting, electrical outlet, and man-door. Extension cords visible in photo were for temporary power to freezers to keep core cold during unit modification (May 16, 2007).

4.3 Project Reporting

- Prepared and presented preliminary results of MountElbert-01 Stratigraphic test to April AAPG, Long Beach, in Alternative Energy Sources: Promises and Pitfalls session meeting
    - Presentation well received by approximately 350 attendees
    - Presentation selected for AAPG Energy and Minerals Division Frank Kottlowski Memorial Award for Best Paper
    - Participated in AAPG Gas Hydrate Subcommittee Meeting

Figure 5: Dave Houseknect, USGS, views Mount Elbert-01 core, May 22, 2007.

Figure 6: Core sample from Mount Elbert-01 library set ½ slab, May 22, 2007

- Participated in and prepared project summary presentation for April Methane Hydrate Advisory Committee Meeting, Golden, Colorado
- Prepared and presented preliminary results of MountElbert-01 Stratigraphic test and significance of drilling operations and data acquisition success to American Association of Drilling Engineers (AADE) April meeting, Anchorage
- Prepared BP Senate Testimony document emphasizing the need for continued government-industry collaborative support for gas hydrate research and the unproven nature of the potential resource; BP submitted testimony April 13, 2007
- Updated project Bibliography, publications, and references; sent to DOE COR
- Provided gas hydrate project update via teleconference to BP Technologies lead, Mark Howard on April 27, 2007
- Submitted entry on Stratigraphic Test accomplishments to BP corporate Helios awards
    - Entry commended, but not awarded
- Completed 1Q07 technical progress and financial reports
- Reviewed Barrow hydrate project results and provided recommendations

4.4 Project Cost Auditing

- Placed project activities on-hold status following project spend update from accounting
- Began preparing project overrun audit, provided preliminary notification of overrun to DOE COR, BP management, and BP Drilling
- Closed project cost centers and initiated cost audits with BP Drilling and subcontractors

4.5 Stratigraphic Test Accomplishments Summary

Significant stratigraphic test well data acquisition accomplishments were included in the 1Q07 technical progress report:

- Successfully demonstrated ability to safely and effectively acquire data within shallow gas hydrate-bearing reservoirs over 7-10 days (versus the normal approach to drill and case within a maximum 2-4 days).
- Validated seismic interpretation of gas hydrate-bearing MountElbert prospect within MPU
- Acquired 430 feet of 3-inch diameter core, 100 feet of which were gas hydrate-bearing
    - Collected 261 onsite subsamples for preservation and analyses at various labs
        - 4 samples preserved in methane-charged pressure vessels (later converted to liquid nitrogen)
        - 7 samples preserved in liquid nitrogen
        - 52 samples for physical property analyses
        - 46 samples for interstitial water geochemistry
        - 5 samples for thermal property study
        - 86 samples for microbiological study
        - 46 samples for organic geochemistry study
        - 15 samples for detailed petrophysical analyses
- Acquired extensive open-hole wireline logs including gamma-ray, resistivity, neutron-density porosity, Dipole Sonic Acoustic porosity, Nuclear Magnetic Resonance, Formation Imaging, Electromagnetic Propagation, caliper

- Acquired 4 extensive, long shut-in period MDT within 2 gas hydrate-bearing reservoirs
  - MDT analyses improving understanding of gas hydrate dissociation, gas production, formation cooling, and long-term production potential
  - MDT analyses providing calibration of reservoir simulation models
  - Obtained 4 gas samples from each test interval
  - Obtained 1 pre-dissociation formation water sample and demonstrated ability to flow mobile connate formation water from hydrate-saturated interval
  - Observed rapid formation cooling during gas hydrate dissociation and gas flow and demonstrated gas dissociation from hydrate with pressure drawdown

The 2007 Alaska North Slope MountElbert-01 Gas Hydrate Stratigraphic Test accomplished several ”firsts”, including:

- First significant ANS gas hydrate bearing core (100 feet of 430 feet acquired)
- First wireline retrievable coring system application on ANS with conventional drilling rig
- First extensive ANS open hole multi-day data acquisition program in gas hydrate section
- First in world open-hole dual packer MDT program in gas hydrate bearing sections
- First ANS MDT sampling of both gas and water in gas hydrate-bearing reservoirs
- First in world temperature data tracking at MDT inlet during MDT flow and shut-in periods

The acquired data has helped calibrate reservoir simulation models and improved consideration of gas hydrate dissociation, gas production, formation cooling, and possible future long-term production test design.

5.0 STATUS REPORT

5.1 Cost Status

Costs for the Phase 3a Stratigraphic Test Well drilling, data acquisition, and associated studies were budgeted in the September 2006 definitization based on project task and cost estimates for required contractual services associated with drilling, data acquisition, data evaluation, and initial Phase 3b planning and feasibility studies.

Comparison of budgeted versus actual cost by task was completed by end-August and will be summarized in the 3Q07 report. Certain task categories exceeded budget estimates and cost overruns were clearly documented, requiring an additional $1.08MM in BP-DOE Contract Amendment 18.

Certain costs were recognized and agreed by BP and DOE to exceed the September 2006 budget prior to drilling of the well, including the switch to oil-based mud (OBM) to improve safety, borehole stability, and data acquisition; this switch to OBM also contributed to some of the increased wireline logging costs.

5.2 Project Task Schedules and Milestones

5.2.1 U.S. Department of Energy Milestone Log, Phase 1, 2002-2004

Note that SOPO in contract amendments 1-8 for Phase 1.

Program/Project Title: DE-FC26-01NT41332: Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay - Kuparuk River Area on the North Slope of Alaska.

Identification Number	Description	Planned Completion Date	Actual Completion Date	Comments
Task 1.0	Research Management Plan	12/02 – 12/04	12/02 and Ongoing	Subcontracts Completed
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	See Technical Progress Reports
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	Ongoing	See Technical Progress Reports
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	See Technical Progress Reports
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Advances	Ongoing		See Technical Progress Reports
Task 6.0	Reservoir and Fluids Characterization Study	12/04	Ongoing to Phases 2 and 3	Interim Results presented, 2004 Hedberg Conference
Subtask 6.1	Characterization and Visualization	12/04	Ongoing to Phases 2 and 3	Interim Results presented, 2004 Hedberg Conference
Subtask 6.2	Seismic Attributes and Calibration	12/04	Ongoing to Phases 2 and 3	Interim Results presented, 2004 Hedberg Conference
Subtask 6.3	Petrophysics and Artificial Neural Net	12/04	Ongoing to Phases 2 and 3	Interim Results presented, 2004 Hedberg Conference
Task 7.0	Laboratory Studies for Drilling, Completion, Production Support	6/04	6/04	
Subtask 7.1	Characterize Gas Hydrate Equilibrium	6/04	6/04	Results presented, 2004 Hedberg Conference
Subtask 7.2	Measure Gas-Water Relative Permeabilities	6/04	6/04	Results presented, 2004 Hedberg Conference
Task 8.0	Evaluate Drilling Fluids	12/04		
Subtask 8.1	Design Mud System	11/03		
Subtask 8.2	Assess Formation Damage	9/05	Into Phase 2	
Task 9.0	Design Cement Program	12/04		
Task 10.0	Study Coring Technology	2/04	2/04	
Task 11.0	Reservoir Modeling	12/04	Ongoing task	Interim Results presented, 2004 Hedberg Conference
Task 12.0	Select Drilling Location and Candidate	9/05		Topical Report submitted, June 2005
Task 13.0	Project Commerciality & Phase 2 Progression Assessment	9/05	Redesigned 2005 Phase 2	BPXA and DOE decision

* Date dependent upon industry partner agreement for seismic data release

5.2.2 U.S. Department of Energy Milestone Log, Phase 2, 2006

Note that SOPO in contract Amendment 9 for Phase 2.

Program/Project Title: DE-FC26-01NT41332: Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay - Kuparuk River Area on the North Slope of Alaska.

Identification Number	Description	Planned Completion Date	Actual Completion Date	Comments
Task 1.0	Research Management Plan	1/05 – 1/06	Ongoing	Subcontracts Completed
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	See Technical Progress Reports
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	Ongoing	See Technical Progress Reports
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	See Technical Progress Reports
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Development and Advances	Ongoing		See Technical Progress/Topical Reports
Task 6.0	Reservoir and Fluids Characterization Study	12/06	Ongoing into Phases 2 and 3	
Subtask 6.1	Structural Characterization	12/06	Ongoing into Phases 2 and 3	
Subtask 6.2	Resource Visualization	12/06	Ongoing into Phases 2 and 3	
Subtask 6.3	Stratigraphic Reservoir Model	12/06	Ongoing into Phases 2 and 3	
Task 7.0	Laboratory Studies for Drilling, Completion, Production Support	12/06		Some Hiatus; Phase 2-3a design, studies, & decision
Subtask 7.1	Design Mud System	12/05		
Subtask 7.2	Assess Formation Damage	1/06		
Subtask 7.3	Measure Petrophysical and Other Physical Properties	9/06	Phase 3a	No Samples Acquired; await Phase 3a acquisition
Task 8.0	Design Completion / Production Test for Gas Hydrate Well	4/06	Mt Elbert-01 strat test only	Design of Phase 3a Strat Test operation Complete
Task 9.0	Field Operations and Data Acquisition Program Planning	4/06	Mt Elbert-01 strat test only	Planning for Potential operations underway
Task 10.0	Reservoir Modeling and Project Commercial Evaluation	1/06		Regional Resource Review & Development Planning
Subtask 10.1	Task 5-6 Reservoir models	Ongoing		
Subtask 10.2	Hydrate Production Feasibility	1/06		
Subtask 10.3	Project Commerciality & Phase 3a Progression Assessment	1/06		January 2006 approval for Phase 3a Stratigraphic Test

* Date dependent upon industry partner agreement for seismic data release

5.2.3 U.S. Department of Energy Milestone Log, Phase 3a, 2006-2007

Note that SOPO in contract Amendment 11 for Phase 3a.

Program/Project Title: DE-FC26-01NT41332: Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay - Kuparuk River Area on the North Slope of Alaska

Identification Number	Description	Planned Completion Date	Actual Completion Date	Comments
Task 1.0	Research Management Plan	1/06 – 12/07	Ongoing	Subcontracts Completed
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	See Technical Progress Reports
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	As-identified	See Technical Progress Reports
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	See Technical Progress Reports
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Development and Advances	Ongoing	As-needed	See Technical Progress/Topical Reports
Task 6.0	Reservoir and Fluids Characterization Study	12/07		Under No-cost Extension
Subtask 6.1	Structural Characterization	12/07		
Subtask 6.2	Resource Visualization	12/07		
Subtask 6.3	Stratigraphic Reservoir Model	12/07		
Task 7.0	Laboratory Studies for Drilling, Completion, Production Support	12/07		Under No-cost Extension
Subtask 7.1	Design Mud System	9/07		
Subtask 7.2	Assess Formation Damage	9/07		
Subtask 7.3	Measure Petrophysical and Other Physical Properties	9/07		
Task 8.0	Implement completion/production Test for gas hydrate well	3/07	3/07	Stratigraphic Test Well Drilled February 3-19, 2007
Task 9.0	Reservoir Modeling and Project Commercial Evaluation	12/07	Ongoing	Regional Resource Review & Development Planning
Subtask 9.1	Task 5-6 Reservoir models	12/07	As-needed	
Subtask 9.2	Project Commerciality & Phase 3b Production Test Decision	12/07	Early decision possible	Phase 3a Stratigraphic Test to mitigate uncertainties

* Date dependent upon industry partner agreement for seismic data release

5.2.4 U.S. Department of Energy Milestone Plans

(DOE F4600.3)

DOE F 4600.3#

U.S. DEPARTMENT OF ENERGY FEDERAL ASSISTANCE MILESTONE PLAN: PHASE 1

1. Program/Project Identification No. DE-FC26-01NT41332	2. Program/Project Title Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay - Kuparuk River Area on the North Slope of Alaska
3. Performer (Name, Address) BP Exploration (Alaska), Inc., 900 East Benson Blvd, P.O. Box 196612, Anchorage, Alaska 99519-6612	4. Program/Project Start Date 10/22/02* 5. Program/Project Completion Date 12/31/07 (through Phase 3a)

6. Identification Number	7. Planning Category (Work Breakdown Structure Tasks)	8. Program/Project Duration (Phase 1, 2002-2004) O N D J F M A M J J A S O N D J F M A M J J A S-D	9. Comments (Primary work Performer)
Task 1.0	Research Management Plan	>>>!>	BPXA
Task 2.0	Technical Data and Expertise	>>>>>>----->>>>------>>>>>>>>------------>>>>>>>>-------->>>>>>>>-->>>>>>>>--!-	BPXA
Task 3.0	Wells of Opportunity - Data	------>>>>>-------------->>>>>--------->>>>>>>>>>>>>>---------->>>>>>>>>>>>>>>!-	BPXA
Task 4.0	Research Collaboration Link	>>>!>	BPXA, USGS, UAF, UA
Task 5.0	Logging/Seismic Technology	>>!	USGS, BPXA
Task 6.0	Characterize Reservoir/Fluid	------->>>!>>	UA
Task 7.0	Lab Studies: Ph Behav, Rel k	-- ----->>!----------	UAF
Task 8.0	Evaluate Drilling Fluids	------->>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>-->>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	UAF
Task 9.0	Design Cementing Program	------->>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	UAF
Task 10.0	Study Coring Techniques	-------->>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>- --	UAF
Task 11.0	Reservoir Modeling	>>>>------------------------>>>>>>>>>>----------------->>>>>>>>>>>>>>>>>>>>>!>>>	UAF, RyderScott
Task 12.0	Drilling Candidate Selection	>>>------ ----->>>>>>------->>>>>>>>>>>>>---->>>>>>>>>>>>>!	BPXA, UA, USGS, RyderScott
Task 13.0	Commerciality Assessment	>>>>>>--------------------------------->>>>>>>>>--------------->>>>>>>----->>>>>>>>>>	BPXA, UAF, Ryder Scott

10. Remarks * Official Contract Date 10/22/02; Funded reduced-cost pre-Phase 1 from 10/01-10/02. Phase 1 project from 10/02 through 12/04.
Explanation of Symbols: (> = Major Task Work); (- = Minor Task Work); (! = Milestones).
Additional significant milestones presented in Quarterly Technical Progress Reports.

DOE F 4600.3#

U.S. DEPARTMENT OF ENERGY FEDERAL ASSISTANCE MILESTONE PLAN: PHASE 2-3a (2005-2006)

1. Program/Project Identification No. DE-FC26-01NT41332	2. Program/Project Title Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay - Kuparuk River Area on the North Slope of Alaska
3. Performer (Name, Address) BP Exploration (Alaska), Inc., 900 East Benson Blvd, P.O. Box 196612, Anchorage, Alaska 99519-6612	4. Program/Project Start Date 10/22/02* 5. Program/Project Completion Date 12/31/07 (through Phase 3a)

6. Identification Task Number	7. Planning Category (Work Breakdown Structure Tasks)	8. Program/Project Duration (Phases 2-3, 2005 - 2006) ← Planning/Analysis → ← DECISION---→ ←Planning--------→← IMPLEMENTATION deferred to 2007→ J F M A M J J A S O N D J F M A M J J A S O N D	9. Comments (Primary work Performer)
Task 1.0	Contracts and Research Management Planning	>>>>>>>!>>>---->>>>>!-->>>>>>>>>>>>>>>>>>!----------->>----->>-->>>>>>>	BPXA, AES
Task 2.0	Technical Data and Expertise	-->>>>>>----->>>>--!---->>>>>>>>>-------!--->>>>>>>>-------->>>>>>>>-->>>>>>>>--	BPXA, AES
Task 3.0	Wells of Opportunity - Data	------------>>>>>-!------------>>>>>---!----->>>>>>>>>>>>>>>----------->>>>>>>>	BPXA, AES
Task 4.0	Research Collaboration Link	---------->>>>>>>>>!---------->>>>>>>>>>!>>	BPXA, USGS, AES, UAF,UA
Task 5.0	Logging/Seismic Technology	>>>>>>>>>>>>>>>>>>!>>>>>>>>>>>>>>>>>>!>>>>>>>>>----------->>	USGS, BPXA
Task 6.0	Characterize Reservoir/Fluid	------->>>>>>>>>>>>>!---------->>>>>>>>>>!>>>>>>>>>>>>>>>>---------->>>>>>>>>>>>>	UA, USGS
Task 7.0**	Lab Studies: Drilling, Completion, Production	----------->>>>>>>!---------->>>>>>>>>>!>>>>>>>----------->----->>>>>>>>>	UAF
Task 8.0**	Stratigraphic Test Decision, Design, and Implementation	-->>>>>>>>>>>!>>>----->>>>>>>>>>>>!>>>>>>>---------->>>>>>>>>>>	APA, BPXA, AES, UAF
Task 9.0**	Field Operations Planning and Implementation	---->>>>>>>>>!>>>------->>>>>>>>>>!>>>>>>>---------->>>>>>>>>>>	APA, BPXA, AES, UAF
Task 10.0**	Reservoir Modeling and Commercial Evaluation	----->>>>>>>>>>>>>>!>>>>>>>>>>>>>>>>>---!----------	RS, AES, BPXA, UAF

10. Remarks * Schedule shows Phases 2-3a from 2005 through end-2006. Phase 2 project from 1/05 through 12/05. Phase 3a stratigraphic test initiated 6/05 and included 9/05 Continuation Application culminating in 1/06 decision to Drill. . Explanation of Symbols: >> Major Task Work; -- Minor Task Work; ! Milestone. Significant technical work and milestones presented in Technical Progress and Topical Reports. **Note new (Phase 2-3a) Task numbers.

DOE F 4600.3#

U.S. DEPARTMENT OF ENERGY FEDERAL ASSISTANCE MILESTONE PLAN: PHASE 3a and 3b

1. Program/Project Identification No. DE-FC26-01NT41332	2. Program/Project Title Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay - Kuparuk River Area on the North Slope of Alaska
3. Performer (Name, Address) BP Exploration (Alaska), Inc., 900 East Benson Blvd, P.O. Box 196612, Anchorage, Alaska 99519-6612	4. Program/Project Start Date 10/22/02* 5. Program/Project Completion Date 12/31/07 (through Phase 3a)

6. Identification Task Number	7. Planning Category (Work Breakdown Structure Tasks)	8. Program/Project Duration (Phases 3a-3b, 2007-2008 projection) ←Phase 3a Strat Test→ ←3b Planning →← 3b Decisioning and Planning → J F M A M J J A S O N D J F M A M J J A S O N D	9. Comments (Primary work Performer)
Task 1.0	Contracts and Research Management Planning	!>>>>>>!>>>---->>>>>---->>>>>>>>>>>>>>>>>>!----------!---------->>!>>>>>>>>	BPXA, AES
Task 2.0	Technical Data and Expertise	!->>>>>>----->>>>------->>>>>>>>>-------!--->>>>>>>>-------!>>>>>>>>-->!>>>>>>--	BPXA, AES
Task 3.0	Wells of Opportunity - Data	!------------>>>>>-------------->>>>---!----->>>>>>>>>>>>>!>----------!>>>>>>>>	BPXA, AES
Task 4.0	Research Collaboration Link	!>>>>>>>>>>>>>>>>>>>----------->>>>>>>>>>!>>>>>>>>>>>>>>>>>!>>>>>>>>>>!>>>>>>>>	BPXA, USGS, AES, UAF,UA
Task 5.0	Logging/Seismic Technology	!>>>>>>>>>>>>>>>>>>->>>>>>>>>>>>>>>>>>>!>>>>>>>>>>>>>>>>>!>>>>>>>>>>!>>>>>>>>	USGS, BPXA
Task 6.0	Characterize Reservoir/Fluid	!------>>>>>>>>>>>>>>----------->>>>>>>>>>!>>>>>>>>>>>>>>>>---!------>>>>>!>>>>>>>>	UA, USGS
Task 7.0	Lab Studies: Drilling, Completion, Production	!----------->>>>>>>----------->>>>>>>>>>!>>>>>>>>>>>>>>>>>!>>>>>>>>>>!>>>>>>>>	UAF
Task 8.0	Implement 2007 Strat Test Evaluate/Design Production Test & Phase 3b progression	! -->>>>>>>>>>>->>>----->>>>>>>>>>>>!>>>>>>>>>>>>>>>>>!>>>>>>>>>>!>>>>>>>>	APA, BPXA, AES, UAF
Task 9.0	Reservoir Modeling and Commercial Evaluation	!---->>>>>>>>>>>>>>->>>>>>>>>>>>>>>>>>>!>>>>>>>>>>>>>>>>>!>>>>>>>>>>!>>>>>>>>	RS, AES, BPXA, UAF

10. Remarks * Schedule shows Phases 3a-3b (3b not approved-indicated in red) from 2007 projected through end-2008. Phase 3a stratigraphic test deferred until early 2007 by 3rd party rig delay. Explanation of Symbols: >> Major Task Work; -- Minor Task Work; ! Milestone. Significant technical work and milestones presented in Technical Progress and Topical Reports. Note that 2008 Drilling Schedule apparently fully dedicated; additional drilling rigs under construction; 2009 Implementation possible.

5.3 2Q07 Reporting Period Significant Accomplishments

Approval to proceed into Phase 3a well operations resulted in drilling and data acquisition in the MountElbert-01 Stratigraphic Test during February 2007. These operations were safely accomplished and all recommended data was successfully acquired, including extensive wireline core, logging, and production testing. Data acquired is under evaluation in preparation for planning, site selection, budgeting, and seeking industry/government approval to proceed into Phase 3b long-term gas hydrate production test operations. Successful Phase 3a operations also proved the ability to safely, effectively, and cost-efficiently operate and acquire data within the shallow gas hydrate-bearing Alaska North Slope reservoir zones. The Phase 3a data analyses will help narrow the significant uncertainties in reservoir properties and productivity potential in preparation for Phase 3b planning activities and operations decision anticipated in 2008.

5.4 Actual or Anticipated problems, delays, and resolution

Phase 3a Stratigraphic Test definitization documents and budgets were approved in late 2006. Contract amendments were completed in December 2006 to better define operations liabilities and extend Phase 3a data analyses and Phase 3b planning activities through end-December 2007. Increases in well costs would have led to expenditure of budgeted funds before end-2007. However, additional funding in BP-DOE Contract Amendment 18 will enable completion of 2007 Phase 3a data analyses and Phase 3b planning activities. Some of the well cost increases were known and agreed prior to drilling and data acquisition operations:

1. Change to oil-based drilling fluid was agreed in early 2007 to increase borehole and gas hydrate stability and to enable higher quality assurance of core, log, and MDT data acquisition.
2. Moderate increase in wireline logging cost was needed to run logs compatible with change to oil-based drilling fluid.

Other cost increases were unforeseen, but have been fully documented, resulting in the additional funding from project Amendment 18. A 2008 work plan, schedule, and budget will be prepared in 4Q07.

5.5 Project Research Products, Collaborations, and Technology Transfer

5.5.1 Project Research Collaborations and Networks

Project objectives significantly benefit from DOE awareness, support, and/or funding of the following associated collaborations, projects, and proposals:

1. **Reservoir Model Comparison studies:** DOE NETL and University of Akron coordination of reservoir modeling significantly increased collaborative reservoir modeling efforts with Japan, Lawrence Berkeley National Lab (LBNL), Pacific Northwest National Lab (PNNL), and University of Calgary and Fekete. This important work has continued into simulation of field-scale gas hydrate bearing reservoirs. The studies to-date have facilitated a common understanding of how these different gas hydrate reservoir models handle the basic physics of gas hydrate dissociation processes within gas hydrate-bearing formations and extend into analyses of Phase 3a stratigraphic test and MDT data. Contributors to this effort include: Masanori Kurihara (Japan Oil Engineering Co., Ltd.), Yoshihiro Masuda (The University of Tokyo), Pete McGrail (Pacific Northwest National Laboratory), George Moridis (Lawrence Berkeley National

Laboratory, University of California), Hideo Narita (National Institute of Advanced Industrial Science and Technology), Mark White (Pacific Northwest National Laboratory), Joseph W. Wilder and Brian Anderson (University of Akron), Scott Wilson (Ryder Scott Company, Consultant to BP-DOE project), Mehran Pooladi-Darvish and Huifang Hong (University of Calgary and Fekete), Timothy Collett (U.S. Geological Survey), and Robert Hunter (ASRC Energy Services; BP Exploration (Alaska), Inc.).

2. **DE-FC26-01NT41248:** UAF/PNNL/BPXA studies to investigate the effectiveness of CO_2 as a potential enhanced recovery mechanism for gas dissociation from methane hydrate. DOE supported this associated project research which may help facilitate a possible future field test of this technology.
3. **UAF/Argonne National Lab project:** This associated project was approved for funding by the Arctic Energy and Technology Development Lab (AETDL), forwarded to NETL for review, and was funded in mid-2004. The project is designed to determine the efficacy of Ceramicrete cold temperature cement for possible future gas hydrate drilling and completion operations. Evaluating the stability and use of an alternative cold temperature cement may enhance the ability to maintain the low temperatures of the gas hydrate stability field during drilling and completion operations and help ensure safer and more cost-effective operations. In early 2006, the Ceramicrete material was approved for field testing at the BJ Services yard in Texas (primary contact Lee Dillenbeck). Although Ceramicrete was not yet field tested in time to be evaluated for use in 2007 Alaska operations, successful future yard testing of the material may enable limited testing in Alaska project operations. However, this project does not appear to have significantly progressed during 2006 through 2007.
4. **Precision Combustion, Inc. (PCI) – DOE collaborative research project:** Potential synergies from this DOE-supported research project with the BPXA – DOE gas hydrate research program were recognized in December 2003 by Edie Allison (DOE). Communications with Precision Combustion researchers indicate possible synergies, particularly regarding potential in-situ reservoir heating. Successful modeling and lab work could potentially proceed into field applications in future gas hydrate operations. BPXA provided a letter in April 2004 in support of progression of PCI's project into their phase 2: prototype tool design and possible surface testing. If the project proceeds into Phase 3b operations, a thermal component of production testing may be recommended and a delivery mechanism could potentially incorporate this technology.
5. **Japan gas hydrate research:** Progress toward completing the objectives of this project remain aligned with gas hydrate research by Japan Oil, Gas, and Metals National Corporation (JOGMEC), formerly Japan National Oil Corporation (JNOC). JOGMEC remains interested in research collaboration, particularly if this project proceeds into production testing operations. Communications with JOGMEC were limited during the reporting period, but were renewed in June 2006, to inform JOGMEC that the BP-DOE project is proceeding into Phase 3a stratigraphic test field operations. JOGMEC may proceed into future (2007-2008) production test operations at the Mallik field site.
6. **India gas hydrate research:** India's Institute of Oil and Gas Production Technology (IOGPT) indicates a continued interest in participating with the BPXA – DOE research program in correspondence/discussion with DOE. Dr. Tim Collett, partner in the BPXA-DOE research team, and Ray Boswell, DOE gas hydrate program, led and participated in, respectively, certain aspects of the data acquisition at multiple offshore India field sites.

India sent a technical observer to view ANS Phase 3a operations and data acquisition. The value of international research collaboration is recognized.

7. **Korea gas hydrate research:** Korea may be developing a gas hydrate research program. Korea has discussed potential participation in future Alaska gas hydrate research with DOE and USGS. BPXA has not initiated direct contact with Korea, but has referred 2007 correspondence to DOE and USGS.
8. **China gas hydrate research:** China is also developing a gas hydrate research program. BPXA has not initiated contact with China, but DOE is collaborating in certain gas hydrate research studies in China.
9. **U.S. Department of Interior, USGS, BLM, State of Alaska DGGS:** An additional collaborative research project under the Department of Interior (DOI) may provide significant benefits to this project. The BLM, USGS, and the State of Alaska recognize that gas hydrate is potentially a large untapped ANS onshore energy resource. To develop a more complete regional understanding of this potential energy resource, the BLM, USGS and State of Alaska Division of Geological and Geophysical Surveys (DGGS) have entered into an Assistance Agreement to assess regional gas hydrate energy resource potential in northern Alaska. This agreement combines the resource assessment responsibilities of the USGS and the DGGS with the surface management and permitting responsibilities of the BLM. Information generated from this agreement will help guide these agencies to promote responsible development if this potential arctic energy resource becomes proven. The DOI project has worked with the BPXA – DOE project to assess the regional recoverable resource potential of onshore natural gas hydrate and associated free-gas accumulations in northern Alaska, initially within current industry infrastructure.

5.5.2 Project Research Technologies/Techniques/Other Products

Multiple technologies are under evaluation in association with this project. With research progression into Phase 3 operations, technologies under evaluation include gas hydrate production techniques such as thermal and/or chemical stimulation to enhance gas dissociation during future Phase 3b production testing, if approved.

5.5.3 Project Research Inventions/Patent Applications

DOE granted an advance patent waiver to the project in 2003. No patents are currently recorded in association with the project.

5.5.4 Project Research Publications

5.5.4.1 General Project References

Casavant, R.R. and others, 2003, Geology of the Sagavanirktok and Gubik Formations, Milne Point Unit, North Slope, Alaska: Implications for neotectonics and methane gas hydrate resource development, AAPG Bulletin.

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Zhao, B., 2003, Classifying Seismic Attributes in the Milne Point Unit, North Slope of Alaska, MS Thesis, University of Arizona, 159 p.

5.5.4.2 University of Arizona Research Publications and Presentations

5.5.4.2.1 Professional Presentations

a. Casavant, R.R., Hennes, A.M., Johnson, R., and T.S. Collett, 2004, Structural analysis of a proposed pull-apart basin: Implications for gas hydrate and associated free-gas emplacement, Milne Point Unit, Arctic Alaska, AAPG Hedberg Conference, Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 5 pp.
b. Hagbo, C. and R. Johnson, 2003, Delineation of gas hydrates, North Slope, Alaska, 2003 Univ. of Arizona Dept. Geosciences Annual GeoDaze Symposium
c. Hagbo, C., and Johnson, R. A., 2003, Use of seismic attributes in identifying and interpreting onshore gas-hydrate occurrences, North Slope, Alaska, Eos Trans. AGU, 84, Fall Meet.
d. Hennes, A., and R. Johnson, 2004, Structural character and constraints on a shallow, gas-hydrate-bearing reservoir as determined from 3-D seismic data, North Slope, Alaska, 2004 Univ. of Arizona Dept. Geosciences Annual GeoDaze Symposium.

5.5.4.2.2 Professional Posters

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b. Geauner, S., Manuel, J., and R.R. Casavant, 2004, Well Log Normalization and Comparative Volumetric Analysis of Gas Hydrate and Free-Gas Resources, Central North Slope, Alaska, AAPG Hedberg Conference, Gas Hydrates: Energy

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5.5.4.2.3 Professional Publications

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d. Hennes, M., Johnson, R.A., And R.R. Casavant, 2004, Seismic Characterization Of A Shallow Gas-Hydrate-Bearing Reservoirs On The North Slope Of Alaska, AAPG Hedberg Conference, Gas Hydrates: Energy Resource Potential And Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 4 pp.
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l. Casavant, R. R., 2002, Tectonic geomorphic characterization of a transcurrent fault zone, Western Brooks Range, Alaska (linkage of shallow hydrocarbons with basement deformation), SPE-AAPG: Western Region-Pacific Section Joint Technical Conference Proceedings, Anchorage, Alaska, May 18-23, 2002, p. 68.

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5.5.4.8 Short Courses

"Natural Gas Hydrates", By Tim Collett (USGS) and Shirish Patil (UAF), A Short Course at the SPE-AAPG: Western Region-Pacific Section Conference, Anchorage, Alaska, May 18-23, 2002, Sponsored by Alaska Division of Geological and Geophysical Surveys and West Coast Petroleum Technology Transfer Council, Anchorage, Alaska.

5.5.4.9 Websites

There are currently no external project-sponsored websites. Project information is available on the DOE website: http://www.fossil.energy.gov/programs/oilgas/hydrates/index.html. A project internal website has been developed for storage, transfer, and organization of project-related files, results, and studies. This website is available to project participants only; information contained on this working website will be finalized and released at project final reporting.

6.0 CONCLUSIONS

The first dedicated gas hydrate coring and production testing well, NW Eileen State-02, was drilled in 1972 within the Eileen gas hydrate trend by Arco and Exxon. Since that time, ANS methane hydrates have been known primarily as a drilling hazard. Industry has only recently

considered the resource potential of conventional ANS gas during industry and government efforts in working toward an ANS gas pipeline. Consideration of the resource potential of conventional ANS gas helped create industry - government alignment necessary to reconsider the resource potential of the potentially large (33 to 100 TCF in-place) unconventional ANS methane hydrate accumulations beneath or near existing production infrastructure. Studies show this in-place resource is compartmentalized both stratigraphically and structurally within the petroleum system.

The BPXA – DOE collaborative research project enables a better understanding of the resource potential of this ANS methane hydrate petroleum system through comprehensive regional shallow reservoir and fluid characterization utilizing well and 3D seismic data, implementation of methane hydrate experiments, and design of techniques to support potential methane hydrate drilling, completion, and production operations.

Following discovery of natural gas hydrate in the 1960-1970's, significant time and resources have been devoted over the past 40 years to study and quantify natural gas hydrate occurrence. However, only in the past decade have there been significant attempts to understand the potential recoverability of methane from hydrate. Although significant in-place natural gas hydrate deposits have been identified and inferred, estimation of potential recoverable gas from these deposits is difficult due to the lack of empirical or even anecdotal evidence.

The potential to induce gas hydrate dissociation across a broad regional contact from adjacent free gas depressurization is demonstrated by the results of the collaborative BPXA-LBNL pre-Phase 1 scoping reservoir model (presented in the March 2003 Quarterly report and technical conferences) and corroborated by the results of continued UAF and Ryder Scott reservoir model research as presented in Section 5.9 of the December 2003 Quarterly report.

The possibility to induce in-situ gas hydrate dissociation through producing mobile connate waters from within an under-saturated gas hydrate-bearing reservoir also emphasizes the importance of saturation and permeability as key variables which, when better understood, could help mitigate productivity uncertainty. A schematic potential development screening study was undertaken to set ranges on the potential resources that might one day be recovered (if production is technically and economically feasible) given various possible production scenarios of the ANS Eileen gas hydrate trend, which may contain up to 33 TCF gas-in-place. Type-well production rates modeled at 0.4-2 MMSCF/d yield potential future peak field-wide development forecast rates of up to 350-450 MMSCF/d and cumulative production of 0-12 TCF gas. Individual wells would exhibit a long production character with flat declines, potentially analogous to Coalbed Methane production.

Results from the various scenarios show a wide range of potential development outcomes. None of these forecasts would qualify for Proved, Probable, or even Possible reserve categories using the SPE/WPC definitions since there has yet to be a fully documented case of economic production from hydrate-derived gas. Each of these categories would, by definition, require a positive economic prediction, supported by historical analogies, prudent engineering judgment, and rigorous geological characterization of the potential resource before a decision on an actual development could proceed.

Phase 3a stratigraphic test field operations enabled acquisition of critical gas hydrate-bearing reservoir data. Key data acquired included wireline cores, logs, and wireline production (MDT) testing of gas hydrate-bearing reservoir sands and associated sediments. Analyses of the core, log, and MDT results is underway and should help reduce the uncertainty regarding gas hydrate-bearing reservoir productivity and improve planning of Phase 3b gas hydrate production test studies, although Phase 3b operations are not currently approved.

7.0 LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Denotation
2D	Two Dimensional (seismic or reservoir data)
3D	Three Dimensional (seismic or reservoir data)
AAPG	American Association of Petroleum Geologists
AAT	Alaska Arctic Terrane (plate tectonics)
AETDL	Alaska Energy Technology Development Laboratory
ADEC	Alaska Department of Environmental Conservation
ANL	Argonne National Laboratory
ANN	Artificial Neural Network
ANS	Alaska North Slope
AOGCC	Alaska Oil and Gas Conservation Commission
AOI	Area of Interest
AVO	Amplitude versus Offset (seismic data analysis technique)
ASTM	American Society for Testing and Materials
BGHSZ	Base of Gas Hydrate Stability Zone
BHA	Bottom Hole Assembly; equipment at bottom hole during drilling operations
BIBPF	Base of Ice-Bearing Permafrost
BLM	U.S. Bureau of Land Management
BMSL	Base Mean Sea Level
BP	BP or BPXA
BPXA	BP Exploration (Alaska), Inc.
CMR	Combinable Magnetic Resonance log (wireline logging tool – see also NMR)
CP	ConocoPhillips
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DGGS	Alaska Division of Geological and Geophysical Surveys
DNR	Alaska Department of Natural Resources
EM	Electromagnetic (referencing potential in-situ thermal stimulation technology)
ERD	Extended Reach Drilling (commonly horizontal and/or multilateral drilling)
FBHP	Flowing Bottom-Hole Pressure (during MDT wireline production testing)
FEL	Front-End Loading, reference to effective pre-project operations planning
FG	Free Gas (commonly referenced in association with and below gas hydrate)
GEOS	UA Department of Geology and Geophysics
GH	Gas Hydrate
GIP	Gas-in-Place
GOM	Gulf of Mexico (typically referring to Chevron Gas Hydrate project JIP)
GR	Gamma Ray (well log)

GTL	Gas to Liquid
GSA	Geophysical Society of Alaska
HP	Hewlett Packard
HSE	Health, Safety, and Environment (typically pertaining to field operations)
JBN	Johnson-Bossler-Naumann method (of gas-water relative permeabilities)
JIP	Joint Industry Participating (group/agreement), ex. Chevron GOM project
JNOC	Japan National Oil Corporation
JOGMEC	Japan Oil, Gas, and Metals National Corporation (reorganized from JNOC 1/04)
JSA/JRA	Job Safety Assessment/Job Risk Assessment; part of BP HSE operations protocol
KRU	Kuparuk River Unit
LBNL	Lawrence Berkeley National Laboratory
LDD	Generic term referencing Logging During Drilling (also LWD and MWD)
LNG	Liquefied Natural Gas
MDT	Modular Dynamics Testing wireline tool for downhole production testing data
MGE	UA Department of Mining and Geological Engineering
MOBM	Mineral Oil-Based Mud drilling fluid used to improve safety and data acquisition
MPU	Milne Point Unit
MSFL	Micro-spherically focused log (wireline log indication of formation permeability)
NETL	National Energy Technology Laboratory
NMR	Natural Magnetic Resonance (wireline or LDD tool – see also CMR)
OBM	Oil Based Mud, drilling fluid
ONGC	Oil and Natural Gas Corporation Limited (India)
PBU	Prudhoe Bay Unit
PNNL	Pacific Northwest National Laboratory
POOH	Pull out of Hole; pulling drillpipe or wireline from borehole during operations
POS	Pump-out Sub (pertaining to MDT tool)
SCAL	Special Core Analyses, references analyses beyond basic porosity/permeability
SPE	Society of Petroleum Engineers
TCF	Trillion Cubic Feet of Gas at Standard Conditions
TCM	Trillion Cubic Meters of Gas at Standard Conditions
T-D	Time-Depth (referencing time to depth conversion of seismic data)
UA	University of Arizona (or Arizona Board of Regents)
UAF	University of Alaska, Fairbanks
USGS	United States Geological Survey
USDOE	United States Department of Energy
Vp	Velocity of primary seismic wave component
Vs	Velocity of shear seismic wave component (commonly useful to identify GH)
VSP	Vertical Seismic Profile
WOO	Well-of-Opportunity

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