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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Dedicated in Memorium to Dave Taylor, USGS, died October 12, 2006

November 6, 2006

DISCLAIMER

ABSTRACT

Methane hydrates 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 indicate 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 Mt Elbert intra-hydrate 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 upside modeling results of pressure-induced, thermally enhanced, or chemically stimulated gas hydrate dissociation into movable gas. Phase 3a field studies to acquire data were approved in January 2006 to help mitigate uncertainty in potential gas hydrate productivity. A Phase 3a stratigraphic test is planned, permitted, and scheduled to drill by February 2007. A Phase 3b production test is not currently approved by DOE or BP.

Successful gas production from gas hydrate would yield both methane and fresh water for potential use in existing or planned ANS developments. The gas could potentially provide fuel-gas to reduce consumption of richer conventional gas, provide lean injection-gas for reservoir energy, provide fuel for potential enhanced viscous oil thermal recovery, or supplement future export-gas. The fresh water could potentially be used in waterfloods and/or in association with produced gas for steam injection. The gas hydrate-bearing reservoirs may also provide a future option for CO_2-sequestration during future gas and associated CO_2 production.

ACKNOWLEDGEMENTS

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

Efforts of DOE National Energy Technology Lab staff Brad Tomer, Ray Boswell, Tom Mroz, Kelly Rose, and others and of DOE Arctic Energy Office staff Jim Hemsath and Brent Sheets 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. 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 continues to promote the importance of this area to 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 potential gas hydrate prospects within the MPU. Scott Wilson at Ryder Scott Co. 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 improved understanding of the structural and stratigraphic architecture and compartmentalization of the shallow gas hydrate-bearing reservoir sands on the Alaska North Slope.

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 and the University of Texas A&M under Dr. Stephen Holditch continue 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 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 make more informed decisions regarding 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 2006 approval to proceed into a 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 remains to be evaluated. Collaborative research partners include U.S. Geological Survey (USGS), Arctic Slope Regional Corporation Energy Services, Ryder Scott Company, APA Engineering, University of Arizona, University of Alaska Fairbanks, and Pacific Northwest National Lab.

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 hydrates 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 within areas of industry infrastructure. In the United States, the ANS onshore and Gulf of Mexico (GOM) offshore are currently known to favorably combine 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. Proving the resource potential of gas hydrate and associated free gas resources 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 production feasibility.

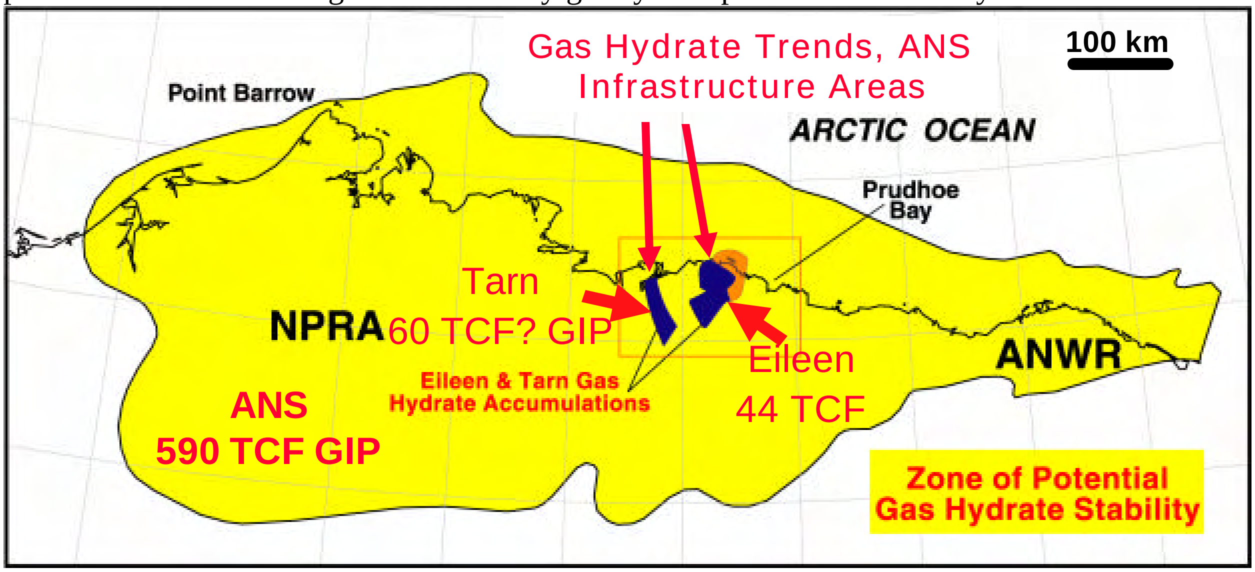

Figure 1: ANS Gas Hydrate Stability Zone Extent. The USGS has estimated 590 TCF methane in place in hydrate form in this region (Courtesy USGS).

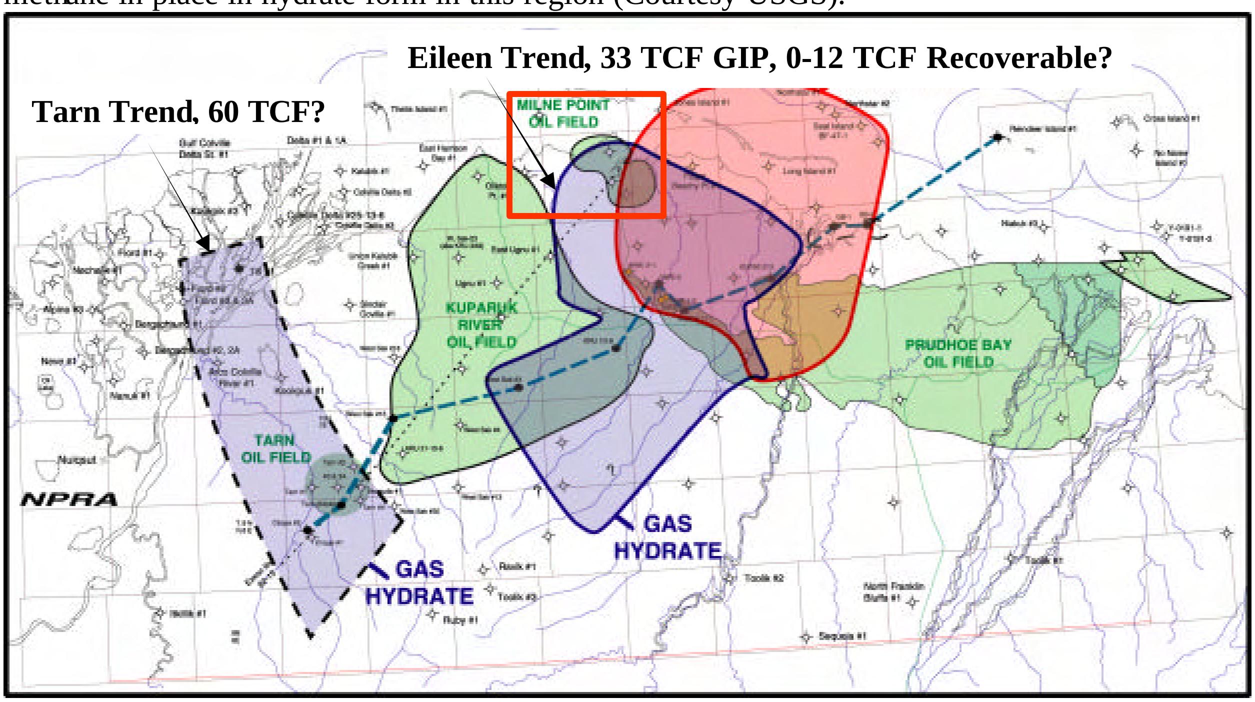

Figure 2: Eileen and Tarn Gas Hydrate Trends and ANS Field Infrastructure (modified after Collett, 1998).

If gas can be technically produced from gas hydrate and if studies help prove production capability at economically viable rates, then methane dissociated from ANS gas hydrate could help supplement fuel-gas, provide additional lean-gas for reservoir energy pressure support, sustain long-term production of portions of the geographically-coincident 20-25 billion barrels viscous oil resource, and/or potentially supplement conventional export-gas in the longer term.

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, the 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 indicate that 0-12 TCF gas may be technically recoverable from 33 TCF in-place 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 ANS. 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 upside model results might occur in a future potential development using pressure-induced, thermally enhanced, and/or chemically stimulated dissociation of gas hydrate into movable 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 Mt Elbert intra-hydrate prospect interpreted from the Milne 3D seismic survey. Phase 3a field studies were approved in January 2006; the data will be acquired to help mitigate uncertainty in potential gas hydrate productivity. The Phase 3a stratigraphic test is planned, permitted, and scheduled to drill by February 2007. Phase 3b studies, if approved, would acquire additional static data and include production testing, likely from a gravel pad within production infrastructure. A Phase 3b production test is not currently approved by DOE or BP.

2.1 Project Open Items

Review of regional resource potential and field operations recommendations based on Phase 1 and 2 studies resulted in the January 2006 decision to proceed into field operations in the Phase 3a stratigraphic test, scheduled to drill by February 2007. Outstanding project status, financial, and technical reports were submitted during this quarter. Phase 3a Stratigraphic Test definitization documents were also submitted in mid-September 2006 and definitization is in-progress with anticipated approval in early November 2006. Another contract amendment is anticipated in November 2006 to define operations liabilities and extend Phase 3a through end-December 2007.

2.2 Project Status Assessment and Forecast

Project technical accomplishments from July 2006 through end-September 2006 are presented by associated project task. The prior Quarterly Technical Report 15 provided detailed Phase 1-2 project accomplishments. The attached milestone form (Appendix A) presents project task duration and completion timelines.

2.3 Project Research Collaborations

Project objectives significantly benefit from DOE awareness, support, and/or funding of the following associated collaborations, projects, and proposals. Section 5.4 provides additional detail on collaborative research accomplishments during the reporting period.

1. **Reservoir Model studies:** DOE NETL coordination of reservoir modeling significantly increased collaborative reservoir modeling efforts with Japan, Lawrence Berkeley National Lab (LBNL), and Pacific Northwest National Lab (PNNL). This important work should continue 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. 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 (National Energy Technology Laboratory, U.S. Department of Energy), Scott Wilson (Ryder Scott Company, Consultant to BP-DOE project), Timothy Collett (U.S. Geological Survey), and Robert Hunter (ASRC Energy Services; BP Exploration (Alaska), Inc.),. PNNL has adapted the reservoir modeling package STORM to model gas hydrate dissociation behavior.

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 currently supports this associated project research which may help facilitate a 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 2006-2007 Alaska operations, successful future yard testing of the material may enable limited testing in Alaska project operations. We remain in communication with ANL and BJ Services. A meeting to discuss yard testing of Ceramicrete was held in Tomball, Texas on August 8, 2006 and attended by the UAF PI, Dr. Shirish Patil.
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 either viscous oil or 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.
5. **UAF shallow resource (gas hydrate and viscous oil) research initiatives:** UAF proposed that AETDL fund Alaska shallow resource research initiatives. This associated research could provide benefits to this project. It should be noted that industry could take a leadership role in these initiatives, similar to the approach taken in this project.
6. **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 recently reinitiated 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.
7. **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. BPXA has not initiated contact with IOGPT. However, Dr. Tim Collett, partner in the BPXA 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. The value of international research collaboration is recognized.
8. **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 USGS. BPXA has not initiated contact with Korea.

9. **U.S. Department of Interior, USGS, BLM, State of Alaska DGGS:** An additional collaborative research project under the Department of Interior (DOI) provides significant benefits to this project. The BLM, USGS, and the State of Alaska recognize that gas hydrate is potentially a large untapped onshore energy resource on the ANS. 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 is working 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.

2.4 Project Performance Variance

Detailed project performance variance is noted by quarter in the Project Status Reports on standard forms 4600.

3.0 EXECUTIVE SUMMARY

This Quarterly report encompasses project work from July 1, 2006 through end-September 2006. Research accomplished during this reporting period included preparation, compilation, and submission of Quarterly Technical Report #15 documenting comprehensive technical accomplishments from 2005 through mid-2006 and preparation of Phase 3a budget period definitization documents. Project accomplishments during the reporting period included:

- Completed combined quarterly technical report documenting 2005-mid-2006 research
- Submitted status and financial reports documentation for 2005 through mid-2006
- Updated project contracts for Phase 3a and modified scope-of-work and budget
    - Planned Phase 3a stratigraphic test well operations and data acquisition
    - Input budget updates to Amendments 13-14 and updated subcontracts
    - Submitted Phase 3a definitization documents and work breakdown structure
- Participated in BP/DOE management teleconference regarding Phase 3a plans and timing
- Maintained project electronic and hardcopy files, documentation, and backups
- Participated in Ugnu and Schrader Bluff core workshop to help ensure program synergies
- Provided project perspective to Washington Internships for Students of Engineering (WISE) student intern inquiry
- Submitted AAPG abstract for project update in at April 2007 Regional Conference
- Considered Schlumberger perforating/completion studies for possible use in Phase 3b
    - July Schlumberger meeting in Anchorage; plan November Houston lab meeting
- Held core workshop in preparation for acquisition and analysis of 400-600 feet core
- Initiated long-lead materials acquisition for Phase 3a well operations
- Prepared procedures, plans, and cost estimates for Phase 3a stratigraphic test well

- Planned Stratigraphic Test Well and held regular weekly meetings with BP/DOE/team
    - Developed plans and initiated contracts, obtained permits, and acquired materials
    - Reviewed NEPA Categorical Exclusion approval documents
    - Identified critical tasks and path for well permits, materials, contracts, and rig
    - Documented risks, addressed concerns, and developed plans to mitigate risks
    - Developed contacts and contracts with appropriate operations subcontractors
    - Prepared and checked surface, ice pad/road, and well bottom hole locations
    - Developed agenda, convened, and moderated weekly well planning meetings
        - Provided action reviews and coordinated well operations plans
    - Evaluated logging-during-drilling, wireline, and MDT program plans
    - Evaluated mud program and incorporated DrillCool, Inc. mudchilling system
    - Planned core program and procedures and evaluated and selected vendors
        - Planned core acquisition parameters with Corion (ReedHycalog)
        - Planned core handling and processing program with OMNI and others
        - Evaluated options for onsite data acquisition and core handling
        - Selected certain time/temperature dependent data for onsite analyses
    - Developed, reviewed, and submitted detailed Phase 3a program drilling, data acquisition, and data evaluation budget
    - Initiated evaluation of short-term DST or short-medium term production testing
        - Evaluated cost versus value and benefits
        - Determined surface and subsurface equipment availability
        - Optional testing addition to base plan data acquisition through MDT logging was determined to be technically unviable and cost-ineffective
- Forwarded BP documents ("retaliation policy") to all vendors associated with project
    - Documents help ensure safety, policy, and procedures compliance

4.0 EXPERIMENTAL

During the reporting time period from July 2006 through end-September 2006, no experimental activities were performed.

4.1 TASK 5.0, Logging and Seismic Technology Advances

Prior quarterly reports and the June 30, 2005 topical report document seismic attribute study within the Milne 3D seismic data and the interpreted relation between seismic amplitude and gas hydrate-bearing zone thickness and saturation. The Mt Elbert-01 stratigraphic test well (Phase 3a) data acquisition wireline logging and coring program was designed to delineate this direct seismic detection of thickness and pore fluid saturation within these interpreted gas hydrate-bearing reservoirs. Seismic modeling and interpretation confirm that seismic velocity, amplitudes, and wavelet character may respond to fluid and reservoir changes within the gas hydrate-bearing reservoirs. Fourteen gas hydrate-bearing prospects containing approximately 600 BCF gas-in-place have been interpreted from MPU seismic data within the northern portion of the Eileen gas hydrate trend. The Mt Elbert-01 stratigraphic test well is designed to delineate the Mt Elbert gas hydrate prospect.

4.2 TASK 6.0, Reservoir and Fluids Characterization

The University of Arizona (UA) did not document significant accomplishments during the reporting period.

4.3 TASK 7.0: Drilling, Completion, and Production Lab Studies

The University of Alaska Fairbanks (UAF) did not document significant accomplishments during the reporting period pending acquisition of additional field data in Phase 3a studies. The phase behavior, relative permeability, and formation damage experiments are planned to study core samples collected within the Eileen trend within the proposed Mt Elbert-01 stratigraphic test well.

5.0 RESULTS AND DISCUSSION

Project technical accomplishments from July 2006 through end-September 2006 are presented in chronological order by associated project task.

5.1 TASK 1.0: Research Management Plan

Task schedules are presented in attached milestones forms (Appendix A). Project expenditures are reported separately on financial forms 269A and 272. Project status reports are reported separately on forms 4600.

- Submitted combined quarterly technical report 15 documenting 2005-mid-2006 research
- Submitted Status and Financial reports documenting 2005-mid-2006 status and finances
- Updated project contracts for Phase 3a and modified scope-of-work and budget
    - Planned Phase 3a stratigraphic test well operations and data acquisition
    - Input budget updates to Amendments 13-14 and updated subcontracts
    - Amendments 12, 13, 14 pending Phase 3a budget definitization approval
- Participated in BP/DOE management teleconference regarding Phase 3a plans and timing
- Developed well operations plans and procedures for stratigraphic test well (Phase 3a)

5.1.1 Work-Breakdown-Structure (WBS) Supporting Narrative and Dictionary

The Work-Breakdown-Structure (WBS) is divided into 5 primary research categories and 3 project phases (Table 1): Project Management (Phases 1-3), Desktop Studies (Phases 1-3), Laboratory Studies (Phases 1-3), Stratigraphic Testing Field Operations (Phase 3a), and Production Testing Field Operations (Phase 3b). Phase 1 studies were accomplished following project authorization in October 2002 through December 2004. Phase 2 studies were designed to help evaluate whether or not to proceed into field operations, were accomplished from January 2005 through December 2005, and culminated in stakeholder approval to acquire additional field data in the Phase 3a Stratigraphic Test. The Stratigraphic Test was planned and permitted at the Mt Elbert prospect site within the Milne Point Unit (MPU) by March 2006. Third-party delay of the drilling rig selected to drill the Stratigraphic Test resulted in deferral until early 2007. The WBS ties to the Statement of Project Objectives (SOPO) contained in the project contract and amendments 1-14. SOPO tasks are denoted on the WBS in shorthand (Table 1): T1 equates to Task 1.0, etc. Project phases 1-3 are color-coded on the WBS; the yellow color references studies occurring within all phases. Project numbered tasks reference the Phase 3a, Contract Amendment 11 SOPO, currently authorized to continue work through December 2006, but designed to transition into Phase 3b operations by December 2007, if stakeholder approval authorizes project progression. The WBS is presented in spreadsheet format, subdivided by the 5 primary project research categories, and linked to the Phase 3a budget for project work in 2006-2007.

5.1.1.1 Project Management

Project management occurs from project conception in April 2001 through project contracting from October 2002 through December 2006 (currently through Amendment 14) and project phases 1, 2, 3a, and 3b. Project management ties to Statement of Project Objectives (SOPO) Tasks 1-4 in budget periods 1-3 (phases 1-3). Additional project management products include project technical, status, and financial reports; project progression facilitation; and initial project planning for Phase 3a (Stratigraphic Testing) and for Phase 3b (Production Testing).

5.1.1.2 Desktop Studies

Project phases 1 and 2 were devoted to desktop studies to characterize the gas hydrate resource potential, quantify the in-place gas hydrate and associated free gas resources within the area-of-interest (AOI), and assess whether or not additional data acquisition would help better define the resource potential. Studies accomplished tie to the SOPO tasks 5, 6, 8, and 9. Task 5 accomplished by the U.S. Geological Survey and Interpretation Services, Inc. developed seismic assessment techniques and applied these to characterization of the gas hydrate and associated free gas resources interpreted within the shallow, sub-permafrost Sagavanirktok reservoir sands within the MPU Milne 3D seismic survey. Task 5 culminated in the ranking and selection of Stratigraphic Testing sites within the MPU AOI, starting in December 2004 and reported in Technical Report #9, July 25, 2005 and in the Topical Report dated June 30, 2005. Task 6 reservoir characterization studies accomplished primarily by the University of Arizona included seismic-based studies within the Milne 3D survey and well-based studies within the larger AOI encompassing the "Eileen Trend" gas hydrate-bearing Sagavanirktok reservoir sands within the Prudhoe Bay Unit (PBU), Kuparuk River Unit (KRU), and MPU. These studies have also interpreted the quality and lateral extent of the Sagavanirktok sand reservoirs within the Eileen Trend based on interpretations of stratigraphic continuity, syn-tectonic depositional controls, and structural compartmentalization. Task 9 reservoir modeling studies progressed significantly during Phase 1-2 to assess the potential productivity of gas hydrate-bearing Sagavanirktok reservoir sands within the Eileen Trend. The Phase 2 modeling studies added scope in late 2004 to include a schematic regional gas hydrate development scenario assessment using techniques commonly applied to major gas field development planning as reported in Technical Report #15, July 31, 2006. This assessment resulted in a Stakeholder decision to approve additional data acquisition in a Phase 3a Stratigraphic Test to help mitigate uncertainty regarding potential recoverable gas resource. Desktop studies continue into Phase 3a to characterize the gas hydrate-bearing reservoirs and will analyze the new data planned to be acquired in the Stratigraphic Test.

5.1.1.3 Laboratory Studies

Project phases 1 and 2 laboratory studies assessed gas hydrate resource potential through phase behavior, relative permeability, drilling fluid, and formation damage experiments and recommended reservoir modeling, drilling, data acquisition, and completion for production testing. Unique laboratory apparatus were designed to assess gas hydrate-bearing porous media. Experimental accomplishments were significant and await further application to new data planned to be collected in the Stratigraphic Test, Phase 3a, and in the Production Test, Phase 3b, if approved. Studies tie to amendment 11 SOPO tasks 7 and 9. The reservoir modeling component resulted in a recommendation to adapt the industry-standard CMG-STARS program to simulate gas hydrate-bearing reservoir behavior through modeled gas field development.

5.1.1.4 Stratigraphic Test

The project field operations phase was split into acquisition of additional stratigraphic and reservoir data (Phase 3a) and production testing (Phase 3b) by recommendation of the 2005 desktop studies and stakeholder decisions. During Phase 1-2, wireline log data was acquired within shallow gas hydrate-bearing intervals in 4 primary wells (MPS-15, MPI-16, PBL-106, and PBL-107) targeting deeper oil-bearing horizons and thus termed "wells-of-opportunity" (WOO). The Stratigraphic Test will acquire the first (since the 1972 NWEileenState-02) dedicated wireline log and core data over an interpreted gas hydrate-bearing prospect (Mt Elbert) from a vertical well beneath an exploration ice pad within an area of the MPU not penetrated by another well. The Mt Elbert prospect is a well-developed seismic anomaly interpreted to contain 2-3 25-75 foot-thick gas hydrate-bearing reservoir sands trapped within a well-constrained fault-bounded 3-way closure as interpreted from the Milne 3D seismic data. Data obtained within this Stratigraphic Test should help assess the recoverable resource potential and properties of the gas hydrate-bearing Sagavanirktok reservoir sands. This data is planned to include long-term (5-10+ hours/station) Modular-Dynamic-Testing (MDT) open-hole (or contingency cased hole) wireline logging. The MDT data were a key component of the 2002 Mallik gas hydrate program and are anticipated to help assess the gas hydrate-bearing reservoir porosity, permeability, and relative permeability, and to help understand the gas hydrate-bearing in-situ reservoir irreducible water, mobile water, and gas hydrate saturations.

5.1.1.5 Production Test

Production Testing (Phase 3b) is not approved at this time. Project stakeholders recognize that production testing is a key objective of the DOE gas hydrate research program. If approved, production testing is anticipated to help determine the recoverable resource potential of gas hydrate-bearing reservoir sands. Detailed planning of a production test should occur during the remainder of Phase 3a to help bridge the research program into these operations. Production test operations may be better-suited to an area within the Eileen Trend AOI, but outside of the MPU AOI. Any operations outside of the MPU would be subject to evaluation (approval or rejection) by non-BP industry Working-Interest-Owners of the KRU (Conoco-Phillips) and/or PBU (Conoco-Phillips and Exxon-Mobil), depending upon site selection. A detailed plan of production test operations could include increasingly complex completion and testing strategies. Initial production testing could merely drill, acquire data, and complete the gas hydrate-bearing reservoir using minimal formation damage strategies. Subsequent production test methods could include reservoir stimulation, fracturing, thermal, and/or chemical enhancements in order of increasing complexity, perhaps over several months, to help determine the recoverable resource potential. If significant amounts of gas were produced during initial production test operations, continued production testing would benefit from onsite gas processing or reinjection to minimize oil-backout from existing facility infrastructure.

Table 1

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
WORK-BREAKDOWN-STRUCTURE, PROJECT PHASES 1, 2, 3A, AND 3B, OCTOBER 2002 – DECEMBER 2008

PROJECT MANAGEMENT

- T1 — Plan Project Scope, Schedule, & Budgets
- T4 — Document & Report Project Studies
- T4 — Track & Report Project Financials
- T2 — Provide Technical Data & Expertise
- T3 — Recommend Data Acquisition Programs
- T4 — Communicate with Project Stakeholders
- T1 — Facilitate Project Progression (CVP)
- T1 — Plan Technical & Experimental Studies
- T8 — Plan Stratigraphic Test Programs/Data
- T9 — Plan Production Test Programs/Data

DESKTOP STUDIES

- T1 — Plan & Implement Technical Studies
- T4 — Document & Report Technical Studies
- T5 — Study Log & Seismic Technologies
- T6 — Reservoir Continuity & Characterization
- Seismic Attribute & Interpretation Studies
- T6 — Petrophysics Studies of Well Log Data
- Artificial Neural Network Modeling
- T9 — Develop Reservoir & Economic Models
- Schematic Production Development Modeling
- T3, 8 — Evaluate/Select Data Acquisition Candidates

LABORATORY STUDIES

- T1 — Plan & Implement Laboratory Studies
- T4 — Document & Report Experiments Studies
- Phase Equilibrium Experiments
- Relative Permeability Experiments
- T7.1 — Drilling Fluid Evaluation
- T7.2 — Formation Damage Assessment
- Cementing Program Designs
- Core Program Designs
- T7 — Completion Program Designs
- T7.3 — Core Experiments with Strat Test Core

STRATIGRAPHIC TEST DATA

- T8 — Plan & Implement Stratigraphic Testing
- T4 — Document & Report Strat Test Studies
- T3 — Acquire "Well-of-Opportunity" Data
- T8 — Acquire & Analyze Well Log Data/MDT
- T8 — Acquire & Analyze Gas Hydrate Core
- T9.1 — Develop Production Test Program(s)
- T9.2 — Assess Production Test Viability/Risk
- T9.2 — Evaluate/Select Production Test Sites

PRODUCTION TEST DATA

- Plan & Implement Production Testing
- Document & Report Prod. Test Studies
- Design Production Test Facility/Site
- T9.2 — Evaluate Alternative Gas Use Technologies
- Acquire & Analyze Logs/Core as-needed
- Acquire & Analyze Production Test Data

Project Phase 3a Tasks, Amendment 11

T1	= Phase 3a, Task 1

Project Phase Color-Codes

- Phase 1 Studies
- Phase 2 Studies
- Phase 3a Studies
- Phase 3b Studies
- Phase 1-3 Studies

See WBS Dictionary for Detail

5.2 TASK 2.0: Provide Technical Data and Expertise

- Maintained project electronic and hardcopy files, documentation, and backups
- Participated in Ugnu and Schrader Bluff core workshops to help ensure MPU 2007 appraisal program synergies with gas hydrate core and MtElbert-01 well objectives
- Provided project perspective to Washington Internships for Students of Engineering (WISE) student intern inquiry

5.3 TASK 3.0: Wells of Opportunity, Data Acquisition

- Monitored BP drilling schedules and communicated with BP operations groups

5.4 TASK 4.0: Research Collaboration Link

- Reviewed, edited, wrote, and approved external publications and interviews as-needed
  - Reviewed gas hydrate literature and recent developments
  - Maintained and transferred knowledge of relevant other-project research
- Submitted AAPG abstract for project update in at April 2007 Regional Conference
- Prepared project overview and Phase 3a stratigraphic test plans presentation
- Considered Schlumberger perforating/completion studies for possible use in Phase 3b
  - Met with Schlumberger in Anchorage in July
  - Plan to followup in November for Houston lab facility meeting with Ian Walton

5.5 TASK 5.0: Logging and Seismic Technology Advances

United States Geological Survey
USGS Principle Investigator: Timothy Collett
USGS Participating Scientists: David Taylor, Warren Agena, Myung Lee, Tanya Inks (IS)

These studies significantly contributed to the selection of the MtElbert prospect for the Phase 3a stratigraphic test. The majority of the research and contributions of USGS staff were funded internally by the U.S. Department of Interior and funded incrementally by this project. Major results of this study were reported in the June 30, 2005 Topical Report and the July 25, 2005 Quarterly Report for the period of June 2004 through December 2004. February 2005 presentation of this MPU seismic study and gas hydrate prospects to MPU staff and management resulted in an improved understanding of significance of project results.

5.6 TASK 6.0: Reservoir and Fluids Characterization

University of Arizona
UA Principle Investigator: Robert Casavant
UA Co-Principle Investigator: Roy Johnson, Mary Poulton
UA Participating Scientists: Karl Glass, Ken Mallon
UA Graduate Students: Casey Hagbo, Bo Zhao, Andrew Hennes, Justin Manuel, Scott Geauner
UA Undergraduate Student Assistant: Greg Gandler

This section discusses gas hydrate research activities that were completed or are in progress between July 1, 2006 through September 30, 2006 at the University of Arizona (UA). UA did not document significant accomplishments during the reporting period. Certain prior accomplishments and plans as documented in Quarterly Report 15 are reiterated herein to emphasize documentation work in-progress. Status update and planning meetings to discuss documentation of accomplished work are currently scheduled for December 7-8, 2006 at UA.

During the reporting period, it was confirmed that UA studies support the selection of the MtElbert prospect area for a stratigraphic test and data acquisition. UA studies indicate that this MPU prospect is interpreted to contain gas hydrate-bearing reservoir sands. This prospect is interpreted on a structurally-high horst block near the eastern edge of the UA-interpreted "East basin", but within what may be the western portion of another Sagavanirktok depocenter basin. The frequency of current well control used in the East basin interpretation (since most well penetrations of the shallow Sagavanirktok interval occur within a few hundred feet of existing gravel production pads) may be less than the interpreted frequency of the fluvial-deltaic Sagavanirktok stratigraphic reservoir variation. Thus, a delineation well in the MtElbert prospect location will help assess both the structural and stratigraphic controls of gas hydrate accumulation within the shallow Sagavanirktok reservoir sands.

The MtElbert prospect location occurs above what are interpreted to be regionally wet Ugnu sands (below the regional Ugnu reservoir viscous oil to water contact). A petroleum system linkage between viscous oil biodegradation in the Ugnu to gas migration through the Ugnu top seal and into the shallower Sagavanirktok sands remains unproven, but is theorized by some researchers. The seismic interpretation clearly indicates gas hydrate-bearing sands in the Sagavanirktok interval as documented in prior reports. The MtElbert-01 stratigraphic test well is also planned to penetrate the upper Ugnu above 4,000 feet TVDss to investigate this potential petroleum system linkage.

UA plans to document the Phase 1-2 regional MPU, KRU, and PBU reservoir characterization studies of gas hydrate and associated free gas resources. The regional reservoir characterization is based primarily on well-log-based interpretations within the area-of-interest. The log interpretations of the shallow Sagavanirktok interval are complicated by the sparse data control, 30-year timespan of log vintages, minimal shallow interval logging programs, and normalization of vintage versus modern open-hole logs and open-hole versus cased-hole logs. A suite of maps is in preparation including fluid interpretations as illustrated in Figure 3-4 and chronostratigraphic correlation map interpretations as illustrated in Figure 5.

The Figure 3 map shows Base of Ice-Bearing Permafrost (BIBPF) derived from the UA log-based expert log interpretation system and incorporates all available published temperature log data. Yellow to purple colors represent shallow to deepening BIBPF depths, respectively. In a few wells where the predicted BIBPF fell within a thick shale or siltstone interval, manual adjustment of the pick was based on the depth of the BIBPF in nearby wells. This interpretation incorporates the small number of wells (13) where downhole temperature data was acquired. The preliminary characterization proposes linkages between deep and shallow structure and associated stratigraphic control on the BIBPF (e.g. Collett et al, 1989; Casavant, 2001). Reactivation of basement-surface fault structures and related facies changes within the ice-bearing permafrost interval may be linked to abrupt variations in depth and orientation of some well-constrained contours observed in several maps. Noted is a spatial coincidence between abrupt changes in the morphology of the gas hydrate stability field and some major fault segments that bound the northwest-trending Eileen fault block and with the distribution of mapped reservoir facies. North-northeast offset and rapid changes in trends from the predominant northwest gradient relates to deep-to-shallow north-northeast-trending faults that studies indicate were reactivated during and since Sagavanirktok time. Linkages to the distribution of certain Sagavanirktok depositional facies types both within and below the gas hydrate stability field were investigated. Documentation of methodology and interpreted tectono-stratigraphic linkages is planned during Phase 3 studies.

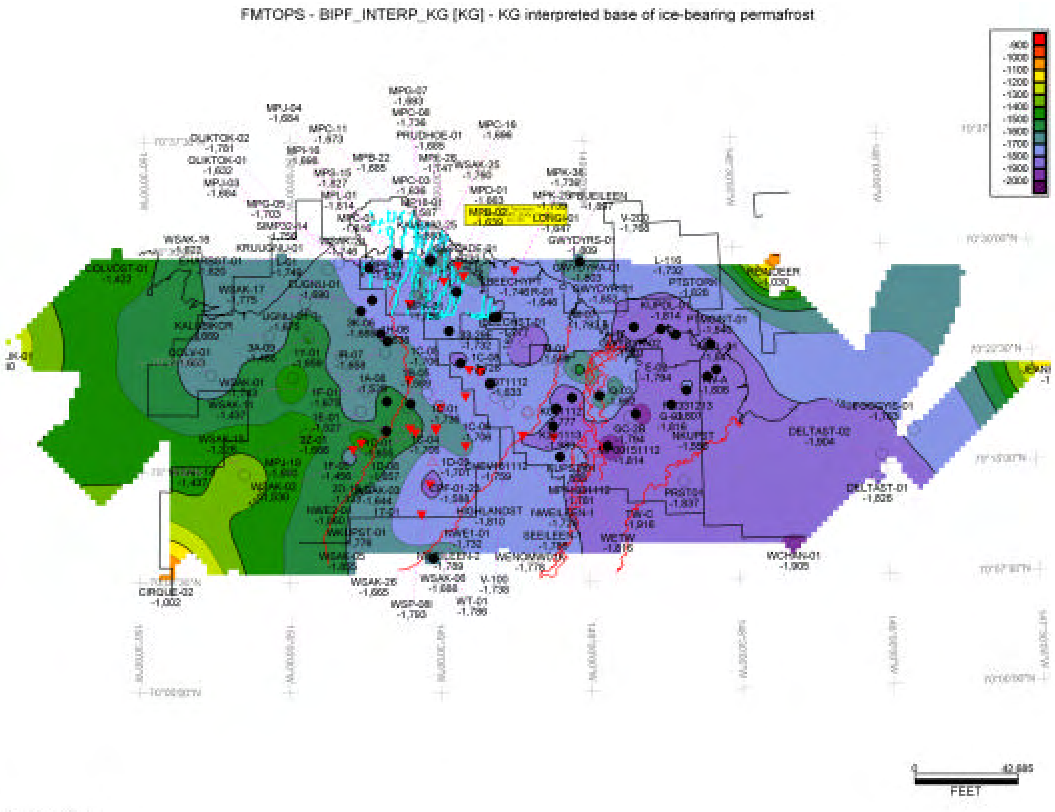

Figure 3: Preliminary PETRA-gridded structure (fluid) map showing depth to the base of the ice-bearing permafrost (BIBPF).

The yellow to purple colors in Figure 4 represent a general shallow to deepening of the gas hydrate stability zone (Pressure-Temperature related fluid horizon) from west to east. Note the position of the MPU in relation to gradients and orientation. The methodology of how this surface was derived, linkages to the geology and distribution of gas hydrate resource, and strategies for exploration are planned to be fully documented during Phase 3 studies.

Documentation of methodology and implications of the maps shown in figures 3-5 regarding characterization of gas hydrate resources are planned in Phase 3 studies. The UA stratigraphic framework shows that the Sagavanirktok formation topset play can be subdivided into several regionally correlable sequences. A clearer understanding of the role of intraformational unconformities on the distribution of stratigraphic units, especially in the western half of the AOI has been achieved. UA analysis (in progress) will show multiple intraformational erosional surfaces (2-3 sequences) removing gas hydrate-bearing sequences from east to west and will more adequately account for the absence and/or preservation of stratigraphic units, facies types, and gas hydrate-bearing reservoir sands along the flanks and nose of a section of the Colville

High known as the southeast-plunging Kuparuk anticline. The chronostratigraphic analysis is tied to both a regional structural characterization across the AOI and to a detailed seismic-based structural study within the MPU. Some of this work is the topic of a MS Thesis by Justin Manuel entitled "A chronostratigraphic framework of the Sagavanirktok formation, North Slope Alaska: Incorporating facies characterization, reservoir continuity and dimensions in relation to gas hydrate and associated free-gas resources."

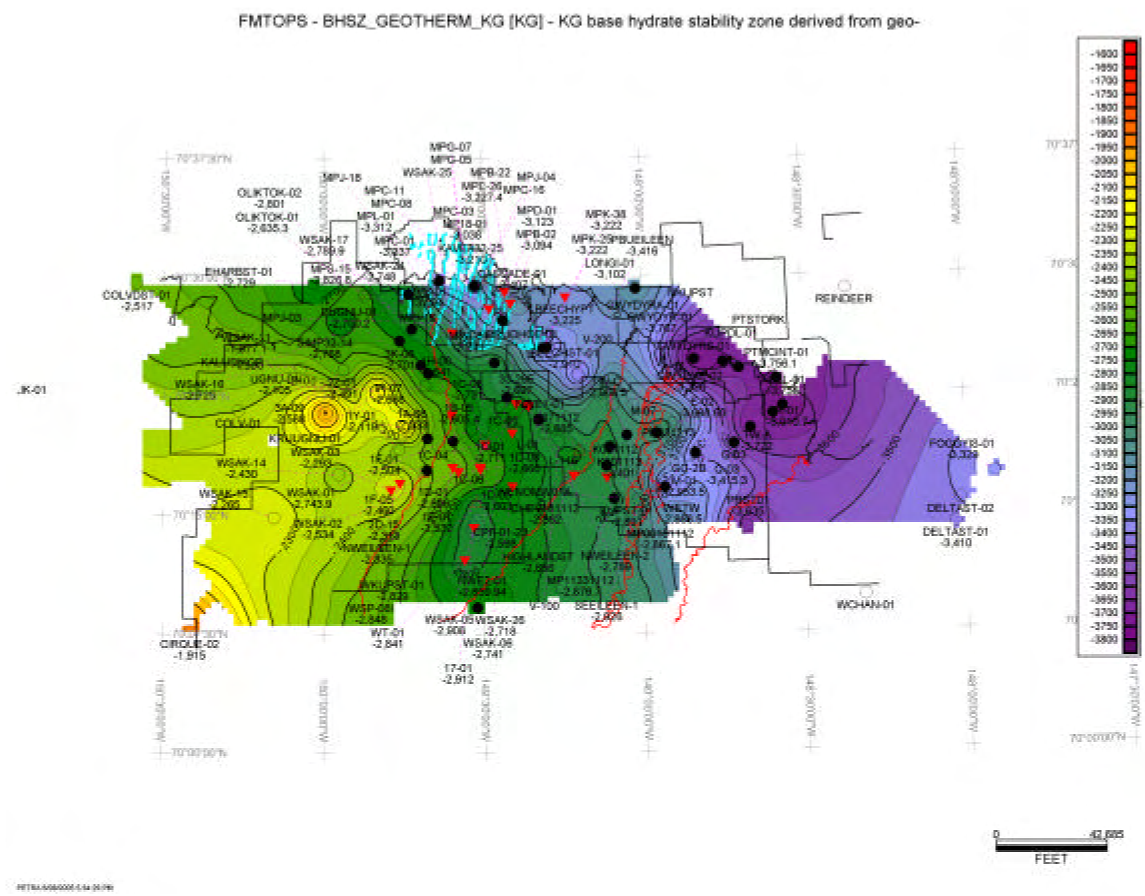

Figure 4: Preliminary UA fluid map on the base of the gas hydrate stability zone (BGHSZ).

Major fluvial, transitional deltaic, and nearshore marine facies belts and their general lateral and vertical distributions have been mapped for several of the major gas hydrate-bearing intervals across the AOI. The structural influence of both north-northeast- and northwest-trending fault systems on the development and extent of ancient fluvio-deltaic systems within the high-stand system tracts and locations of incised channel deposits within low-stand systems tracts is now much better understood (Figure 5). This integrative structural-stratigraphic study is anticipated to help distinguish control types and combinations that have the greatest or most frequent effect on gas hydrate and free-gas distributions and entrapment. The final UA analysis on fluid distributions is anticipated to be completed during Phase 3 studies and a final volumetrics review will be completed for several interpreted gas hydrate-bearing reservoir prospective areas.

The upper gas hydrate bearing units in the Northwest Eileen State-02 well belong to two separate sequences defined by unconformities and different depositional sequences. The map illustrated in Figure 5 shows a thinning over two (and possibly three) underlying northwest-trending "hingelines" across the AOI which coincide with the location of structural flats (dip changes) along the eastern flank of the underlying southeast-plunging mid-Tertiary Kuparuk high. These are interpreted to be faulted zones at the Sagavanirktok level. To the east of the easternmost hinge, facies are dominated by nearshore marine, whereas to the west, facies are dominated by a mixture of highly-variable transitional and fluvial facies. Chronostratigraphic slices above and below the stratigraphic interval shown on this map (Figure 5) show the migration of the facies and locations of interpreted persistent incised valley channel sand deposits (not shown well here) that fed these systems and incised into the underlying deltaic and marine facies. As-yet unpublished manually contoured maps better highlight many of these features. Sand body types and dimensions are being analyzed for future modeling and volumetric purposes.

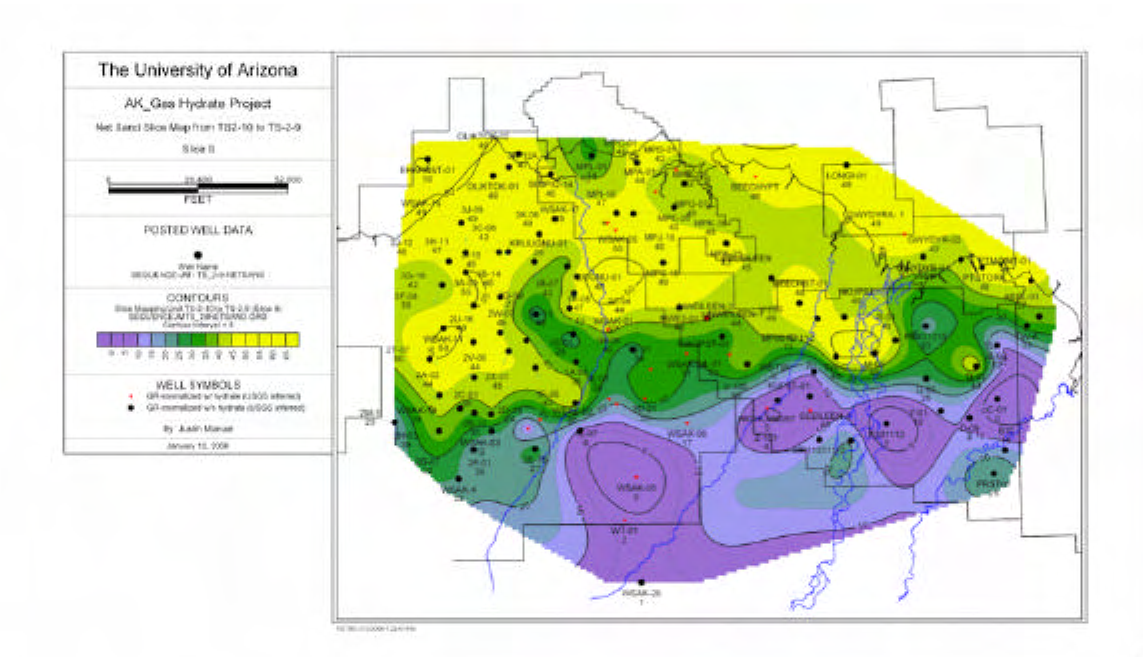

Figure 5: Regional 5-foot contoured net sand slice map in the uppermost part of the thickest gas hydrate-bearing parasequence within the Northwest Eileen-02 well (Zone C). *(PI Note: Note that the L-106 and V-107 log data should be incorporated into this analysis.)*

5.7 TASK 7.0: Drilling, Completion, and Production Lab Studies

<u>University of Alaska Fairbanks (UAF)</u>

UAF Principle Investigator: Shirish Patil
UAF Co-Principle Investigator: Abhijit Dandekar
UAF Research Professional: Narender R Nanchary
UAF Graduate Students: *Jason Westervelt, Stephen Howe,* Namit Jaiswal, Prasad Kerkar, Hemant Phale
UAF Undergraduate Student Assistant: Phillip Tsunemori

This section discusses gas hydrate research activities that were completed or are in progress between July 1, 2006 through September 30, 2006 at the University of Alaska Fairbanks (UAF). UAF did not document significant accomplishments during the reporting period, but plans to apply experimental work in phase behavior, relative permeability, and formation damage to gas hydrate-bearing Sagavanirktok reservoir core samples acquired in Phase 3a.

Phase 1 study tasks were completed and documented in detail in Quarterly Reports 1-15. UAF is expected to continue to play a key role in Alaska gas hydrate research to address potential productivity issues. The gas-water relative permeability data for gas hydrate systems was studied in Phase 1 for reconstituted sediment samples from sands not within the Sagavanirktok formation since no samples of these sands were available. Phase 3a Sagavanirktok formation core samples will enable obtaining ANS-specific gas-water relative permeability data for gas hydrate systems. These field samples are critical inputs to the reservoir simulation work, as gas-water relative permeability data provides direct input to reservoir and fluid flow modeling. Additionally, issues related to the kinetic reaction parameters and ice formation reactions also need to be resolved to enable comparison of results with existing simulators such as the EOSHYDR TOUGH2. Experiments are expected to determine if formation of ice may inhibit or contribute to gas dissociation from gas hydrate during production and to compare the order of magnitude of heat released while forming ice to that of becoming resistant to gas flow. Similarly, there is also a need to investigate the phase behavior characteristics of gas hydrate systems in the field samples, as the prior studies focused mostly on synthetic samples. This is also an important aspect of reservoir simulation as this directly relates to the production of 'additional' gas from gas hydrate dissociation.

In Phase 3 studies, UAF will play key role in analyzing core samples acquired from field work by measuring rock and fluid properties, helping design appropriate mud systems, assessing formation damage and core studies, while continuing the work on production modeling and economic studies.

5.7.1 Petrophysical and Other Physical Properties of Gas Hydrate Core Samples

No core samples were acquired during the reporting period.

5.8 Phase 3a Task 8.0: Plan and Implement Drilling of Stratigraphic Test Well

Detailed Phase 3a well plans will be reported following completion of in-progress well planning studies. A summary of work accomplished during the reporting period includes:

- Initiated long-lead materials acquisition for Phase 3a well operations
- Prepared procedures, plans, and cost estimates for Phase 3a stratigraphic test well
- Planned Stratigraphic Test Well and held regular weekly meetings with BP/DOE/team
    - Developed plans and initiated contracts, obtained permits, and acquired materials
    - Reviewed NEPA Categorical Exclusion approval documents
    - Identified critical tasks and path for well permits, materials, contracts, and rig
    - Documented risks, addressed concerns, and developed plans to mitigate risks
    - Developed contacts and contracts with appropriate operations subcontractors
    - Prepared and checked surface, ice pad/road, and well bottom hole locations
    - Developed agenda, convened, and moderated weekly well planning meetings

    - Provided action reviews and coordinated well operations plans
  - Evaluated logging-during-drilling, wireline, and MDT program plans
  - Evaluated mud program and incorporated DrillCool, Inc. mudchilling system
  - Planned core program and procedures and evaluated and selected vendors
    - Planned core acquisition parameters with Corion (ReedHycalog)
    - Planned core handling and processing program with OMNI and others
    - Evaluated options for onsite data acquisition and core handling
    - Selected certain time/temperature dependent data for onsite analyses
  - Developed, reviewed, and submitted detailed Phase 3a program drilling, data acquisition, and data evaluation budget
  - Initiated evaluation of short-term DST or short-medium term production testing
    - Evaluated cost versus value and benefits
    - Determined surface and subsurface equipment availability
    - Optional testing addition to base plan data acquisition through MDT logging was determined to be technically unviable and cost-ineffective (October 2006)
- Forwarded BP documents ("retaliation policy") to all vendors associated with project
  - Documents help ensure safety, policy, and procedures compliance

The planning and execution of a stratigraphic test well within the MPU Mt. Elbert prospect is an integral project objective. This objective is defined as Task 8.0 within Amendment 11 of the BP-DOE Cooperative Agreement:

"Task 8.0 - Plan and Implement Drilling of Stratigraphic Test Well:

Recipient will implement appropriate data acquisition consisting of a drilling and evaluation program based on a single vertical stratigraphic test well with appropriate logging, coring and MDT testing of the previously documented "Mt. Elbert" or comparable prospect within the Milne Point Unit. The field activity will be designed to determine the validity of pre-drill seismically-based predictions of gas hydrate occurrence and reservoir quality and to collect other data as necessary to enable a decision whether or not to conduct future dedicated gas hydrate reservoir production testing on the Alaska North Slope. Recipient will maximize synergies with existing and planned ANS developments. Recipient will either plug and abandon the well before moving off or suspend the well with or without instrumentation for future use as an observation well"

The well plan engineering and operations procedures are in-review due to the change in rig assignment from Doyon Arctic Fox to Doyon 14. In particular, the change from a kelly rotary (Doyon Arctic Fox) to top drive (Doyon 14) system would affect both specification of down hole drilling assemblies and specific operational sequences. The final Operational Well Plan, which would incorporate all equipment specifications, operational sequences and specialized service procedures, should be completed well in advance of rig mobilization to the location.

Figure 6 illustrates a type log of the Sagavanirktok interval from an offset well, MPE-26. The planned core and wireline log data acquisition intervals are shown in the figure. Figure 7 illustrates the surface location of the MtElbert prospect with respect to the MPU B-pad, E-pad, and Central Processing Facility (CPF) industry infrastructure.

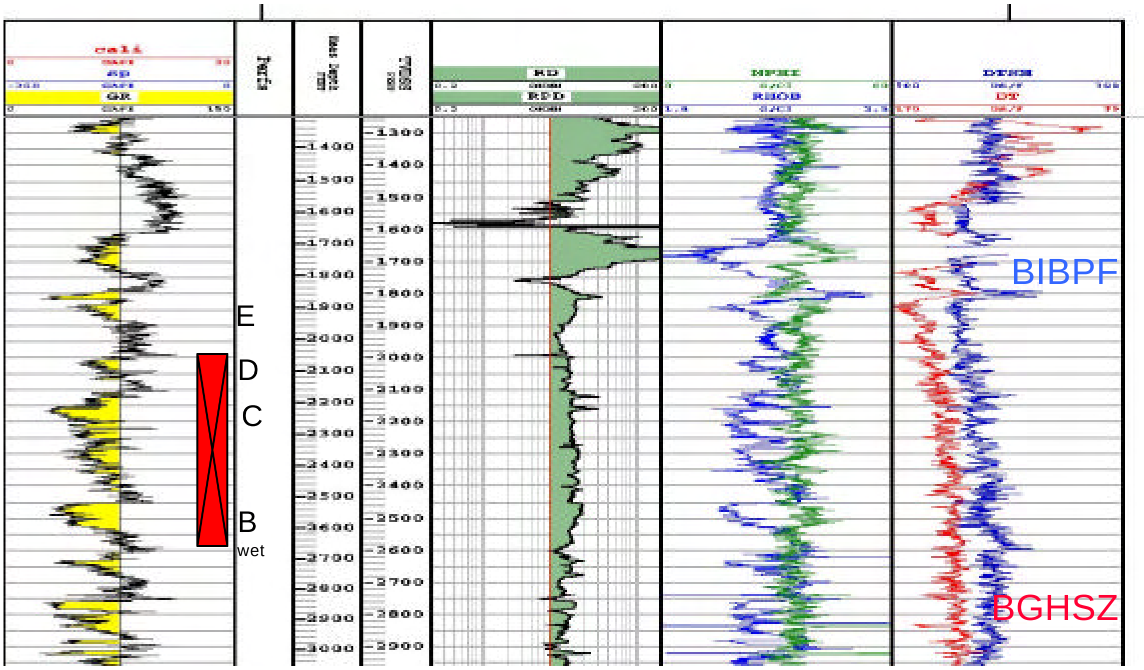

Figure 6: MPE-26 Type Log showing planned intervals of wireline log and core data acquisition between BIBPF and BGHSZ.

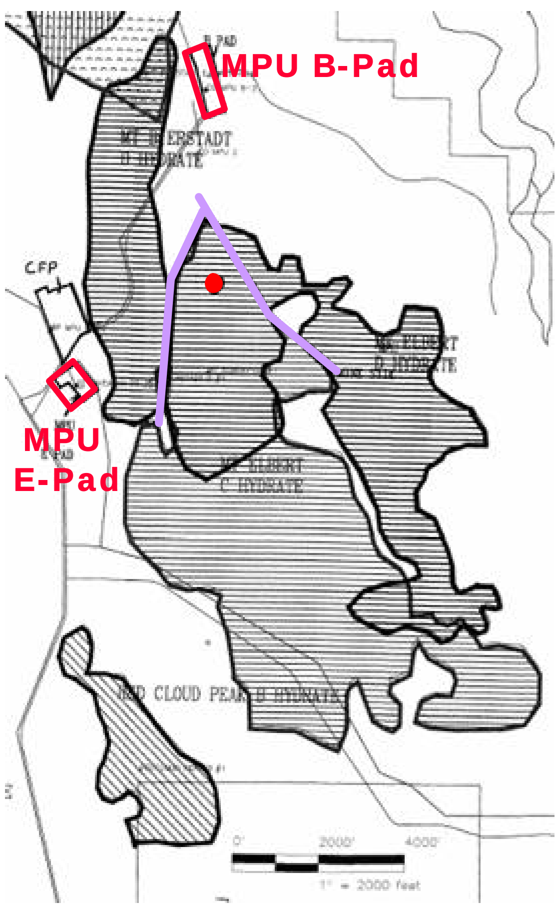

Figure 7: Mt Elbert-01 well location (red circle) within MPU Mt Elbert gas hydrate prospect.

5.8.1 Gas Hydrate Core Workshop Results

A core workshop was held in late September 2006 to develop gas hydrate project field operations plans for core acquisition, handling, onsite analyses, onsite equipment, sub-sample preservation, transportation, offsite analyses, and cold-storage. The coring operation is a key element of the gas hydrate appraisal program stratigraphic test. The core workshop initiated a core program design to help ensure planning of methods to successfully acquire and analyze this core. Final core program plans and costs are in-development and should be completed by December 2006 to enable adequate setup and funding of key program components. The core workshop was a working meeting designed to initiate and prepare the core plan, not a review meeting of a completed core plan. Table 2 shows project staff and supporting personnel who contributed to the workshop and Table 3 shows the final workshop agenda.

Table 2: Core Workshop Attendees, Support Personnel, and Function

Meeting Attendees:	**Organization/Function**
Bob Hunter	ASRC Energy Services / BPXA – DOE Gas Hydrate project lead
Tim Collett	USGS / Gas Hydrate Program and Field Operations lead
Kyle Johnson	BPXA / Geologist and lead for Ugnu-Schrader Bluff core program
Dennis Urban	BPXA / Geophysics/Well Planning
Dan Kara	BPXA / Lead Drilling Engineer
Larry Vendl	BPXA / MPU Development Team Lead
Kevan Sincock	BP / EPTG Core Acquisition Specialist
Kevin Webb	BP / EPTG Core Specialist
Henderson Watkins	OMNI / Lead Core Program specialist
Mike Walker	OMNI / Core Program specialist
Tracie Komm	OMNI / Core Program sales
Melanie Dunn	OMNI / Core Program Analyses specialist
Kevin Lerux	Corion-Reed-Hycalog Coring Services / Operations specialist
Kurt Huettl	Corion / Sales Manager, Geologist
Patrick M. Collins	Petroleum Geomechanics Inc. / Geomechanics
Meeting Support:	**Organization/Function**
Doug Kinsella	Corion / Wireline Core Advisor
Tony Worthen	DrillCool, Inc. / Mud Chilling Advisor
Dave Foster	OMNI / Core Program specialist
Steve Hancock	APA Engineering / MDT field specialist advisor
Jim Seccombe	BPXA / Petrophysics
Ray Boswell	DOE / Gas hydrate program lead
Jim Hemsath	DOE / Gas hydrate Contracting Officer Representative
Paul Hanson	BPXA / Senior Drilling Engineer
Scott Digert	BPXA / MPU Subsurface Lead
Cash Faye	BPXA / Permitting Specialist
Scott Wilson	Ryder Scott Co. / Reservoir Engineer
Mark Fairbanks	MI / Drilling Mud Engineer

Table 3: Final Core Workshop Agenda

Time	**Activity**
8:00 am	BPXA Office, Obtain visitor passes at security
	Discussion Items by Agenda # – *Discussion Leader*
8:10 am	Welcome and Introductions, Review Meeting Objectives / Draft Agenda – *Bob H.*
8:15 am	1. Gas Hydrate Stratigraphic Test Appraisal Objectives and Research Overview – *Bob H.*
9:35 am	HSE / Policy and BP open culture (non-retaliation/safety) – *Bob H.*
9:45 – BREAK	
10:00 am	2a. Core Acquisition/Processing Strategies/Past Data Acquisition Analogs – *Tim C.*
10:10 am	Mallik gas hydrate onshore analog program review
10:30 am	Drillsite Core layout/processing flow diagram review
10:35 am	2c. Drilling Mud Parameters and Mud Chilling – *Bob H., Mark Fairbanks, Tony W. – teleconf.;* also some discussion on Doyon 14 rig capacities, rig systems *(Dan K.)*
11:00 am	DST discussion/evaluation; possible synergy to and similarity with Ugnu program
11:15 am	2b. Wireline Coring/Acquisition through Layout – *Kurt Huettl* - Core rates/bits, mud pump rates/circulation, core recovery/layout, safety
11:45 am	3. Core Handling from Layout through Processing Flow – *Mike Walker* - Core stabilization/temperature, processing flow consistent with coring rates, safety
12:00 pm	Working Lunch at BP, move to Conference Room 560, begin discussion topic #5
12:15 pm	4. Core Onsite Analyses and Equipment Recommendations – *Tim C., Melanie D.* - Time/Temperature-dependent analyses consistent with core rates/processing flow - Primary Objectives of core analyses, special needs, mud tracer?, safety
1:25 pm	5. Core Sub-sample Preservation Recommendations/Techniques – *Tim C., others* - Subsample MATRIX, core preservation parameters, safety 7. Core Offsite Analysis - Routine and Special analysis – *Melanie D., Tim C., others* - Primary Objectives of core analyses, special needs, feedback to #4 onsite analyses - Ability to analyze core in Alaska vs. shipping offsite, pros/cons, feedback to #5
2:45 pm	BREAK
3:00 pm	6. Core Transportation Requirements, Containers, and Storage – *Tim C., Mike W.* - Temperature constraints, refrigerated trucking, storage/lab facility, safety
Not Covered in-depth	8. HSE issues and Risk Mitigation – *Larry V., Bob H., others* - Program summary/review, safety analysis, risk analysis, risk mitigation
Not Covered in-depth	9. Core Program Cost Estimation – *Bob H., others*
4:00 pm	Review Outstanding Concerns/Actions/Responsibilities/Deadlines – *Bob H., others* - Restate actions from meeting; communicate clear responsibilities and deadlines - Address any remaining concerns or issues from 'Parking Lot' - Safety and other training requirements (NSTC, Smith Driving?, other)

5.8.1.1 Core Workshop Responsibility/Actions Summary/Status

1. Bob discuss with Cash / Consider abandonment with Coiled Tubing with U-tube 3/8" DTS measurement (Abandonment must meet Regulatory standards) / Base plan abandonment without DTS due to regulatory and MPU constraints
2. Paul Hanson and Tony W. (DC) / Work shipping details and rig-specific hookup concerns – Doyon14 to DrillCool chiller equipment / In-progress, contracted and scheduled
3. Paul and Doyon / Likely dike in external lines to mud chiller on location for extra precaution
4. Bob to track/need HSE representative / Ensure NSTC (North Slope Training Cooperative Training and other required training for all onsite staff / per BPXA standard requirements
5. Bob, Scott Wilson, Tim Collett, BP, and DOE / Consider ability to setup DST or short-medium term production test program as add-on option following MDT / 10/26/06 BPXA-DOE Decision that no DST or short or medium term testing will occur to due operational constraints for ice-pad location and high cost for uncertain benefit (versus long-term Phase 3b production testing)
6. Paul / Oil-based mud system advantages discussed. Doyon (annular preventers, etc), Drill Cool, and Corion need to calculate impacts to equipment and planned data acquisition / Oil-based mud is base-plan to maximize operation safety and data acquisition parameters
7. Tim, Bob / Mallik lessons learned – see Data portion of Mallik CD – use this in program planning / Incorporating into program plans
8. Corion / writeup detailed core recovery process from borehole to rigfloor to pipeshed / In-progress in association with #13.
9. OMNI / Core layout facilities need to be constructed fit-for-purpose & available to BP program in field by December / Trailers and equipment located and in-progress
10. OMNI, Corion, Doyon / Consider options to drop temperature in pipe-shed on initial core recovery to surface or potentially wind-proof "tunnel" area between pipe-shed and core trailer or connex / Core trailers for layout will be located between borehole and rig around corner from pipeshed due to blast zone safety requirements; will attempt to design program to layout core within 5-10 minutes of core-to-surface.
11. Team, OMNI / Writeup detailed processing system for core, including core data onsite through transportation offsite and subsequent data analyses / In-progress
12. OMNI / Refrigerated truck – note potential to have remnant OBM versus Dry Ice – setup base plan using Dry Ice? / Refrigerated trailer located at significant cost savings; option in-progress.
13. Tim, OMNI, Bob, Kevan, Team / writeup detailed subsampling fit-for-purpose protocols (likely base this on outline presented by Tim C. beginning at 12:15pm. Refine WORD file outline and add detail on support analysis for each of samples; safety protocol overlay / Draft complete and in-edit
14. OMNI, USGS / If setup core gamma onsite, consider using same skate setup for IR, white light cameras (probably will not setup video in lieu of multiple white light cameras to capture initial core layout)./ in-progress and working with #13
15. Tim / Consider gamma-gamma-density system from Geotek – Peter S. – Tim C. to check availability? / unknown
16. Tim, OMNI, Bob: Evaluate temperature dependencies of onsite data acquisition; limit onsite data to critical time/temperature-dependent parameters – include in program writeup / in-progress and working with #13
17. Tim, OMNI: Develop expert subsampling decision tree and maintain lithologic and fluid

contacts in core / in-progress and working with #13

18. OMNI / Consider 12-foot long temperature reading bar (versus probes with core damage concern) / in-progress and working with #13
19. OMNI, USGS: Still-shot camera(s) likely best option (vs. video); consider inverted tripod(s), up to 12 cameras / in-progress and working with #13
    a. Quickshot (6 megapixels) for onsite cameras (note must be cold-tolerant)
    b. Nikon – USGS camera, very high-quality
    c. Sony DVD (option) – consider digital video if can setup good skate over core in Corion trailer
20. Kevan S. – consider and recommend (writeup) proper reservoir sand subsampling and onsite vs. offsite analyses programs in cooperation with OMNI & USGS / in-progress and working with #13
21. Corion / provide "rabbit" at top of core to record temperature/pressure as core acquired/processed (off-shelf system available?) – ensure pressure limit ok / Plans finalized and working
22. OMNI / evaluate core trailer options, including Cratex (consider order 3 20' containers – one for backup) / in-progress and working with #13
23. Tim, Schlumberger / Oil-based mud system – must evaluate petrophysical (wireline log) impacts? / In-progress; program nearly finalized
24. OMNI / evaluate and purchase refrigeration unit for core transport, storage, layout, slabbing, etc. Unit must be fitted with gas monitors and ability for own power system backup / Unit identified, plans in-progress
25. Corion / evaluate inner core barrel stiffness of steel versus potential need to use cradle / unknown
26. OMNI / All onsite trailers must be setup to monitor gas (LEL), oxygen, and H2S, and CO2 / Unit identified, parameters recognized, plans in-progress
27. All / Safety protocols must be fully written, understood, and rehearsed before/during core recovery / Plans in-progress, working in conjunction with #13
28. HSE / Consider cleanup of oil-based or invert emulsion mud – rag control, etc. / Incorporating into detailed core handling and safety plan
29. Tim, Mark Fairbanks / Consider potential of oil-based mud to form type-H hydrate, thus inducing core damage; need detailed chemical analysis of mud, filtrate, mineral oil (GC Mass Spec – what hydrocarbons are in system) of oil-based mud & mineral oil – Mark Fairbanks (LVT-200) / Analysis complete with input from Tom Lorenson (USGS); do not anticipate hydrate-forming chemicals in mud system.
30. OMNI / Core-gamma: better to run core through tool than tool over core (ensure consistent background) – in-progress, working into final core program plan
31. Corion, Schlumberger – setup communication with wireline company to ensure access to 5/16" braided WL / Unknown
    a. Ensure proper connections cross-over subs to Schlumberger WL
    b. Corion spangs, overjars, running gear, etc.
32. Tim / provide list outline, refine sampling recommendations, provide presentation / Draft provided
33. Bob / pdf of presentation to team (edit proprietary data) / in-progress
34. Paul, Doyon14 / Ensure excellent rig communications system, possibly including webcam for DOE access; ? if Ray onsite (DOE)? / unknown

35. OMNI / writeup core analyses recommendations with input from USGS list/outline / in-progress and working with #13
    a. Populate sampling frequency
    b. USGS supply syringe testing, etc. – coordinate onsite events and equipment
    c. Clearly define breakpoint of onsite versus offsite core analyses and iterate with team
36. Team / by November 15th, clearly identify risks and mitigations for input to Risk Register and Statement of Requirements / Drafts completed by November 2, 2006 in team meetings
37. Pat Collins - Geotechnical concern: consider mini-frac at end MDT analysis program (Pat Collins has done this with straddle-pack DST) – could also put this at end of DST program, if run DST – consider correct placement of mini-frac & propagation of frac in hydrate-bearing reservoir sand – may need this at beginning of DST to kick-off production? / No DST or production test will occur in Phase 3a
38. Paul, Doyon14, MPU / Rig and tool layout – must have tool-staging area for all of these tools; this must be planned 3-4 weeks before on-location (December 1st) for entire 3-well program. Options for pipe, trailers, etc to consider include MPU A-pad, B-pad (versus Deadhorse)./ Planning in-progress; attempting to locate warm warehouse for DrillCool equipment yard-test prior to hookup to Doyon 14 rig equipment.
39. Tim, Bob, OMNI, Kevan S. / Must calculate and plan personnel on-location needed for core shifts (estimate was 4 + 2 (core hands from rig?) per shift (to include Tim & Bob) / in-progress and working with #13.
40. Onsite Team / Must conduct dry-run training onsite for core layout procedures and subsampling/onsite core analyses procedures / Will be incorporated into baseplan in-progress and working with #13.
41. BPXA, HSE / Forward necessary pre-onsite training list to vendors – possibly some of this might be available in Calgary & Houston through BP or other providers / Plans in-progress to standardize vendor and ANS training requirements.
42. Corion, Doug K. / calculate flow rates/pump rates expected during coring / Completed

5.8.1.2 Outstanding Core Workshop Concerns Summary/Status

1. Need to contract **core processing trailer/**shed to house USGS equipment and hookup to rig power – multiple options, but need to land this aspect soon – also in actions, above / in-progress, unit identified
2. **Surface Casing** – need to fully define desired location, likely in shale beneath hydrate-permafrost-bearing “Zone E” – SOR process / Done; final selection by onsite geologists (Tim and Bob)
3. **Surface Casing** – define kick tolerance and strength necessary – Paul / Done, input into wellplan.
4. **Temperature monitoring** after abandonment – possible DTS system through U-tube – is this still considered “abandoned” by regulatory agencies? There is some precedent for this in Canada, but unsure in US; possible to have fiber optics on outside of casing (requires production tubing, but would need this if DST) / Base plan abandonment not with DTS per Regulatory and MPU constraints
5. Potential **Drilling Concern** – some uncertainty in presence of gas hydrate and/or free gas (Mt Elbert prospect not penetrated). Some discussion of Pilot hole, but recognition of

considerable added expense. As long as proper well-control mitigation, agreement to keep to single well. Still significant concern regarding circulating sub during core recovery to surface (potential to swab gas if no means of circulating above core barrel) / Done, ability to meet BP Drilling requirements demonstrated.

   a. **Oil Based mud** vs. Water based mud – OBM bad for organic geochemistry and gas detection, but good for pure-logging and control over pore-waters and formation water saturations (major uncertainty in gas hydrate-bearing section) / Done, Recommendation to use OBM completed.

6. **Hole diameter** during coring – Agreed that 7 7/8” best versus 8 ½”; allows drillout and cleanup before logging / Done
7. **DrillCool chiller** – particle size concern – Have Y-strainers capable of handling up to 1/8” / Done, not a concern.
8. **Drilling – with Corion wireline system**, swabbing concern and circulation-sub must be worked in detail and risks fully understood. Also need to be aware of hydrocarbon-bearing zone & potential for dropped objects. / Done; system meets Drilling specifications.
9. **Develop skate** in core layout trailer for camera, etc. scanning – ok in actions also / Working with #13, Actions.
10. **Core processing shifts** – concern over cold-exposure – 8 vs. 12 hour shifts, maximum 16 hours / Working with #13, Actions.
11. Consider **geomechanical parameters** affected by core recovery, processing, transportation – consider involvement of University of Alberta? / Working with #13, Actions.
12. **Core cycle time & onsite data** acquisition needs drive core processing staff requirements / Working with #13, Actions.
13. **DOT-approved cylinders** for some subsampling requirements and special core transport – some be available from GOM DOE JIP hydrate project / Working with #13, Actions.

5.8.1.3 Miscellaneous Core Workshop Notes

1. Oil-based mud (OBM) likely to improve borehole stability, data acquisition, and HSE
   a. OBM would compromise organic geochemistry, but this is lower-priority data
   b. Mallik used polymer Water-Based mud (WBM)
   c. Pore water salinities would be much better understood if use OBM
   d. 200 degree flashpoint
2. MtElbert prospect site has many similarities to Mallik 2002 site
   a. Note Mallik much higher salinities (fresh system on Alaska shallow sediments)
3. Base plan for 3” WL retrievable core with 7 7/8” hole (ideal with this equipment setup)
4. Mudchilling – surface solids control – proper chilling all about rig heat…
   a. If start with WBM, would have to take system apart to purge…
   b. Thus, if use WBM in surface hole, recommend not use chiller / Decided no chiller for surface hole.
   c. Thus, consider OBM in surface hole to break-in chiller system / No, decided no chiller for surface hole.
   d. Need to Test chiller system at mud plant before hookup to rig? Else Hook-up at rig. Mud Plant test was done at MI prior to Hot Ice project. MI (Mark) to workout will DrillCool (Tony)
   e. Drill Cool Power requirement is 400 amps (have backup generator also)

   f. Shipping requires 3-4 week leadtime from Carlise – Seattle to Anchorage on ship, then truck to Slope
   g. Prefer to assemble warm in Deadhorse or other staging area
5. Corion Coring – 3" core system
   a. Inner barrel is setup to identify if jammed or full
   b. Past gas hydrate experience was 90% recovery (very good compared to other gas hydrate programs)
   c. Ability to watch core progress (jamming, etc.) helps
   d. Small annular space helps keep system clean
6. Mallik lessons
   a. Need to review Data CD for lessons-learned and apply to this operation
   b. Note that core self-froze once reached surface
   c. Inner-barrel with 2 12' sections butted together
7. Core at surface process
   a. Separate Al inner barrel from steel outer barrel
   b. Break off shoe
   c. Break off / separate inner barrel (simultaneous with b to prevent freeze-off)
   d. Have not had to pump out inner barrel in past operations…
   e. Have tools onsite in case jamming occurs (not common)
   f. 2 12' tubes – fork-liftable (? Bending/damage?)
   g. Expected base-plan – core 24' every 2-3 hours (~8 hours per 100')
   h. Note absolute shift limit on Slope is 16 hours
      i. USGS (Tim C.) will provide core analyses and subsampling outline (not duplicated here).

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 (44 – 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 establishes 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. 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.

Approved field operations will enable acquisition of gas hydrate-bearing reservoir data within Phase 3a stratigraphic test studies (2006-2007). A key part of this analysis will be acquisition cores and wireline logging of gas hydrate-bearing reservoir sands and associated sediments. The wireline logging is planned to include Modular Dynamic Testing (MDT). Analysis of the core, log, and MDT results may help reduce the uncertainty regarding gas hydrate-bearing reservoir productivity and may lead to Phase 3b gas hydrate production test studies, although these Phase 3b studies are not currently approved.

7.0 PROJECT AND RELATED REFERENCES

7.1 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.

Casavant, R.R. and Gross, E., 2002, Basement Fault Blocks and Subthrust Basins? A Morphotectonic Investigation in the Central Foothills and Brooks Range, Alaska, at the SPE-AAPG: Western Region-Pacific Section Conference, Anchorage, Alaska, May 18-23, 2002.

Casavant, R.R. and Miller, S.R., 2002, Tectonic Geomorphic Characterization of a Transcurrent Fault Zone, Western Brooks Range, Alaska, at the SPE-AAPG: Western Region-Pacific Section Conference, Anchorage, Alaska, May 18-23, 2002.

Collett, T.S., 1993, "Natural Gas Hydrates of the Prudhoe Bay and Kuparuk River Area, North Slope, Alaska", The American Association of Petroleum Geologist Bulletin, Vol. 77, No. 5, May 1993, p. 793-812.

Collett, T.S., 2001, Natural-gas hydrates: resource of the twenty-first century? In M.W. Downey, J.C. Treet, and W.A. Morgan eds., Petroleum Provinces of the Twenty-First Century: American Association of Petroleum Geologist Memoir 74, p. 85-108.

Collett, T.S., 2001, MEMORANDUM: Preliminary analysis of the potential gas hydrate accumulations along the western margin of the Kuparuk River Unit, North Slope, Alaska (unpublished administrative report, December 6, 2001).

Collett et al., 2001, Modified version of a multi-well correlation section between the Cirque-2 and Reindeer Island-1 wells, depicting the occurrence of the Eileen and Tarn gas hydrate and associated free-gas accumulations (unpublished administrative report).

Collett et al., 2001, Modified version of a map that depicts the distribution of the Eileen and Tarn gas hydrate and associated free-gas accumulations (unpublished administrative report).

Collett, T.S., 2002, Methane hydrate issues – resource assessment, In the Proceedings of the Methane Hydrates Interagency R&D Conference, March 20-22, 2002, Washington, D.C., 30 p.

Collett, T.S., 2002, Energy resource potential of natural gas hydrates: Bulletin American Association of Petroleum Geologists, v. 86, no. 11, p. 1971-1992.

Collett, T.S., and Dallimore, S.R., 2002, Detailed analysis of gas hydrate induced drilling and production hazards, In the Proceedings of the Fourth International Conference on Gas Hydrates, April 19-23, 2002, Yokahama, Japan, 8 p.

Digert, S. and Hunter, R.B., 2003, Schematic 2 by 3 mile square reservoir block model containing gas hydrate, associated free gas, and water (Figure 2 from December, 2002 Quarterly and Year-End Technical Report, First Quarterly Report: October, 2002 – December, 2002, Cooperative Agreement Award Number DE-FC-01NT41332

Geauner, J.M., Manuel, J., and Casavant, R.R., 2003, Preliminary subsurface characterization and modeling of gas hydrate resources, North Slope, Alaska, , in: 2003 AAPG-SEG Student Expo Student Abstract Volume, Houston, Texas

Howe, Steven J., 2004, Production modeling and economic evaluation of a potential gas hydrate pilot production program on the North Slope of Alaska, MS Thesis, University of Alaska Fairbanks, 141 p.

Hunter, R.B., Casavant, R. R. Johnson, R.A., Poulton , M.., Moridis, G.J., Wilson, S.J., Geauner, S. Manuel, J., Hagbo, C., Glass, C.E., Mallon, K.M., Patil, S.L., Dandekar, A., And Collett, T.S., 2004, Reservoir-fluid characterization and reservoir modeling of potential gas hydrate resource, Alaska North Slope, 2004 AAPG Annual Convention Abstracts with Program.

Hunter, R.B., Digert, S.A., Casavant, R.R., Johnson, R., Poulton, M., Glass, C., Mallon, K., Patil, S.L., Dandekar, A.Y., and Collett, T.S., 2003, "Resource Characterization and Quantification of Natural Gas-Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay-Kuparuk River Area, North Slope of Alaska", Poster Session at the AAPG Annual Meeting, Salt Lake City, Utah, May 11-14, 2003. Poster received EMD, President's Certificate for Excellence in Presentation.

Hunter, R.B., Pelka, G.J., Digert, S.A., Casavant, R.R., Johnson, R., Poulton, M., Glass, C., Mallon, K., Patil, S.L., Chukwu, G.A., Dandekar, A.Y., Khataniar, S., Ogbe, D.O., and Collett, T.S., 2002, "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", presented at the Methane Hydrate Inter-Agency Conference of US Department of Energy, Washington DC, March 21-23, 2002.

Hunter, R.B., Pelka, G.J., Digert, S.A., Casavant, R.R., Johnson, R., Poulton, M., Glass, C., Mallon, K., Patil, S.L., Chukwu, G.A., Dandekar, A.Y., Khataniar, S., Ogbe, D.O., and Collett, T.S., 2002, "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", at the SPE-AAPG: Western Region-Pacific Section Conference, Anchorage, Alaska, May 18-23, 2002.

Hunter, R.B., et. al., 2004, Characterization of Alaska North Slope Gas Hydrate Resource Potential, Spring 2004 Fire in the Ice Newsletter, National Energy Technology Laboratory.

Jaiswal, Namit J., 2004, Measurement of gas-water relative permeabilities in hydrate systems, MS Thesis, University of Alaska Fairbanks, 100 p.

Lachenbruch, A.H., Galanis Jr., S.P., and Moses Jr., T.H., 1988 "A Thermal Cross Section for the Permafrost and Hydrate Stability Zones in the Kuparuk and Prudhoe Bay Oil Fields", Geologic Studies in Alaska by the U.S. Geological Survey during 1987, p. 48-51.

Lee, M.W., 2002, Joint inversion of acoustic and resistivity data for the estimation of gas hydrate concentration: U.S. Geological Survey Bulletin 2190, 11 p.

Lee, M.W., 2004, Elastic velocities of partially gas-saturated unconsolidated sediments, Marine and Petroleum Geology 21, p. 641–650.

Lee, M. W., 2005, Well-log analysis to assist the interpretation of 3-D seismic data at the Milne Point, North Slope of Alaska, U. S. Geological Survey Scientific Investigation Report SIR 2005-5048, 18 p.

Lewis, R.E., Collett, T.S., and Lee, M.W., 2001, Integrated well log montage for the Phillips Alaska Inc., Kuparuk River Unit (Tarn Pool) 2N-349 Well (unpublished administrative report).

Khataniar, S, Kamath, V.A., Omenihu, S.D., Patil, S.L., and Dandekar, A.Y., 2002, "Modeling and Economic Analysis of Gas Production from Hydrates by Depressurization Method", The Canadian Journal of Chemical Engineering, Volume 80, February 2002.

Werner, M.R., 1987, Tertiary and Upper Cretaceous heavy-oil sands, Kuparuk River Unit area, Alaska North Slope, in Meyer, R.F., ed., Exploration for heavy crude oil and natural bitumen: American Association of Petroleum Geologists Studies in Geology 25, p. 537-547.

Westervelt, Jason V., 2004, Determination of methane hydrate stability zones in the Prudhoe Bay, Kuparuk River, and Milne Point units on the North Slope of Alaska, MS Thesis, University of Alaska Fairbanks, 85 p.

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

7.2 University of Arizona Research Publications and Presentations

7.2.1 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.

7.2.2 Professional Posters

a. Poulton, M.M., Casavant, R.R., Glass, C.E., and B. Zhao, 2004, Model Testing of Methane Hydrate Formation on the North Slope of Alaska With Artificial Neural Networks, AAPG Hedberg Conference, Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 2 pp.
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

Resource Potential and Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 4 pp.

c. Gandler, G.L., Casavant, R.R., Johnson, R.A., Glass, K, and T.S.Collett, 2004, Preliminary Spatial Analysis of Faulting and Gas Hydrates-Free Gas Occurrence, Milne Point Unit, Arctic Alaska, AAPG Hedberg Conference, Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 3 pp.
d. Hennes, M., Johnson, R.A., and R.R. Casavant, 2004, Seismic Characterization of a Shallow Gas-Hydrate-Bearing Reservoir 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.
e. Hennes, A., and R. Johnson, 2004, Pushing the envelope of seismic data resolution: Characterizing a shallow gas-hydrate reservoir on the North Slope of Alaska, 2004 Univ. of Arizona Dept. Geosciences Annual GeoDaze Symposium.
f. Geauner, J.M., Manuel, J., And Casavant, R.R., 2003, Preliminary Subsurface Characterization And Modeling Of Gas Hydrate Resources, North Slope, Alaska, in: Student Abstract Volume, 2003 AAPG-SEG Student Expo, Houston, Texas.

7.2.3 Professional Publications

a. Poulton, M.M., Casavant, R.R., Glass, C.E., and B. Zhao, 2004, Model Testing of Methane Hydrate Formation on the North Slope of Alaska With Artificial Neural Networks, AAPG Hedberg Conference, Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 2 pp.
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 Resource Potential and Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 4 pp.
c. Gandler, G.L., Casavant, R.R., Johnson, R.A., Glass, K, And T.S.Collett, 2004, Preliminary Spatial Analysis Of Faulting And Gas Hydrates-Free Gas Occurrence, Milne Point Unit, Arctic Alaska, AAPG Hedberg Conference, Gas Hydrates: Energy Resource Potential And Associated Geologic Hazards, September 12-16, 2004, Vancouver, BC, Canada, 3 pp.
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.
e. Johnson, R. A., 2003, Shallow Natural-Gas Hydrates Beneath Permafrost: A Geophysical Challenge To Understand An Unconventional Energy Resource, News From Geosciences, Department Of Geosciences Newsletter, V. 8, No. 2, p. 4-6.
f. 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. Suppl., Abstract OS42B-06.

g. Geauner, J.M., Manuel, J., And Casavant, R.R., 2003, Preliminary Subsurface Characterization And Modeling Of Gas Hydrate Resources, North Slope, Alaska; in: Student Abstract Volume, 2003 AAPG-SEG Student Expo, Houston, Texas.
h. 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.
i. Hennes, A., and R. Johnson, 2004, Pushing the envelope of seismic data resolution: Characterizing a shallow gas-hydrate reservoir on the North Slope of Alaska, 2004 Univ. of Arizona Dept. Geosciences Annual GeoDaze Symposium.
j. Hagbo, C. and R. Johnson, 2003, Delineation of gas hydrates, North Slope, Alaska, 2003 Univ. of Arizona Dept. Geosciences Annual GeoDaze Symposium.
k. Geauner, J.M., Manuel, J., and Casavant, R.R., 2003, Preliminary subsurface characterization and modeling of gas hydrate resources, North Slope, Alaska; in: Student Abstract Volume, 2003 AAPG-SEG Student Expo, Houston, Texas.
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.

7.2.4 Sponsored Thesis Publications

a. Hennes, A.M., 2004, Structural Constraints on Gas-hydrate Formation and Distribution in the Milne Point, North Slope of Alaska, M.S. Thesis (Prepublication Manuscript), Dept. of Geosciences, University of Arizona, Tucson, 76 pp.
b. Hagbo, C.L., 2003, Characterization of Gas-hydrate Occurrences using 3D Seismic Data and Seismic Attributes, Milne Point, North Slope, Alaska, M.S. Thesis, Dept. of Geosciences, University of Alaska, Tucson, 127 pp.
c. Zhoa, Bo, 2003, Classifying Seismic Attributes in the Milne Point Unit, North Slope of Alaska, M.S. Thesis, Dept. of Mining and Geological Engineering, University of Arizona, Tucson, 159 pp.

7.2.5 Artificial Neural Network References

Bishop, C., 1995, Neural Networks for Pattern Recognition: Oxford Press.

Broomhead, D., and Lowe, D., 1988, Multivariable functional interpolation and adaptive networks: Complex Systems, 2, 321-355.

Casavant, R. R., 2001, Morphotectonic Investigation of the Arctic Alaska Terrane: Implications to Basement Architecture, Basin Evolution, Neotectonics and Natural Resource Management: Ph.D thesis, University of Arizona, 457 p.

Casavant, R., Hennes, A., Johnson, R., and Collett, T., 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 ONFERENCE, "Gas Hydrates: Energy

Resource Potential and Associated Geologic Hazards" September 12-16, 2004, Vancouver, BC, Canada.

Collett, T., Bird, K., Kvenvolden, K., and Magoon, L., 1988, Geologic interrelations relative to gas hydrates within the North Slope of Alaska: USGS Open File Report, 88-389.

Darken, C., and Moody, J., 1990, Fast adaptive K-means clustering: Some empirical results: IEEE INNS International Joint Conference on Neural Networks, 233-238.

Gandler, G., Casavant, R., Glass, C., Hennes, A., Hagbo, C., and Johnson, R., 2004, Preliminary Spatial Analysis of Faulting and Gas Hydrate Occurrence Milne Point Unit, Arctic Alaska: AAPG HEDBERG CONFERENCE, "Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards" September 12-16, 2004, Vancouver, BC, Canada.

Geauner, S., Manuel, J., Casavant, R., Glass, C., and Mallon, K., 2004,Well Log Normalization and Comparative Volumetric Analyses of Gas Hydrate and Free-gas Resources, Central North Slope, Alaska: AAPG HEDBERG CONFERENCE, "Gas Hydrates: Energy Resource Potential and Associated Geologic Hazards" September 12-16, 2004, Vancouver, BC, Canada.

Girosi, F. and Poggio, T., 1990, Networks and the best approximation property: Biological Cybernetics, 63, 169-176.

Glass, C. E. 2003, Estimating pore fluid concentrations using acoustic and electrical log attributes, Interim Report, UA Gas Hydrate Project.

Hagbo, C., 2003, Characterization of gas-hydrate occurrences using 3D seismic data and seismic attributes, Milne Point, North Slope, Alaska: MS Thesis, University of Arizona, Tucson, Arizona.

Hashin, Z and S. Shtrikman, 1963, A variational approach to the theory of the elastic behavior of multiphase materials, Journal of the Mechanics and Physics of Solids, Vol. 11, p. 127-140.

Haykin, S., 1994, Neural Networks. A Comprehensive Foundation: Macmillan.

Light,W., 1992, Some aspects of radial basis function approximation, in Singh, S., Ed., Approximation Theory, Spline Functions and Applications: NATO ASI series, 256, Kluwer Academic Publishers, 163-190.

Mavco, G., T. Mukerji and J. Dvorkin, 1988, The rock physics handbook, Cambridge University Press.

Moody, J., and Darken, C., 1989, Fast learning in networks of locally-tuned processing units: Neural Computation, 1, 281-294.

Musavi, M., Ahmed,W., Chan, K., Faris, K., and Hummels, D., 1992, On the training of radial basis function classifiers: Neural Networks, 5, 595-603.

Poggio, T. and Girosi, F., 1989, A theory of networks for approximation and learning: A.I. Memo No. 1140 (C.B.I.P . Paper No. 31), Massachusetts Institute of Technology, Artificial Intelligence Laboratory.

Poulton, M., 2002, Neural networks as an intelligence amplification tool: A review of applications: Geophysics, vol. 67, no. 3, pp. 979-993.

Poulton, M., (Ed.), 2001, Computational Neural Networks for Geophysical Data Processing: Pergamon, Amsterdam, 335p.

Powell, M., 1987, Radial basis functions for multivariable interpolation: A review, in Mason, J. and Cox, M., Eds., Algorithms for Approximation: Clarendon Press.

Zell, A., 1994, Simulation Neuronaler Netze: AddisonWesley.

Zhao, B., 2003, Classifying Seismic Attributes In The Milne Point Unit, North Slope of Alaska: MS Thesis, University of Arizona, Tucson, Arizona.

7.3 Gas Hydrate Phase Behavior and Relative Permeability References

ASTM, 2000, “Standard Test Method for Permeability of Granular Soils (constant head) D 2434-68”, American Society for Testing and Materials, Annual Book of ASTM Standards, West Conshohocken, PA, 202-206.

Dvorkin, J., Helgerud, M.B., Waite, W.F., Kirby, S.H. and Nur, A., 2000, “Introduction to Physical Properties and Elasticity Models”, in Natural Gas Hydrate in Oceanic and Permafrost Environments, edited by M.D. Max, pp 245-260, Kluwer, Dordrecht.

Gash, B.W., 1991, “Measurement of Rock Properties in Coal for Coalbed Methane Production”, Paper 22909 presented at the 1991 SPE annual Technical conference and Exhibition, Dallas, October 6-9.

Johnson, E.F., Bossler, D.P., and Neumann, V.O., 1959, “Calculation of Relative Permeability from Displacement Experiments”, Trans. AIME, 216, 370- 372.

Jones, S.C. and Roszelle, W.O., 1978, “Graphical Techniques for Determining Relative Permeability from Displacement Experiments”, JPT, (May 1978), 807-817.

Joseph W. W. and Duane H.S., 2002, “Upper Limits on the Rates of Dissociation of Clathrate Hydrates to Ice and Free Gas”, J. Phys. Chem. B., (May 2002), 106, 6298-6302.

Makogon, Y.F., Makogon, T.Y. and Holditch, S.A., 1998, “Several Aspects of the Kinetics and Morphology of Gas Hydrates”, Proceedings of the International Symposium on Methane Hydrates: Resources in the Near Future?, Chiba City, Japan, 20-22, October 1998.

Masuda, Y., Ando, S., Ysukui, H., and Sato, K., 1997, "Effect of Permeability on Hydrate Decomposition in Porous Media", International Workshop on Gas Hydrate Studies, Tsukuba, Japan, Mar 4-6, 1997.

Mehrad, N., 1989, "Measurement of gas permeability in hydrate saturated unconsolidated cores", M.S thesis, University of Alaska Fairbanks.

Owens, W.W., Parrish, D.R., and Lamoreausx, W.E., 1956, "An Evaluation of Gas Drive Method for Determining Relative Permeability Relationships", Trans., AIME 207, 275-280.

Scheidegger, A.E., 1998, The Physics of Flow Through Porous Media, Macmillan, New York.

Sloan, E.D., 1998, Clathrate Hydrates of Natural Gases, Mercel Dekker, New York.

Spangenberg,W., 2001, "Modeling of the influence of gas hydrate content on the electrical properties of porous sediments", J of Geophys. Res B., 106, 6535-6549.

Stern, L.A., Kirby, S.H., Durham, W.B., Circone, S. and Waite, W.F., 2000, " Laboratory synthesis of pure methane hydrate suitable for measurement of physical properties and decomposition behavior" in Natural Gas Hydrate in Oceanic and Permafrost Environments, edited by M.D. Max, pp 323-348, Kluwer, Dordrecht.

Tooth, J., Bodi, T., et al., 2000, "Analytical Techniques for Determination of Relative Permeability from Displacement Experiments", Progress in Mining and Oilfield Chemistry, Vol-2, 91-100.

Westervelt, J.V., 2004. "Determination of methane hydrate stability zones in the Prudhoe Bay, Kuparuk River, and Milne Point units on the North Slope of Alaska". MS Thesis, University of Alaska Fairbanks, Fairbanks, AK.

Wilder, J.W., Seshadri, K. and Smith, D.H., 2001, "Modeling Hydrate Formation in Media With Broad Pore Size Distributions", Langmuir 17, 6729-6735.

Winters, W.J., Dillon, W.P., Pecher, I.A. and Mason, D.H., 2000, "GHASTLI-Determining physical properties of sediment containing natural and laboratory formed gas hydrate" in Natural Gas Hydrate in Oceanic and Permafrost Environments, edited by M.D. Max, pp 311-322, Kluwer, Dordrecht.

7.4 Drilling Fluid Evaluation and Formation Damage References

7.4.1.1 Formation Damage Prevention References, In-Review Publication

The following references were used in developing Section 5.7.3 of this report.

1. Collett, T.S.: "Well Log Characterization of Sediments in Gas-Hydrate-Bearing Reservoirs", SPE 49298, presented at SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana, September 27-30, 1998.

2. Collett, T.S., Bird, K.J., Magoon, L.B.: "Subsurface Temperatures and Geothermal Gradients on the North Slope of Alaska", SPE 19024, Society of Petroleum Engineers, 1988.

3. Collett, T.S.: "Natural Gas Hydrates of the Prudhoe Bay and Kuparuk River Area North Slope, Alaska", The American Association of Petroleum Geologists Bulletin, Vol. 77, No. 5, pp. 793-812, May 1993.

4. Dallimore, S.R., Uchida, T., Collett, T.S.: "Scientific Results from JAPEX/JNOC/GSC Mallik 2L-38 Gas Hydrate Research Well, Mackenzie Delta, Northwest Territories, Canada", Geological Survey of Canada Bulletin 544, February 1999.

5. Dvorkin, J., Helgerud, M.B., Waite, W.F., Kirby, S.H., Nur, A., "Introduction to Physical Properties and Elasticity Models, in Natural Gas Hydrate in Oceanic and Permafrost Environments, edited by M.D. Max, pp. 245-260, Kluwer, Dordrecht, 2000.

6. Ginsburg, G., Soloviev, V., Matveeva, T., Andreeva, I.: "Sediment Grain Size Control on Gas Hydrate Presence, Sites 994, 995, and 997", Proceedings of the Ocean Drilling Program, Scientific Results, Leg 164, edited by C.K. Paul et al., chap. 24, Ocean Drilling Program, College Station, Texas, 2000.

7. Kamath, V.A., Patil, S.L.: "Description of Alaskan Gas Hydrate Resources and Current Technology", studies by University of Alaska Fairbanks, January 1994.

8. Kerkar, P.B.: "Assessment of Formation Damage from Drilling Fluids Dynamic Filtration in Gas Hydrate Reservoirs of the North Slope of Alaska", M.S. Thesis, University of Alaska Fairbanks, August 2005.

9. Marshall, D.S., Gray, R., Byrne, M.: "Development of a Recommended Practice for Formation Damage Testing", SPE 38154, presented at the SPE European Formation Damage Conference, Hague, Netherlands, June 2-3, 1997.

10. Matsumoto, R., "Comparison of Marine and Permafrost Gas Hydrates: Examples from Nankai Trough and Mackenzie Delta, Proceedings of the Fourth International Conference on Gas Hydrates, Yokohama, 19-23 May 2002a.

11. Murlidharan, V., Putra, E., Schechter, D.S.: "Investigating the Changes in Matrix and Fracture Properties and Fluid Flow under Different Stress-state Conditions", M.S. Thesis, Texas A & M University, 2002.

12. Shipboard Scientific Party: "Leg 204 Preliminary Report, Drilling Gas Hydrates on Hydrate Ridge, Cascadia Continental Margin", ODP Texas A & M University, December 2002, Available from World Wide Web:

http://www-odp.tamu.edu/publications/prelim/204_prel/204PREL.PDF.

13. Winters, W.J., Dallimore, S.R., et al.: "Physical properties of sediments from the JAPEX/JNOC/GSC Mallik 2L-38 Gas Hydrate Research Well", in Geological Survey of Canada Bulletin 544: Scientific Results from JAPEX/JNOC/GSC Mallik 2L-38 Gas Hydrate Research Well, Mackenzie Delta, Northwest Territories, Canada, edited by Dallimore, S.R. et al. Geological Survey of Canada, Ottawa, 1999.

14. Yousif, M.H., Abass, H.H., Selim, M.S., Sloan, E.D.: "Experimental and Theoretical Investigation of Methane-Gas-Hydrate Dissociation in Porous Media"; SPE 18320, SPE Reservoir Engineering, February 1991.

7.4.1.2 Formation Damage Prevention References, General

Anselme, M.J., Reijnhout, M.J., Muijs, H.M., Klomp, 1993, U.C.; World Pat. WO 93/25798.

Belavadi, M.N., 1994, "Experimental Study of the Parameters Affecting Cutting Transportation in a Vertical Wellbore Annulus"; M.S.Thesis, UAF; Sept., 1994.

Bennion D.B., Thomas F.B., Bietz R.F., 1996, "Low permeability Gas Reservoirs: Problems, Opportunities and Solution for Drilling, Completion, Simulation and Production"; SPE 35577; May 1996.

Bennion D.B., Thomas F.B., Bietz R.F., 1996 "Formation Damage and Horizontal Wells- A Productivity Killer?" SPE 37138; International Conference on Horizontal Well Technology, Calgary; Nov. 1996.

Bennion D.B., Thomas F.B., Bietz R.F., 1995, "Underbalanced Drilling and Formation Damage-Is it a Total Solution?"; The Journal of Canadian Petroleum Tech.; Vol. 34 (9); Nov. 1995.

Bennion D.B., Thomas F.B., et al., 1995, "Advances in Laboratory Core Flow Evaluation to minimize Formation Damage Concerns with Vertical/Horizontal Drilling Application"; CAODC; Vol. 95 (105).

Bennion D.B., Thomas F.B, Jamaluddin, K.M., Ma T.; "Using Underbalanced Drilling to Reduce Invasive Formation Damage and Improve Well Productivity- An Update"; Petroleum Society of CIM; PTS 98-58.

Chadwick J., 1995, "Exploration in permafrost"; Mining Magazine; February, 1995.

Chen, W., Patil S.L., Kamath, V.A., Chukwu, G.A., 1998, "Role of Lecithin in Hydrate Formation/Stabilization in Drilling Fluids"; JNOC; October 20, 1998.

Chilingarian G.V., Vorabutr P., 1983, "Drilling and drilling fluids"; Elsevier; NY.

Cohen J.H., Williams T.E., 2002, "Hydrate Core Drilling Tests: Topical Report"; Maurer Technology Inc., Houston, Texas; November 2002.

Crowell, E.C., Bennion, D.B., Thomas, F.B., Bennion, D.W., 1992, "The Design & Use of Laboratory Tests to Reduce Formation Damage in Oil & Gas Reservoirs"; 13th Annual Conference of the Ontario Petroleum Institute.

Dallimore, S.R., Uchida, T., Collett, T.S., 1999, "Scientific Results from JAPEX/JNOC/GSC Mallik 2L-38 Gas Hydrate Research Well, Mackenzie Delta, Northwest Territories, Canada"; Geological Survey of Canada Bulletin 544; February, 1999.

Drill Cool Systems Canada Inc., www.drillcool.com.

Duncum, S.N., Edwards, A.R., Osborne, C.G., 1993, Eur. Pat. 536,950.

Francis P.A., Eigner M.R.P., et. al.., 1995, "Visualization of Drilling-Induced Formation Damage Mechanisms using Reservoir Conditions Core Flood Testing"; paper SPE 30088 presented at the 1995 European Formation Damage Conference, The Hague, May 15-16.

Fu, S.B., Cenegy, L.M., Neff C.S., 2001, "A Summary of Successful Field Application of A Kinetic Hydrate Inhibitor"; SPE 65022.

Hammerschmidt E.G., 1934, Ind.Eng.Chem.; 26, 851.

Howard S.K., 1995, "Formate Brines for Drilling and Completion: State of the Art"; SPE 30498.

I.F.P. patents: Fr.Pats. 2,625,527; 2,625,547; 2,625,548; 2,694,213; 2,697,264: Eur. Pats. 594,579; 582,507323,775; 323307: US Pat. 5,244,878. Can.Pat. 2,036,084.

Jamaluddin A.K.M., Bennion D.B., et. al.; "Application of Heat Treatment to Enhance Permeability in Tight Gas Reservoirs"; Petroleum Society of CIM; Paper No. 98-01.

Kalogerakis N., Jamaluddin, et. al., 1993, "Effect of Surfactants on Hydrate Formation Kinetics"; SPE 25188.

Kamath V.A., Mutalik P.N., et. al., 1991, "Experimental Study of Brine Injection and Depressurization Methods for Dissociation of Gas Hydrate"; SPE Formation Evaluation; December 1991.

Kastube T.J., Dallimore S.R., et. al., 1999, "Gas Hydrate Investigation in Northern Canada"; JAPEX; Vol. 8; No. 5.

Kelland, M.A., Svartaas, T.M., Dybvik, L.A., 1994, "Control of Hydrate Formation by Surfactants and Polymers"; SPE 28506; p. 431-438.

Kotkoskie T.S., AL-Ubaidi B., et. al., 1990, "Inhibition of Gas Hydrates in Water-Based Drilling Mud"; SPE 20437.

Kutasov I.M., 1995, "Salted drilling mud helps prevent casing collapse in permafrost"; Oil & Gas Journal; July 31, 1995.

Marshal, D.S., Gray, R., Byrne, M.; 1997, "Development of a Recommended Practice for Formation Damage Testing"; SPE 38154; Presented at the 1997 SPE European Formation Damage Conference; Netherlands, 2-3 June 1997.

Maury V., Guenot A., 1995, "Practical Advantages of Mud Cooling Systems for Drilling"; SPE Drilling & Completion, March 1995.

Max M.D., 2000, "Natural Gas Hydrate in Oceanic & Permafrost Environments"; Kluwer Academic Publishers; Boston; 2000.

Muijs, H.M., Beers, N.C., et al., 1990, Can. Pat. 2,036,084.

Oort E.V., Friedheim J.M., Toups B., 1999, "Drilling faster with Water-Base Mud"; American Association of Drilling Engineers – Annual Technical Forum; Texas; March 30-31, 1999.

Paez, J.E., Blok, R., Vaziri, H., Islam M.R., 2001, "Problems in Hydrates: Mechanisms and Elimination Methods"; SPE 67322.

Pooladi-Darvish M., Hong, H., 2003, "A Numerical Study on Gas Production From Formations Containing Gas Hydrates"; Canadian International Petroleum Conference, Calgary, June 10-12, 2003.

Reijnhout, M.J., Kind, C.E., Klomp, 1993, U.C.; Eur. Pat. 526,929.

Robinson L.; 1977, "Mud equipment manual, Handbook 1: Introduction to drilling mud system"; Gulf Publishing Company; Houston.

Sasaki K., Akibayashi S., Konno S., 1998, "Thermal and Rheological properties of Drilling Fluids and an Estimation of Heat Transfer Rate at Casing pipe"; JNOC-TRC, Japan; October 20-22, 1998.

Schofield T.R., Judis A., Yousif M., 1997, "Stabilization of In-Situ Hydrates Enhances Drilling Performance and Rig Safety"; SPE 32568 ; Drilling & Completion.

Sira J.H., Patil S.L., Kamath V.A., 1990, "Study of Hydrate Dissociation by Methanol and Glycol Injection"; SPE 20770.

Sloan, E.D., 1994, World Pat. WO 94/12761.

Spence G.D., Hyndman R.D., 2001, "The challenge of Deep ocean Drilling for Natural Gas Hydrate"; Geoscience Canada; Vol.28 (4); December, 2001.

Sumrow Mike, 2002, "Synthetic-based muds reduce pollution discharge, improve drilling"; Oil & Gas Journal; Dec. 23, 2002.

Szczepanski R., Edmonds B., et. al., 1998, "Research provides clues to hydrate formation and drilling-hazard solutions"; Oil & Gas Journal; Vol. 96(10); Mar 9, 1998.

Toshiharu O., Yuriko M., et. al., 1998, "Kinetic Control of Methane Hydrates in Drilling Fluids"; JNOC-TRC; October 20-22, 1998.

Urdahl, O., Lund, A., Moerk, P., Nilsen, T-N, 1995 "Inhibition of Gas Hydrate Formation by means of Chemical Additives: Development of an Experimental Set-up for Characterization of Gas Hydrate Inhibitor Efficiency with respect to Flow Properties and Deposition"; Chem. Eng. Sci.; 50(5), 863.

Vincent M., Guenot Alain, 1995, "Practical Advantages of Mud Cooling System for Drilling"; SPE Drilling & Completion; March 1995.

Weidong C., Patil S.L., Kamath V.A., Chukwu G.A., 1998, "Role of Lecithin in Hydrate Formation/Stabilization in Drilling Fluids"; JNOC-TRC; October 20-22, 1998.

Yuliev, A.M.; Gazov, Delo, 1972, 10, 17-19, Russ.

Zakharov A.P., 1992, "Silicon-based additives improve mud Rheology"; Oil & Gas Journal; Aug. 10, 1992.

7.5 Coring Technology References

Amann, H. et al., 2002, "First Successful Deep-Sea Operations of OMEGA-MAC, the Multiple Auto Corer, during the OTEGA-I campaign on Hydrate Ridge". Fachgebiet Maritime Technik. August 2002.

Carroll, John, 2002, "Natural Gas Hydrates: A Guide for Engineers". Gulf Professional Publishing. October 30, 2002.

Dickens, Gerald R. et al., 2000, "Detection of Methane Gas Hydrate in the Pressure Core Sampler (PCS): Volume-Pressure-Time Relations During Controlled Degassing Experiments". *Proc. of the Ocean Drilling Program*, Vol. 164.

Francis, T.J.G., 2001, "The HYACINTH project and pressure coring in the Ocean Drilling Program". Internal Document: Geotek, Ltd. July 2001.

Hohnberg, H.J. et al., 2003, "Pressurized Coring of Near-Surface Gas Hydrate Sediment on Hydrate Ridge: The Multiple Autoclave Corer, and First Results from Pressure Core X-Ray CT Scans". Geophysical Research Abstracts, Vol. 5. European Geophysical Society.

"HYACE", 2003, [www] http://www.tu-berlin.de/fb10/MAT/hyace/description/describe.htm. Accessed June 15th, 2003.

"Methane Hydrate Recovery", JNOC Website. [www] http://www.mh21japan.gr.jp/english/mh/05kussaku.html#e.

"Methane Hydrates: A US Department of Energy Website". www.fossil.energy.gov

"Natural Gas Demand". [www] www.naturalgas.org/business/demand.asp.

"Patent No. 6,214,804: The Pressure-Temperature Coring System". U.S. Patent Office. [www]http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=/netahtml/srchnum.htm&r=1&f=G&l=50&s1=6,216,804.WKU.&OS=PN/6,216,804&RS=PN/6,216,804. Viewed July 14, 2003.

Rack, Frank R, "In-Situ Sampling and Characterization of Naturally Occurring Marine Hydrate Using the D/V JOIDES Resolution". Joint Oceanographic Institute, Cooperative Agreement DE-FC26-01NT41329.

Shukla, K., et al., 2002, "Overview on Hydrate Coring/Handling/Analysis". Westport Technology Center International. Prepared for DOE on December 12, 2002 under award No. DE-PS26-NT40869-1.

7.6 Reservoir and Economic Modeling References

Brown, G., Storer, D., and McAllister, K., 2003, Monitoring Horizontal Producers and Injectors during Cleanup and Production Using Fiber-Optic-Distributed Temperature Measurements, SPE 84379.

Chuang Ji, Goodarz Ahmadi, Duane H.Smith. 2003; "Constant rate natural gas production from a well in a hydrate reservoir"; Energy Conversion and Management 44, 2403-2423.

Chuang Ji, Goodarz Ahmadi, Duane H. Smith, 2001, "Natural gas production from hydrate decomposition by depressurization"; Chemical eng. science 56, 5801-5814.

Stephen J Howe, 2004, Production modeling and economic evaluation of a potential gas hydrate pilot production program on the north slope of Alaska", MS Thesis, University of Alaska Fairbanks, Fairbanks, AK.

Howe, S.J., Nanchary, N.R., Patil S.L., Ogbe D.O., Chukwu G.A., Hunter R.B and Wilson S.J., "Production Modeling and Economic Evaluation of a Potential Gas Hydrate Pilot Production Program on the North Slope of Alaska", *Manuscript Under Preparation*.

Howe, S.J., Nanchary, N.R., Patil S.L., Ogbe D.O., Chukwu G.A., Hunter R.B and Wilson S.J., "Economic Analysis and Feasibility study of Gas Production from Alaska North Slope Gas Hydrate Resources", Submitted for Presentation at the AAPG Hedberg Conference in Vancouver in September 2004.

Jaiswal N.J presented on "Measurement of Relative Permeabilities for Gas-Hydrate Systems" and received third prize in International Thermal Operations and Heavy-Oil Symposium and SPE Regional Meeting Bakersfield, California, USA.

Jaiswal, N.J., Dandekar, A.Y., Patil, S.L. and Chukwu, G.C., "Measurement of Relative Permeability for Gas-Hydrate System", at 54th Arctic Science Conference, 23rd Sept-2003.

Jaiswal N.J., Westervelt J.V., Patil S.L., Dandekar A.Y., Nanchary, N.R., Tsunemori P and Hunter R.B., "Phase Behavior and Relative Permeability of Gas-Water-Hydrate System", Submitted for Presentation at the AAPG Hedberg Conference in Vancouver in September 2004.

McGuire, P.L., 1982, "Recovery of gas from hydrate deposits using conventional technology," SPE/DOE 10832, *Proc. Unconventional Natural Gas Recovery Symposium Pittsburgh PA*, pp. 373-387, Society of Petroleum Engineers, Richardson Texas.

McGuire, Patrick L., 1982, "Methane hydrate gas production by thermal stimulation"; proceedings of the 4th Canadian Permafrost Conference, pp.356-362.

Moridis, G. J., 2002, "Numerical Studies of Gas Production from Methane Hydrates". Paper SPE 75691, presented at the SPE Gas Technology Symposium, Calgary, Alberta, Canada, 30 April – 2 May 2002b.

Moridis, G.J. and Collett, T.S., 2004 in-press, "Gas Production from Class 1 Hydrate Accumulations".

Moridis, G., Collett, T.S., Dallimore, S.R., Satoh, T., Hancock, S. and Weatherill, B., 2003, "Numerical simulation studies of gas production scenarios from hydrate accumulations at the Mallik site, Mackenzie Delta, Canada". In, Mori, Y.S., Ed. Proceedings of the Fourth International Conference on Gas Hydrates, May 19-23, Yokohama, Japan, pp 239-244.

Nanchary, N.R., Patil S.L., Dandekar A.Y., "Numerical Simulation of Gas Production from Hydrate Reservoirs by Depressurization", Journal of Petroleum Science & Engineering (Elseveier publication), *Under Review*.

Nanchary, N.R., Patil S.L., Dandekar A.Y and Hunter, R.B., "Numerical Modeling of Gas Hydrate Dissociation in Porous Media", Submitted for Presentation at the AAPG Hedberg Conference in Vancouver in September 2004.

Swinkles, W.J.A.M. and Drenth, R.J.J., 1999, "Thermal Reservoir Stimulation Model of Prediction from Naturally Occurring Gas Hydrate Accumulations", Society of Petroleum Engineers, SPE 56550, 13 p.

Tsunemori, Phillip, 2003, presented "Phase Behavior of Natural Gas from Gas Hydrates" and received first in International Thermal Operations and Heavy-Oil Symposium and SPE Regional Meeting Bakersfield, California, USA.

Tsypkin, G.G. 1992, Appearance of two moving phase transition boundaries in the dissociation of gas hydrates in strata. Dokl. Ross. Akad. Nauk. 323. 52-57 (in Russian).

Yousif, M., H., Abass H., H., Selim, M., S., Sloan E.D., 1991, Experimental and Theoretical Investigation of Methane-Gas-Hydrate Dissociation in Porous Media, SPE Res. Eng. 18320, pages 69-76.

Tsypkin, G.G. 1991, Effect of liquid phase mobility on gas hydrate dissociation in reservoirs. Izvestiya Akad. Nauk SSSR. Mekh. Zhidkosti i Gaza. 4: 105-114 (in Russian).
Westervelt J.V: MS Thesis: "Determination of methane hydrate stability zones in the Prudhoe Bay, Kuparuk River, and Milne Point units on the North Slope of Alaska".

7.7 Regional Schematic Modeling Scenario Study References

Collett, Timothy S.: "Natural Gas Hydrates of the Prudhoe Bay and Kuparuk River Area, North Slope, Alaska," AAPG Bulletin, Vol. 77, No. 5, May, 1993, p 793-812.

S. J. Howe, N. R. Nanchary, S. L. Patil, D. O. Ogbe, and G. A. Chukwu, R. B. Hunter, S. J. Wilson. "Economic Analysis and Feasibility Study of Gas Production from Alaska North Slope Gas Hydrate Resources," AAPG Hedberg Conference, September, 2004.

S.H. Hancock, T.S. Collett, S.R. Dallimore, T. Satoh, T. Inoue, E. Huenges, J. Henninges, and B. Weatherill: "Overview of thermal-stimulation production-test results for the JAPEX/JNOC/GSC et al. Mallik 5L-38 gas hydrate production research well" 2004.

Richard Sturgeon-Berg, "Permeability Reduction Effects Due to Methane and Natural Gas Flow through Wet Porous Media," Colorado School of Mines, MS thesis T- 4920, 9/30/96.

Stephen John Howe, "PRODUCTION MODELING AND ECONOMIC EVALUATION OF A METHANE HYDRATE PILOT PRODUCTION PROGRAM ON THE NORTH SLOPE OFALASKA," University of Alaska, Fairbanks MS Thesis, May, 2004.

Hong H., Pooladi-Darvish, M., and Bishnoi, P. R.:Analytical Modeling of Gas Production from Hydrates in Porous Media," *Journal of Canadian Petroleum Technology (JCPT)* November 2003, Vol. 42 (11) p. 45-56.

7.8 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.

8.0 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
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)
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)
FG	Free Gas (commonly referenced in association with and below gas hydrate)
GEOS	UA Department of Geology and Geophysics
GH	Gas Hydrate
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
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)
KRU	Kuparuk River Unit
LBNL	Lawrence Berkeley National Laboratory
LDD	Generic term referencing Logging During Drilling (also LWD and MWD)
LNG	Liquefied Natural Gas
MGE	UA Department of Mining and Geological Engineering
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)
ONGC	Oil and Natural Gas Corporation Limited (India)
PBU	Prudhoe Bay Unit

PNNL Pacific Northwest National Laboratory
Sag Sagavanirktok formation
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) (also component in Di-pole sonic logging tool)
VSP Vertical Seismic Profile
WOO Well-of-Opportunity

9.0 APPENDICES

9.1 APPENDIX A: Project Task Schedules and Milestones

9.1.1 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 – 12/06	12/02 and Ongoing	Subcontracts Completed Research Management
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	Ongoing, See Technical Progress Report
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	Ongoing	Ongoing, See Technical Progress Report
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	Ongoing, See Technical Progress Report
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Advances	Ongoing		Ongoing, See Technical Progress Report
Task 6.0	Reservoir and Fluids Characterization Study	12/06	Ongoing to Phases 2 and 3	Interim Results presented, 2004 Hedberg Conference
Subtask 6.1	Characterization and Visualization	12/06	Ongoing to Phases 2 and 3	Interim Results presented, 2004 Hedberg Conference
Subtask 6.2	Seismic Attributes and Calibration	12/06	Ongoing to Phases 2 and 3	Interim Results presented, 2004 Hedberg Conference

Subtask 6.3	Petrophysics and Artificial Neural Net	12/06	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	12/06	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

9.1.2 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 Research Management
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	Ongoing, See Technical Progress Report; Industry Support more feasible?
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	Ongoing	Ongoing, See Technical Progress Report
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	Ongoing, See Technical Progress Report
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Development and Advances	Ongoing		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

9.1.3 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 Research Management
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: ** KRU: **	MPU: 12/02 PBU: ** KRU: **	Ongoing, See Technical Progress Report; Industry Support more feasible?
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	As-identified	Ongoing, See Technical Progress Report
Task 4.0	Research Collaboration Link	Ongoing	Ongoing*	Ongoing, See Technical Progress Report
Subtask 4.1	Research Continuity	Ongoing	Ongoing*	
Task 5.0	Logging and Seismic Technology Development and Advances	Ongoing*	As-needed	Ongoing, See Technical Progress/Topical reports
Task 6.0	Reservoir and Fluids Characterization Study	12/07		Evaluating extension into 2007 for defined scope
Subtask 6.1	Structural Characterization	12/07		Current contract to 12/06
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	12/06		Evaluating extension into 2007 for defined scope
Subtask 7.1	Design Mud System	9/07*		Current contract to 12/06
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*		Stratigraphic Test on 2007 Drilling Schedule
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 Phase 3a continuation through December 2007 (amendments 15^{+})
** Date dependent upon industry partner agreement for seismic data release

9.1.4 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 (Currently illustrates 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 (Currently illustrates Phases 2-3, 2005 - 2006) ← Planning/Analysis → ← DECISION---→ ←Planning--------→← IMPLEMENTATION …delayed 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 (Currently illustrates Phases 3a-3b, 2007-2008 projection) ←Phase 3a Strat Test→ ←3b DECISION→←3b Planning→←POTENTIAL PHASE 3b IMPLEMENTATION→ 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.