Oil and Natural Gas Technology

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Twenty-First and Twenty-Second Quarterly Report: October 2007 – March 2008

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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Office of Fossil Energy

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PROJECT ABSTRACT

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

Phase 2 studies included rate forecasts and hypothetical well scheduling, methods typically employed to evaluate the development potential of large conventional 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 schematic development schemes. Phase 2 studies culminated in recommendations to acquire Phase 3a reservoir data including 400-600 feet core, extensive wireline logs, and MDT wireline tests within the Mount Elbert intra-hydrate MPU prospect interpreted from the Milne 3D seismic survey. Phase 3b studies, if approved, would acquire additional static data and include production testing, likely from a gravel pad within production infrastructure.

Phase 2 production forecast and regional schematic modeling studies included downside, reference, and upside cases. Reference case forecasts with type-well depressurization-induced production rates of 0.4-2.0 MMSCF/D predict that 2.5 TCF of gas might be produced in 20 years, with up to 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 confirms reference case or upside modeling results of pressure-induced, thermally enhanced, and/or chemically stimulated gas hydrate dissociation into producible gas. Successful Phase 3a MountElbert-01 stratigraphic test drilling and data acquisition was completed between February 3-19, 2007. Phase 3a data analyses are helping to mitigate uncertainty in potential gas hydrate productivity and are a key element of initial Phase 3b production test design planning. However, Phase 3b long-term production testing is not currently approved by resource owners.

ACKNOWLEDGEMENTS

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

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

The USGS has led ANS gas hydrate research for three decades. Dr. Tim Collett coordinates USGS partnership in the BPXA-DOE CRA Alaska gas hydrate research. Seismic studies accomplished by Tanya Inks at Interpretation Services and by USGS scientists Tim Collett, Myung Lee, Warren Agena, and David Taylor identified multiple MPU gas hydrate prospects. Support by USGS staff Bill Winters, Bill Waite, and Tom Lorenson and Oregon State University staff Marta Torres and Rick Colwell is gratefully acknowledged. Steve Hancock at APA (RPS Energy) and Peter Weinheber at Schlumberger helped design the Phase 3a wireline testing program. Scott Wilson at Ryder Scott Co. has progressed reservoir models from studies by the University of Calgary (Dr. Pooladi-Darvish) and the University of Alaska Fairbanks (UAF). Steve Hancock and Scott Wilson also lead preliminary production test design planning. Dr. Shirish Patil and Dr. Abhijit Dandekar have maintained the University of Alaska (UAF) School of Mining and Engineering as an arctic region gas hydrate research center. University of Arizona reservoir characterization studies led by Dr. Bob Casavant with Dr. Karl Glass, Ken Mallon, Dr. Roy Johnson, and Dr. Mary Poulton described the structural and stratigraphic architecture of Eileen trend ANS Sagavanirktok formation gas hydrate-bearing reservoir sands.

Current related studies of gas hydrate resource potential are too numerous to mention here. National Labs studies include Dr. Pete McGrail, CO_2 Injection, and Dr. Mark White, reservoir modeling, at Pacific Northwest National Lab and Dr. George Moridis, reservoir modeling, at Lawrence Berkeley National Lab. Dr. Joe Wilder and Dr. Brian Anderson have led significant efforts of an International Reservoir Modeling Comparison team. The Colorado School of Mines under the leadership of Dr. Dendy Sloan continues to progress laboratory and associated studies of gas hydrate. The significant efforts of international gas hydrate research projects such as those supported by the Directorate General of Hydrocarbons by the government of India and by the Japan Oil, Gas, and Metals National Corporation (JOGMEC) with the government of Japan and by others 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 2007-2008 Mallik project gas hydrate studies in Northwest Territories, Canada are gratefully acknowledged. This cooperative DOE-BPXA research project builds upon the accomplishments of many prior government, academic, and industry studies.

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2.0 PROJECT INTRODUCTION

The Cooperative Research Agreement (CRA) between BP Exploration (Alaska), Inc. (BPXA) and the U.S. Department of Energy (DOE) is helping characterize and assess Alaska North Slope (ANS) methane hydrate resource and identify technical and commercial factors that could enable government and industry to understand the future development potential of this unconventional energy resource. Results of Phase 1-2 reservoir characterization, reservoir modeling, regional schematic modeling, and associated studies culminated in approval to proceed into a 2007 Phase 3a stratigraphic test to acquire data designed to help mitigate potential recoverable resource uncertainty. Future Phase 3b production testing is a key goal of the Federal Research and Development program and may follow, but this remains under evaluation by resource owners. Current collaborative research partners include U.S. Geological Survey (USGS), ASRC Energy Services, Ryder Scott Co., and APA RPS Engineering working with the University of Alaska Fairbanks, Oregon State University, OMNI Labs, Lamont-Dougherty Earth Observatory, Canada National Research Council, Lawrence Berkeley National Lab (LBNL), and others as detailed below.

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

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

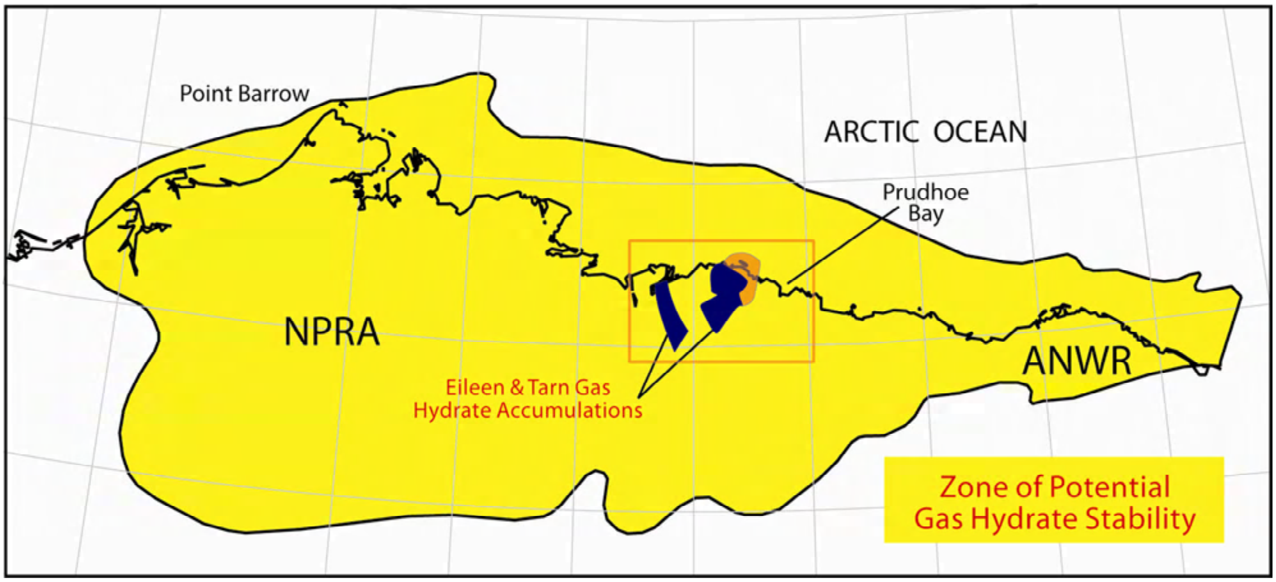

Figure 1: ANS gas hydrate stability zone with Eileen and Tarn gas hydrate trends (Collett, 1993).

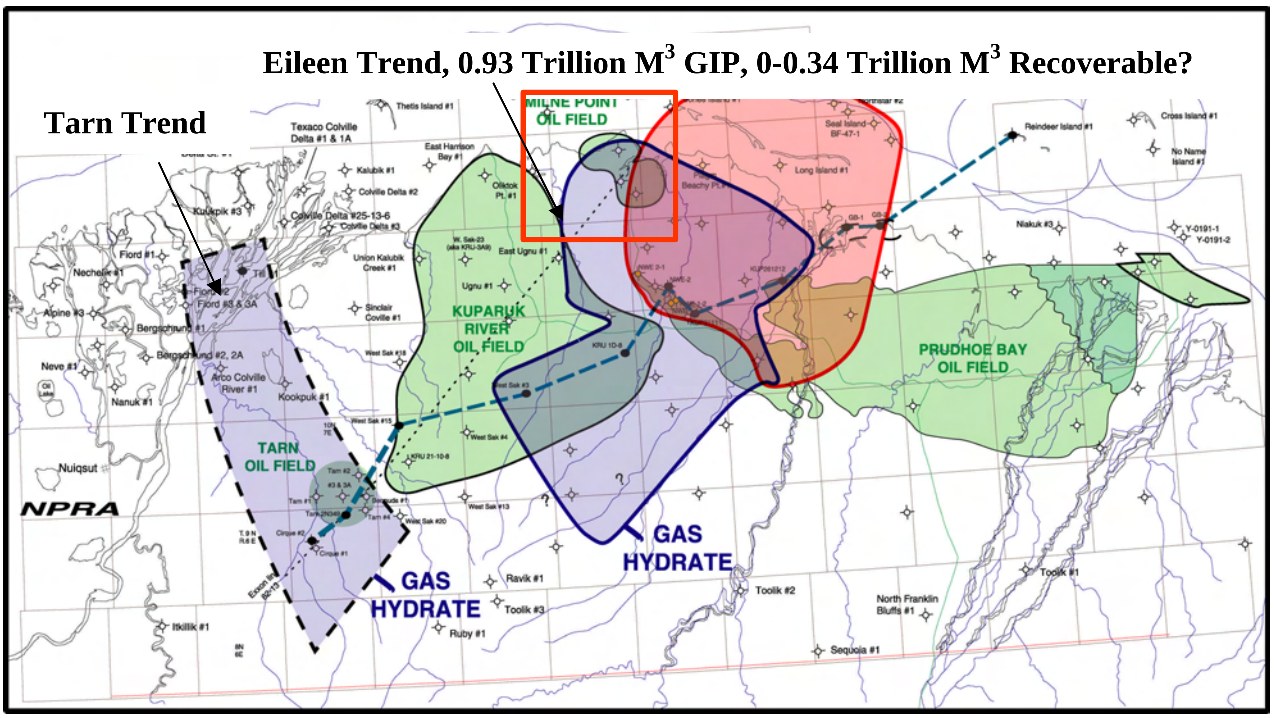

Figure 2: Eileen and Tarn Gas Hydrate Trends and ANS Field Infrastructure (modified after Collett, 1998) and including potential Eileen trend gas-in-place (GIP) and recoverable resource.

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 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.

Past unconventional resource research and development has been commonly hindered by a lack of proven positive examples necessary before generating 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/oil resources in the 1990-2000's. In each case, the resource was thought to be technically infeasible and uneconomic until the combination of market, technology (new or newly applied), and positive field experience helped motivate widespread adoption of unconventional recovery techniques in an effort to prove whether or not the resource could be technically and commercially produced. In an attempt to bridge this gap, Phase 2 gas hydrate reservoir modeling efforts were coupled with a series of possible regional schematic models to quantify a suite of potential recoverable resource outcomes and Phase 3a stratigraphic test data acquisition helped mitigate gas hydrate-bearing reservoir uncertainty and validate numerical model results.

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

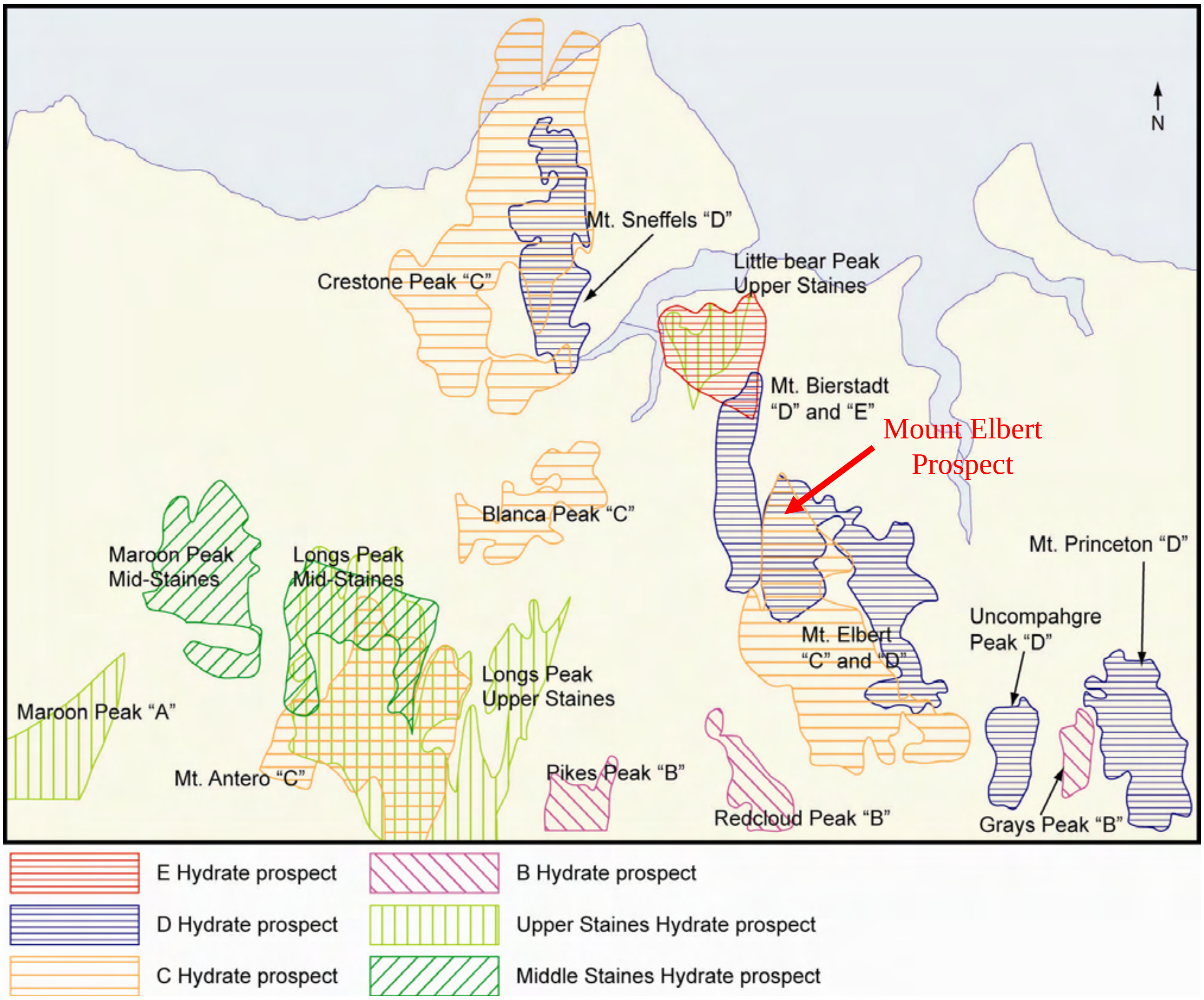

Figure 3: MPU gas hydrate prospects interpreted from Milne 3D seismic data, including Mount Elbert (Inks, T., Lee, M., Taylor, D., Agena, W., Collett, T. and Hunter, R., in press).

3.0 EXECUTIVE SUMMARY

This report encompasses project work from October 1, 2007 through end-March 2008. This research program is designed to determine whether the ANS gas hydrate resource may become a new unconventional gas reserve. Research objectives accomplished during this reporting period included project management, budget augmentation documentation for Phase 3 work, data analyses workshop, preliminary production test planning workshop, and project reporting.

4.0 QUARTERLY RESULTS, 4Q07 and 1Q08

4.1 Project Management Summary, 4Q07 and 1Q08

Primary project management tasks accomplished during the reporting period included:

- Planned remaining Phase 3a schedule, meetings, workshop, and stratigraphic test data analyses in collaboration with USGS and DOE
- Prepared and reviewed detailed subcontractor input to data analyses plans for 2008 Phase 3a budget update and DOE/BP contract amendment supporting documentation
    - Engaged subcontractors to develop scope, cost, schedule, and deliverables buyin
    - Submitted budget augmentation supporting documents to amendments 18-20
    - Prepared detailed cost information, work statements, and remaining Phase 3a work
- Reviewed Barrow gas hydrate project results and recommended forward plans
- Met with UAF faculty/students to identify project objectives, experiments, and procedures
- Prepared and submitted letter for termination of University of Arizona subcontract
- Maintained core storage integrity and coordinated replacement of backup thermal air sensor
- Provided project review for transition from Alaska Gas to Technical Directorate team
- Updated and submitted US Treasury Automated Standard Application for Payments form for transition to Technical Directorate and to document project authority changes
- Participated in weekly teleconference project progress reviews with DOE and USGS
- Reviewed compiled September 2007 project Panel Reviews with selected subcontractors
- Coordinated Amendment 18 evaluation and approvals and updated subcontracts
- Teleconferenced to discuss adapting possible thermal component of production test design
- Met with BP viscous oil engineers to discuss potential thermal technology plan synergies
- Met with CP WSak engineers to discuss coiled tubing technologies synergies
- Met with coiled tubing technology provider to discuss gas hydrate completion adaptation
- Prepared for Spring 2008 science team meeting; compile data analyses and develop agenda
- Planned Spring 2008 Mt Elbert data analyses workshop
    - Coordinated science and management team input to agenda and status updates
    - Prepared introductory presentations and participated in March 4-5 science workshop, March 6-7 production test workshop, and summary notes/actions
- Coordinated Amendment 20 evaluation and approvals and updated subcontracts
- Maintained communications with technology provider for potential downhole combustion
- Reviewed project invoices and cost allocations to ensure reasonable and prudent

4.2 Data Analyses Summary, 4Q07 and 1Q08

Primary data analyses tasks accomplished during the reporting period included:

- Compiled and sent interstitial water data analyses to OMNI for input to core analyses
- Worked with Schlumberger to finalize stratigraphic test wireline data processing
- Worked with USGS to inventory/review log data in preparation for stakeholder distribution
- Worked with Halliburton to finalize and distribute final LWD and mudlog data
- Distributed final stratigraphic test wireline and LWD data to stakeholders within project
- Arranged Geotek core scanning logistics and procedures for December core scanning
    - Developed and reviewed procedures for core scanning
    - Reviewed core scan images and data with Geotek staff

    - Coordinated addition of scale consistent with onsite core processing and labeling
- Participated in Reservoir Model Comparison team teleconferences, recommendations, and publication reviews
    - Reviewed and responded to zone C2 MDT reservoir modeling history matching
- Reviewed Mt Elbert-01 petrophysical data with BP EPTG for potential gas hydrate support work proposal in 2008
- Coordinated OMNI core analyses with input from core scans and project scientists
- Teleconferenced with University of Oregon for status update and developed forward plans
- Completed initial core gamma ray to wireline log high-resolution density log correlation
    - Product will support core to log data comparison studies
- Developed procedure for UAF minipermeameter study on Mount Elbert-01 core
    - Ran test procedure; compared favorably to conventional permeability analyses
    - Redesigned UAF minipermeameter tool to work efficiently with core boxes and minimize core damage
    - Worked with AES Fab Shop personnel to provide onsite support to UAF students
- Provided onsite support to DOE sedimentology study on Mount Elbert-01 core

4.2.1 Gas Data Analyses

Gas data analyses were summarized in prior reports.

4.2.1.1 Isotech Laboratory, PI Steven Pelphrey

Isotech Laboratory completed geochemical analyses of isotubes from the Mount Elbert-01 well in 2007. These data are available on the project-internal ftp site and within prior project reports.

4.2.2 Core Data Analyses

Core studies during the reporting period included additional conventional and special analyses by OMNI and core scanning by Geotek.

4.2.2.1 OMNI Laboratory, PI Mike Walker

OMNI Laboratory tasks include studies of the Mount Elbert-01 gas hydrate stratigraphic test core. Core studies include conventional core analyses (porosity, permeability, etc.), special core analyses, physical property analyses, and geomechanical analyses. OMNI Laboratory coordinates conventional and special core analyses measurements. Completed preliminary core analyses are available to project participants on the project ftp site.

Phase I core studies include:

1. Core Screening by CT Scanning: 14 Whole Core samples
2. Twin plugging of suitable whole core samples: 35 plugs taken
3. CT Scanning of all plugs obtained from whole core plugging: 35 plugs plus 9 drilled in at OMNI Anchorage Lab
4. Routine / Basic Rock Properties (porosity, permeability, and grain density): 16 samples
5. Rock Mechanics – Mohr Coulomb Failure: 2 locations. (one hydrate bearing zone and one non-hydrate bearing zone)
6. Laser particle size analysis (LGSA): 23 samples (results in prior report)
7. X-ray Diffraction (bulk & clay) – Mineral composition: 10 samples
8. Thin Section Petrography: 10 samples

Table 1 summarizes the core samples at OMNI.

Sample Number	Sample Type	Core Run	Section Number	Sample Section Top (in.)	Sample Section Bottom (in.)	Top Depth (ft.)	Bottom Depth (ft.)	Actual Depth	Total Sample ID	Overburden Pressure	Brine Salinity	Routine Core Analysis	LGSA	NMR Analysis	Petrographic Analysis	Advanced Core Analysis	Rock Mechanics	Grain Density	Water Content
1	Proposed	2	1	20	26	2015.7	2016.17	2016.00	2-1-17	572			X					X	X
2	Proposed	2	2	7	13	2017	2017.5	2017.10	2-2-8	572		X	X		x				
3	Existing	2	2	21	27	2018.2	2018.62	2018.35	2-2-21-27B	572		X	X		x		x		
4	Proposed	2	5	14	20	2026.5	2026.96	2026.70	2-4-17	575			X					X	X
5	Proposed	2	7	11	17	2031.9	2032.42	2032.40	2-5-17	576		X	X	X	X	X			
6	Existing	2	8	14	20	2035.2	2035.62	2035.40	2-8-14-20A	577			X					X	X
7	Proposed	3	4	2	8	2045.8	2046.25	2045.90	3-7-3	580		X	X	X	X	X			
8	Existing	3	5	28	34	2051.2	2051.62	2051.35	3-5-28-34B	582		X	X						
9	Existing	5	8	1	6	2106.3	2106.75	2106.60	5-8-1-6A	597		X	X	X	X	X			
10	Existing	6	5	30	36	2124.6	2125	2124.75	6-5-30-36A	602		X	X		x				
11	Existing	7	5	8	14	2146.7	2147.12	VC	7-5-8-14A	609			X					X	X
12	Proposed	8	3	7.5	13.5	2163	2163.5	2163.40	8-12-12	613		X	x	x	x	x			
13	Existing	8	5	9	13	2169.1	2169.58	2169.20	8-5-9-13A	615			X					X	X
14	Existing	9	1	2	7	2180.2	2180.54	2180.25	9-1-2-7A	618		X	x	x	x	x			
15	Existing	12	3	6	12	2224.1	2224.58	2224.15	12-3-6-12A	631		X	x		x		x		
16	Existing	14	4	30	33	2274.6	2274.79	2274.70	14-4-30-33A	645		X	x						
17	Proposed	15	5	4	10	2301	2301.5	2301.10	15-17-5	652		X	x						
18	Proposed	18	2	3	9	2363	2363.5	2363.20	18-18-5A	670			X					X	X
19	Existing	20	2	32	36	2414.9	2415.25	2414.85	20-2-32-36A	685			X					X	X
20	Existing	21	4	30	35	2433.3	2433.67	2433.35	21-4-30-35A	690		X	x						
21	Existing	22	4	20	23	2454.9	2455.12	2454.85	22-4-20-23B	696		X	x	X	x	X			
22	Proposed	23	1	6	12	2470.5	2471	2470.60	23-22-7	700		X	x						
23	Existing	23	5	0	5	2482	2482.33	2482.05	23-5-0-5B	704		X	x						

Table 1: Core analyses work underway at OMNI Laboratory

4.2.2.1.1 Conventional Core Analyses

Table 2 summarizes conventional core analyses. Samples were vacuum oven-dried at 140°F.

SUMMARY OF ROUTINE CORE ANALYSES RESULTS

Vacuum Oven Dried at 140°F

BP Alaska
MT. Elbert - 01 Well

Alaska, USA
File: HH-36510

Core Number	Sample Number	Sample Depth, feet	Net Confining Stress, psi	Median Grain Size, microns	Permeability, millidarcys		Porosity, percent		Grain Density, gm/cc
					to Air	Klinkenberg	Ambient	NCS	
2	2-2-8	2017.10	572	10.27	12.2	10.1	33.2	33.1	2.70
2	2-2-21-27B	2018.35	572	6.76	4.74	3.78	32.6	32.5	2.71
2	2-5-17	2032.40	576	94.54	2100.	2020.		42.6	2.71
3	3-7-3	2045.90	580	74.55	1370.	1310.		43.0	2.71
3	3-5-28-34B	2051.45	582	88.60	1630.	1570.		42.3	2.72
5	5-8-1-6A	2106.60	597	6.94	1.46	1.15	32.0	31.9	2.72
6	6-5-30-36A	2124.75	602	25.25	145.	131.		34.2	2.72
8	8-12-12	2163.40	613	58.42	675.	636.		41.0	2.71
9	9-1-2-7A	2180.25	618	210.07	7650.	7470.		39.9	2.67
12	12-3-6-12A	2224.15	631	15.58	1.01	0.789	29.0	28.9	2.74
14	14-4-30-33A	2274.70	645	7.97	2.68	2.12	27.5	27.4	3.21
15	15-17-5	2301.10	652	62.24	815.	772.		40.1	2.71
21	21-4-30-35A	2433.35	690	12.80	1.31	1.03	29.4	29.3	2.71
22	22-4-20-23B	2454.95	696	9.99	1.34	1.06	30.4	30.3	2.70
23	23-22-7	2470.60	700	7.23	0.887	0.685	30.5	30.4	2.72
23	23-5-0-5B	2482.15	704	10.80	0.770	0.586	29.5	29.4	2.71
		Average values:		43.87	900.	871.	30.5	34.8	2.74

Table 2: Porosity, permeability, and grain density analyses results

4.2.2.1.2 Grain Size Analyses

Sieve and laser derived grain size studies were summarized in a prior report. Most of the reservoir sands from the core are very-fine to fine-grained. Minor exceptions include coarse-grained to pebbly probable transgressive lags present in less than one-inch to ten-inch thick beds. Future plans are to link these and other core analyses studies directly to the completed core scans for visualization and sedimentology. The very fine grain size and higher clay contents would significantly affect production and completion design for sand-control during hydrate dissociation.

Table 3 summarizes the grain size analyses results.

BP Alaska
MT. Elbert-01 Well

OMNI Laboratories, Inc.

Conventional Core Plug Trim
File: HH-36510
Date: 2-21-08

LASER GRAIN SIZE SUMMARY

Core	Depth,	ID	Sand					Silt					Clay
Run	feet	Number	Crs %	Med %	Fine %	Vf %	Total	Crs %	Med %	Fine %	Vf %	Total	Clay %
2	2016.00	2-1-17	0.0	0.0	0.5	2.7	**3.1**	7.2	13.1	20.6	24.4	**65.3**	31.6
2	2017.10	2-2-8	0.0	0.0	0.1	5.8	**5.9**	15.7	17.3	18.5	18.6	**70.1**	24.0
2	2018.35	2-2-21-27B	0.0	0.0	0.0	1.3	**1.3**	8.3	15.0	20.3	23.0	**66.6**	32.1
2	2026.70	2-14-17	0.0	0.3	22.9	42.6	**65.8**	14.4	5.9	5.9	3.5	**29.8**	4.4
2	2032.40	2-5-17	0.0	0.6	28.9	43.6	**73.1**	11.4	4.3	4.6	2.8	**23.1**	3.8
2	2035.40	2-8-14-20A	0.0	0.0	17.0	42.0	**58.9**	18.9	6.5	6.6	4.1	**36.0**	5.1
3	2045.90	3-7-3	0.0	0.0	16.2	43.6	**59.8**	16.7	5.3	6.9	4.6	**33.6**	6.7
3	2051.45	3-5-28-34B	0.0	0.0	16.7	60.0	**76.8**	7.5	1.9	6.0	3.3	**18.7**	4.5
5	2106.60	5-8-1-6A	0.0	0.0	0.0	0.5	**0.5**	4.0	15.7	25.3	22.4	**67.4**	32.1
6	2124.75	6-5-30-36A	0.0	0.0	0.1	12.2	**12.3**	29.6	20.8	13.0	10.6	**73.9**	13.8
7	2146.70	Whole Core	0.0	0.0	7.5	32.2	**39.7**	22.7	10.3	10.1	7.6	**50.6**	9.7
8	2163.40	8-12-12	0.0	0.0	9.6	36.7	**46.2**	24.0	7.5	7.7	6.1	**45.3**	8.5
8	2169.20	8-5-9-13A	0.0	0.0	13.1	44.1	**57.2**	21.9	6.0	6.2	3.8	**37.9**	4.9
9	2180.25	9-1-2-7A	0.5	32.4	55.7	6.9	**95.4**	0.5	1.7	0.7	0.9	**3.9**	0.7
12	2224.15	12-3-6-12A	0.0	0.1	1.3	5.8	**7.2**	18.6	23.9	16.4	12.1	**71.0**	21.8
14	2274.70	14-4-30-33A	0.0	0.0	0.0	1.2	**1.2**	8.2	18.7	22.3	21.5	**70.7**	28.1
15	2301.10	15-17-5	0.0	0.0	9.9	39.6	**49.5**	24.3	7.4	7.1	5.0	**43.8**	6.7
18	2363.20	18-18-5A	0.0	0.0	0.1	1.5	**1.6**	11.6	23.1	21.6	18.4	**74.7**	23.8
20	2414.85	20-2-32-36A	0.0	0.0	2.9	28.8	**31.7**	29.4	10.4	9.8	8.3	**57.9**	10.4
21	2433.35	21-4-30-35A	0.0	0.0	0.0	2.4	**2.4**	16.2	24.7	20.4	15.9	**77.2**	20.4
22	2454.95	22-4-20-23B	0.0	0.0	0.0	0.5	**0.5**	7.5	23.3	27.5	19.5	**77.8**	21.7
23	2470.60	23-22-7	0.0	0.0	0.0	0.3	**0.3**	3.7	14.8	27.6	26.3	**72.4**	27.3
23	2482.15	23-5-0-5B	0.0	0.0	0.0	1.9	**1.9**	12.2	23.0	23.0	18.3	**76.5**	21.6

Table 3: Grain size analyses summary

4.2.2.1.3 XRD Results

Table 4 summarizes preliminary X-ray diffraction (XRD) analyses results. In particular, clays may become an issue for completion and production testing design.

OMNI LABORATORIES, INC.
X-RAY DIFFRACTION
(WEIGHT %)

Client: BP Exploration Alaska
Well: Mt. Elbert 01
Area: Milne Point Field, North Slope Borough, Alaska
Sample Type: Conventional Core

File No: HH-36510
Date: 02/28/08
Analyst: G. Walker

Sample	CLAYS				CARBONATES			OTHER MINERALS						TOTALS		
Identity	Chlorite	Kaolinite	Illite	Mx I/S*	Calcite[1]	Dol/Ank	Siderite	Quartz	K-spar	Plag.	Pyrite	Zeolite	Barite	Clays	Carb.	Other
2-2-8	12	3	13	2	0	0	Tr	54	1	6	9	0	0	30	Tr	70
2-2-21-27B	14	3	17	3	0	0	Tr	47	1	7	8	0	0	37	Tr	63
6-5-30-36A	7	2	9	1	0	0	Tr	67	1	12	1	0	0	19	Tr	81
8-12-12	6	1	7	1	0	0	Tr	73	1	10	1	0	0	15	Tr	85
9-1-2-7A	2	1	2	Tr	0	0	Tr	90	1	3	1	0	0	5	Tr	95
12-3-6-12A	11	2	12	2	0	0	Tr	61	1	10	1	0	0	27	Tr	73
22-4-20-23B	13	3	15	3	0	0	Tr	53	1	11	1	0	0	34	Tr	66
AVERAGE	9	2	11	2	0	0	Tr	64	1	8	3	0	0	24	Tr	76

* Randomly interstratified mixed-layer illite/smectite; Approximately 90-95% expandable layers
[1] May include the Fe-rich variety

Table 4: XRD analyses results

4.2.2.1.4 Physical and Geomechanical Property Analyses

Preliminary triaxial strength measurements are shown in Table 5.

OMNI HH-36510

SUMMARY OF TRIAXIAL COMPRESSIVE TESTS
saturated with 2% KCl

BP Alaska
Mt. Elbert - 01

Sample No.	Depth (ft)	Confining Pressure (psi)	Compressive Strength (psi)	Static Young's Modulus ($x10^6$ psi)	Static Poisson's Ratio
2-2-21-27RMV-1	2018.30	570	not failed	0.04	0.22

Table 5: Preliminary triaxial compressive strength test

Preliminary ultrasonic velocity and elastic property measurements are shown in Table 6.

OMNI HH-36510

SUMMARY OF ULTRASONIC VELOCITIES AND DYNAMIC ELASTIC PARAMETERS
saturated with 2% KCl

BP Alaska
Mt. Elbert - 01

Sample No.	Depth (ft)	Confining Pressure (psi)	Bulk Density (g/cc)	Ultrasonic Wave Velocity				Dynamic Elastic Parameter			
				Compressional		Shear*		Young's Modulus ($x10^6$ psi)	Poisson's Ratio	Bulk Modulus ($x10^6$ psi)	Shear Modulus ($x10^6$ psi)
				ft/sec	μsec/ft	ft/sec	μsec/ft				
2-2-21-27RMV-1	N/A	570	2.16	6343	157.66	3858	259.17	1.05	0.21	0.59	0.43

* Best engineering judgement.

Table 6: Preliminary ultrasonic velocities and dynamic elastic parameters measurement

Table 7 presents preliminary rock mechanics results.

OMNI HH-36510

Result of Mohr-Coulomb Failure Analysis

BP Alaska
Mt. Elbert - 01

Depth Interval: 2018.3 ft (using compressive strength at 2% axial strain)

Sample No.	Depth (ft)	Confining Pressure, $Pc = \sigma_3$ (psi)	Differential Stress, $\sigma_1 - \sigma_3$ (psi)	Compressive Strength, σ_1 (psi)	Slope on σ_1 vs Pc	Unconfined Compressive Strength (psi)	Angle of Internal Friction (deg)	Coeff. of Internal Friction	Cohesion (psi)
27RMV-3	2018.30	0	74	74	1.61	114	13.5	0.24	45
27RMV-2	2018.30	285	299	584					
27RMV-1	2018.30	570	562	1132					
27RMV	2018.30	855	566	1421					

Table 7: Preliminary rock mechanics results.

All samples showed basically similar behaviors of continuous hardening and no failure. Therefore, the compressive stress of each sample taken at 2% of axial strain was used for Mohr-Coulomb analysis, even though the samples did not fail.

The shear wave velocity was not conclusive and the reported value is the best estimate considering the sample nature.

Future plans for petrophysical analyses include:
1. NMR at Confining Pressure – 4 samples
2. Electrical Resistivity with Porous Plate Capillary Pressure – 4 samples
3. Unsteady-State Relative Permeability (Gas / Water) – 4 samples
4. Optional Special Core Analyses, Additional Plugs Considered – Approval Pending

4.2.2.1.5 Core Gamma

After transporting the Mount Elbert-01 core to Anchorage for storage and additional subsampling, but prior to slabbing, OMNI Labs ran a core gamma ray and “gapped” the core gamma to account for gaps due to both non-recovery of core and onsite core subsampling. The core gamma has been correlated to log field prints and only shows a discrepancy of zero to three feet throughout the cored intervals. The core gamma will be recorrelated and shifted to the final log dataset.

4.2.2.1.6 Core CTscans

Core plugs and whole core were analyzed by CTscan at OMNI laboratory and LBNL, respectively. The CTscanning revealed multiple processing-associated or drilling induced fractures that will complicate the planned mechanical rock property studies. Previous pressure-core studies by Geotek Labs (personal communication, December 2007) suggest that the “processing-associated” fractures likely propagated during dissociation of gas hydrate into free gas and water during core recovery operations at atmospheric temperatures and pressures.

4.2.2.2 Geotek, PI Peter Schultheiss

Geotek core scanning services were substituted for core photography due to the higher resolution images provided by Geotek versus standard core photography. Geotek studies were delayed until December 2007 due to the 2007 budget overruns documented in prior reports. The high-resolution core scans of the library set of Mount Elbert-01 core were completed in December 2007. The scans were successfully resulted in images better than can be observed through the naked-eye or a low-power hand-lens. Jpeg reductions of the high-resolution images are available on the project-internal ftp site; full-size images are available to project participants on-request.

The Library Set of Mount Elbert-01 cores were imaged by Geotek personnel using the Geoscan IV linescan camera and automated track from Dec 5-10, 2007. All imaging was performed in the refrigerated storage unit at a temperature of 42^{o}F. High-resolution image data were provided on a hard disk. The folder "mtelbert01" includes all the core images. Each folder represents a single core and folders are named ME-01-core number. Within each core folder are three sets of 16-bit TIFF core section images, two with rulers (cm and in) and one without, and a set of XML files. The XML files are used by the Geotek imaging software. The files are numbered IMsectionnumber, e.g., IM002_01.tif is an image of section number 2 in a given core. Section number "66" was used for the core catcher. TIFF files that are followed by an "R" have a cm ruler appended to the image left edge. Subsequent additional TIFF files were created followed by an “_in” showing an inches ruler appended to the image left edge. Smaller jpeg files were created and transferred to the project internal ftp site in the folder pathway Mount Elbert #1 Core Photos / CoreScans-GeoTek. The folder "CoreBoxes" contains snapshots of each core box as it was opened. The folder "CoreHandling" contains pictures documenting the imaging procedure as shown in figures 4-19.

Core images can be viewed in the newer versions of many image-manipulation programs. Programs such as ImageJ (free, http://rsb.info.nih.gov/ij/; http://en.wikipedia.org/wiki/ImageJ) can read 16-bit images and export 8-bit images. Cores invaded with oil-based drilling fluid appear very dark, but details are still visible when the brightness and contrast are adjusted. CoreWall (free, http://www.corewall.org/), developed by NSF, is a program designed to allow core images, log data, and other information to be presented together on a set of screens.

Figure 4, Step 1: Boxes of library set core sections were removed from the freezer (temperature ~20°F), one at a time.

Figure 5, Step 2: The tape was slit and the boxes opened.

Figure 6, Step 3: Plastic wrap, if present, was removed from the cores

Figure 7, Step 4: The core box including a hand-written label was photographed for records.

Figure 8, Step 5: Core sections were carefully placed into one-third liners (see "Potential Artifacts," below).

Figure 9, Step 6: Complete placement of core sections into one-third liners

Figure 10, Step 7: Core sections in liner were placed on the Geotek imaging track.

Figure 11, Step 8: Cores were scanned at a resolution of 200 pixels per centimeter at a single set of lighting and aperture conditions, and the camera was consistently calibrated with an 18% grey card so that each image is comparable with every other image.

Figure 12, Step 9: Core surfaces were heated using a heat gun to melt surface frost, typically resulting in a wet surface when imaged (see "Potential Artifacts," below).

Figure 13, Step 10: Core sections within the liner were removed from the camera track.

Figure 14, Step 11: The core sections in the core liner were aligned with the core box in preparation for removal.

Figure 15, Step 12: The core sections were gently removed from the track in the liner and placed back into the core storage box.

Figure 16, Step 13: Core sections were placed back into their storage box.

Figure 17, Step 14: Plastic wrap, if present, was replaced over the core surfaces. Bubble wrap (flat side to the core) was substituted if no plastic wrap was present.

Figure 18, Step 15: Core storage boxes were closed with strapping tape wrapped around each end.

Figure 19, Step 16: Core storage boxes were placed into a temporary storage freezer until all cores from original freezer are processed. Cores are then replaced in the correct order in the original storage freezer. Cores were out of the freezer for a maximum of 20 minutes at 42°F.

Potential artifacts are evident on core surfaces. Cores were unlined and friable within the core storage boxes. The delicate, unlined core was very difficult to transfer to the one-third liners used to support the cores during imaging. While no core pieces were destroyed, desiccated edges tended to crumble. Cores could not be scraped. The frozen core surfaces could not be scraped to present a fresh surface for imaging. Any artifacts from cutting the core (e.g., potential smearing of clay into sands) remain in the images. Saw marks, though visible to the eye, are not visible in images due to the uniform lighting. The library set was, however, lightly sanded by OMNI prior to placement in the core boxes to remove most saw marks.

Cores were colder than the temperature at which they were imaged. The cold cores condensed moisture from the warmer air (42^{o}F) and frosted over. The surface frost was melted using a heat gun immediately before imaging and this moisture soaked into the core, relieving the need to wet the surface of the core for imaging. However, occasional patches of ice may be present in the images. Some non-gas hydrate-bearing sandy cores were fully invaded with oil-based drilling fluid; the melted ice could not soak into the core and formed droplets of water on the surface of the core. Large droplets were blotted with a paper towel when possible.

Cores were differentially desiccated. Cores were originally stored with plastic wrap sealing the tops of the cores, but this plastic wrap was not tightly stretched and not always present. Swirls and whorls were present in the core images, especially in clay or shale sections, due to wrinkles in the plastic wrap. Where the plastic wrap was not in contact with the cores, the cores desiccated ("freezer-burn"). Some of the desiccation was ameliorated by the melting of the condensed frost before imaging, but swirls, whorls, and drying at the edges of the core (mainly in sands) can be seen in the images.

Cores were different thicknesses. Because the cores were not always split evenly, the height of the split core varied. Core material that departed significantly from the median core height may be slightly out of focus.

Recommendations for current cores include:

1. Seal cores better to prevent further desiccation,
2. Further work on the cores should be performed while they are their foam trays to prevent damage and loss of core material.

Recommendations for future coring work includes:

1. Cores should be imaged as soon as possible after being split,
2. Cores should be scraped if possible and a wet surface imaged to bring out the fine detail in the cores,
3. Consider splitting and storing cores in a liner so that they can be handled later; if cores are stored in a liner, they may not need to be frozen,
4. Seal cores well against desiccation using heavy-duty plastic.

4.2.2.3 Oregon State University (OSU), PI Marta Torres and Co-PI Rick Colwell

OSU tasks include pore water and microbiological analyses studies of the Mount Elbert-01 gas hydrate stratigraphic test core.

Preliminary results of pore water analyses indicate that the pore waters are very fresh (Figure 20), especially in the gas hydrate-bearing zones C and D.

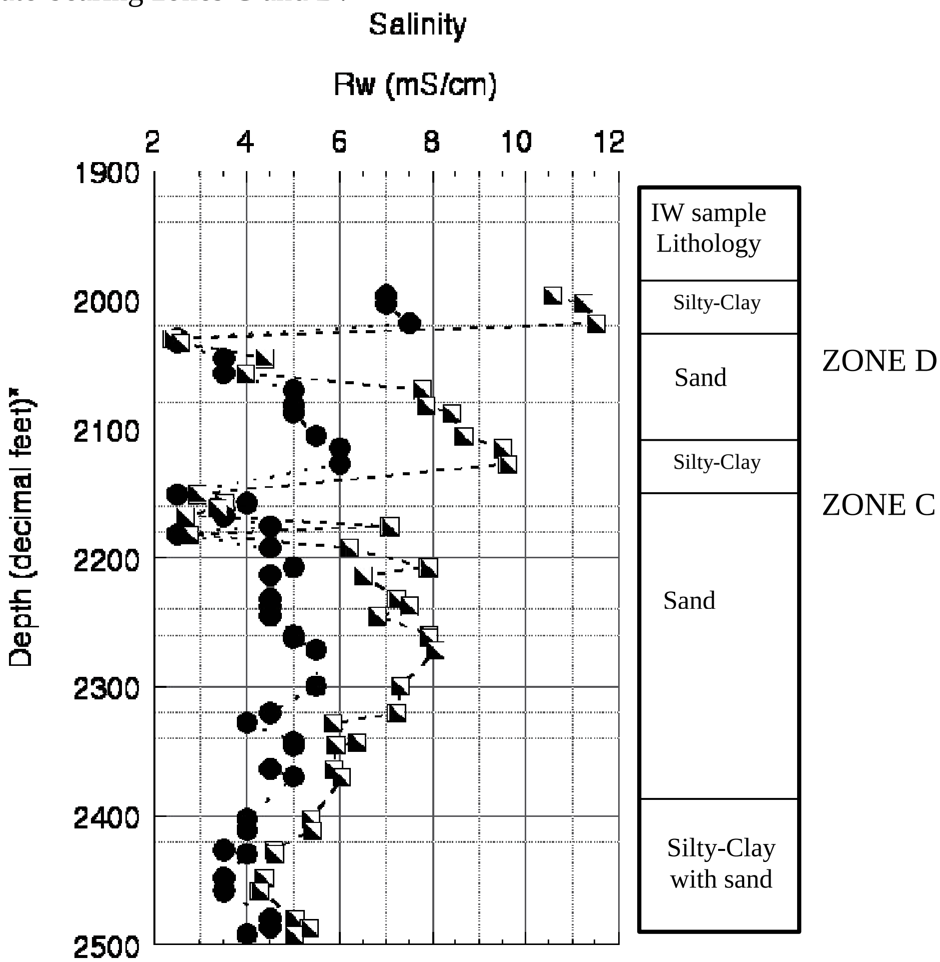

Figure 20: Pore water salinity from Mt Elbert-01 interstitial water (IW) samples.

Gas hydrate-bearing sand reservoirs C and D occupy up to 90% of the pore space. Estimates from chloride data correspond very well to gas hydrate saturation values derived from core log data (NMR). As shown previously in the Mallik and Cascadia margin sites, gas hydrate preferentially occupies the sand reservoir lithologies. Gas hydrate content correlates well with sand content of the sediment. The pore fluid chemistry reflects a mixture of meteoric water with formation fluids. There are no indications of a remnant seawater end-member.

Preliminary results of microbiological studies detected 11 phylotypes. Plans include complete DNA extractions, perform T-RFLP analysis, detect and quantify methanogen genes (mcrA), enumerate fluorescent microsphere tracers, and possibly perform whole genome amplification.

Additional studies may include PhyloChip (detailed diversity information), GeoChip (detailed functional information), study link to abiotic properties in sediments, comparison to Mallik studies and other hydrate environments, and possibly contribution to the modeling of carbon dynamics.

4.2.2.4 University of Alaska Fairbanks (UAF), PI Dr. Shirish Patil, Co-PI Dr. Abhijit Dandekar

4.2.2.4.1 UAF Minipermeameter Study

UAF initiated minipermeameter feasibility studies during the reporting period. Based on these feasibility studies showing values and variation (Table 8) reasonably similar to conventional core analyses, the UAF minipermeameter will be modified to allow core analyses without removing the core from storage boxes and measurements are planned on approximately six-inch intervals for the entire core sample set.

Minipermeameter Core Depth	Minipermeameter Permeability (md)
2022.63	1434.0
2023.04	629.0
2023.54	738.0
2024.04	92.3
2024.75	261.0
2025.08	347.0
2026.58	2016.0
2026.63	956.0
2026.83	814.0
2027.29	-999.0
2028.25	836.0
2028.63	-999.0
2028.83	1368.0
2029.17	1635.0
2029.38	785.0
2029.63	-999.0
2143.21	526.0
2143.46	131.0
2143.50	163.0
2145.08	560.0
2149.50	2.5
2149.75	307.0
2149.92	932.0
2151.67	868.0
2151.92	1220

Table 8: UAF minipermeameter feasibility study data (-999.0 indicates inability to measure, typically due to soft sediment and high reservoir quality)

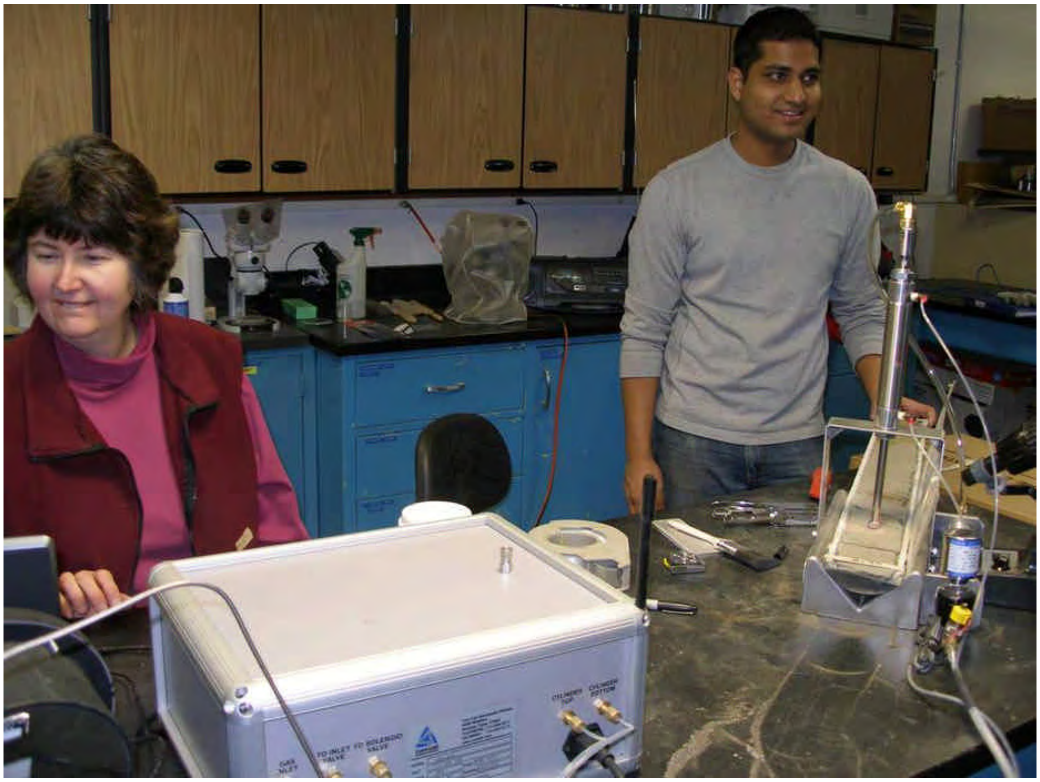

Figure 21: UAF Professor Kathy Hanks and graduate student Aditya U Deshpande at Alaska Geologic Materials Center (GMC) with minipermeameter studies of Ugnu core (March 2008).

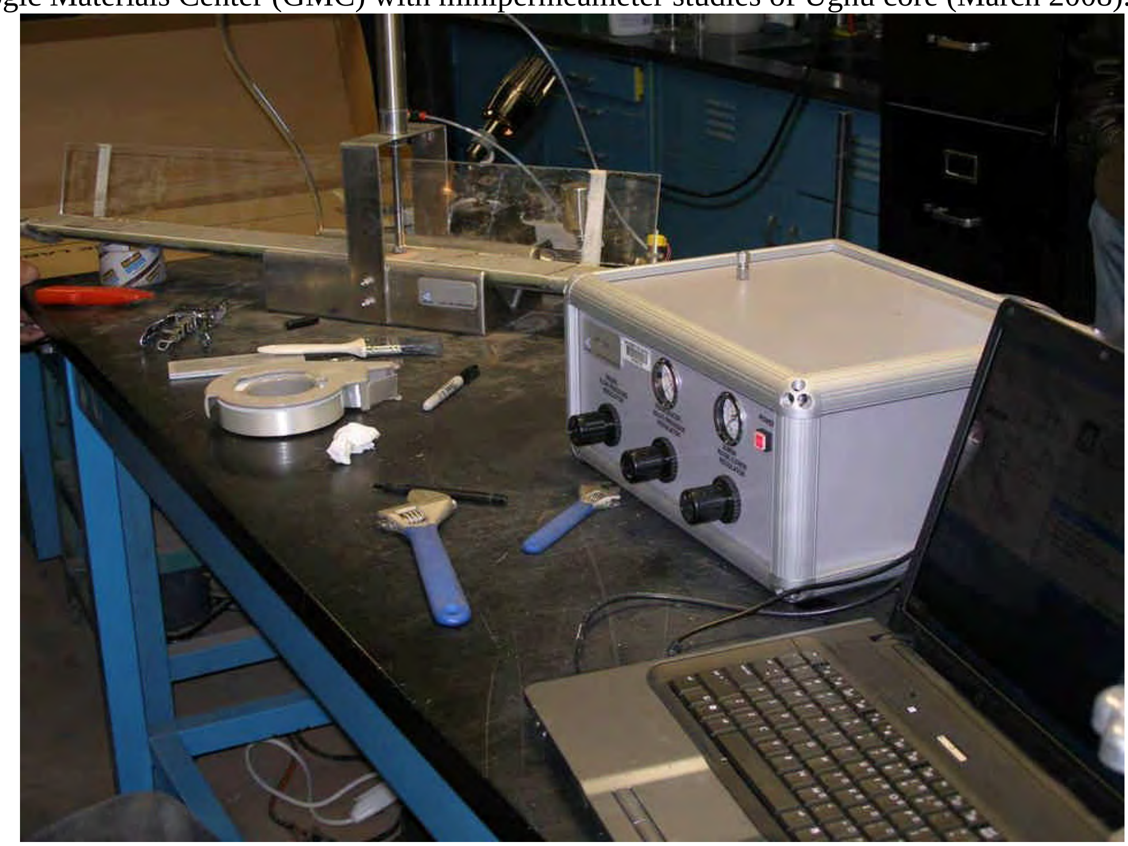

Figure 22: UAF Minipermeameter apparatus and setup, GMC (March 2008)

Figure 23: UAF Minipermeameter feasibility test setup in gas hydrate core storage unit (March 2008)

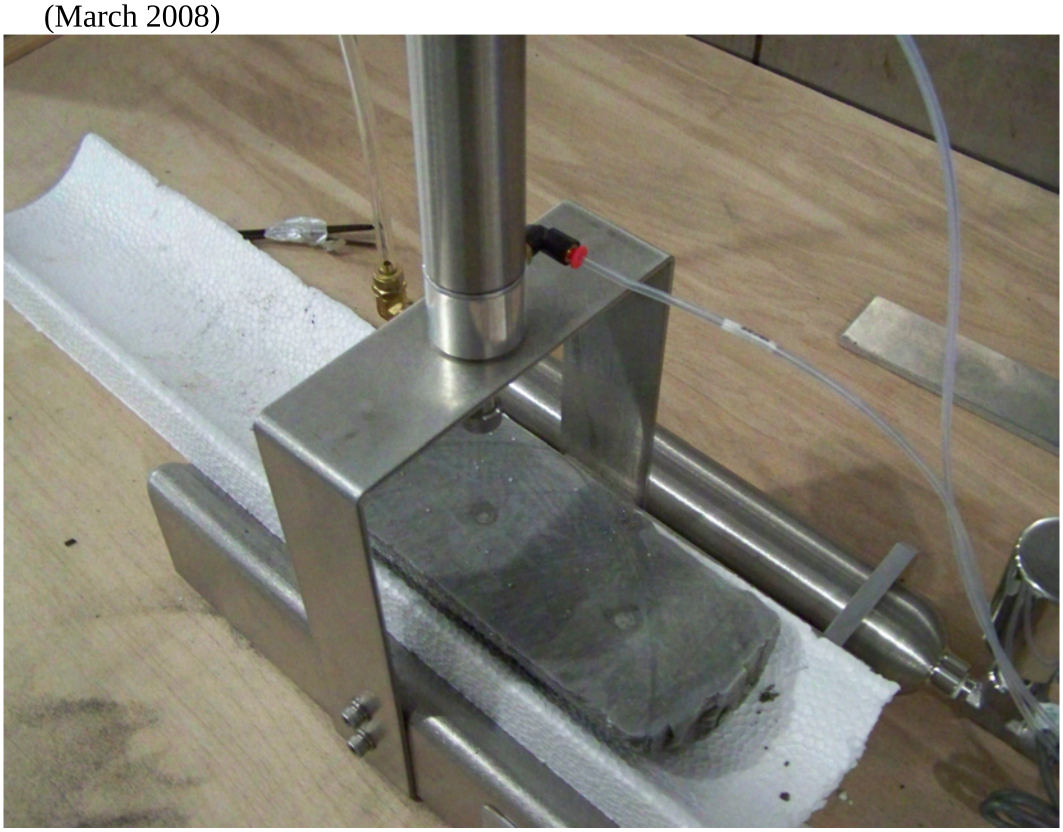

Figure 24: Mt Elbert core in minipermeameter apparatus during feasibility test (March 2008)

4.2.2.4.2 UAF Relative Permeability Study

UAF core studies are planned to continue prior laboratory studies using the experimental apparatus designed for relative permeability analyses.

Task 1: Conduct relative permeability experimental studies with Mt. Elbert core samples and incorporate the results to improve reservoir modeling.

- Apply experimental apparatus developed to relative permeability studies of Mt. Elbert core samples
- Study hydrate saturations, distributions, and dynamic changes affected by relative permeabilities
- Fine tune the Pressure-Temperature data with Mt. Elbert gas compositions and pore water salinities
- Reevaluate gas hydrate stability zones in bulk and porous media using Mt-Elbert core samples
- Generate relative permeability data with Mt. Elbert core samples for input into reservoir models and improve the capabilities of the modeling effort
- Build on reservoir models by Scott Wilson (CMG Stars) and the Reservoir Modeling Comparison team
- Improve reservoir model and incorporate the Mt. Elbert-01 data and new relative permeability data

4.2.2.5 Core Palynology Studies

In May 2008, the core was sampled for Palynology studies by D. Houseknecht, USGS. Results from this work are not yet available. Thirty-nine samples were taken for analyses from 1990 through 2484 core depths.

4.2.2.6 Additional Core Studies

Certain subsamples were sent to special hydrate core laboratories at Lawrence Berkeley National Laboratory (LBNL), National Research Council, Canada (NRC), Pacific Northwest National Laboratory (PNNL), Colorado School of Mines (CSM), and USGS for various analyses. Preliminary reports on some of these studies were provided at the Mt Elbert data workshop in March 2008. Formal results will be provided in subsequent reporting.

4.2.2.7 Core Sedimentology, PI Kelly Rose, DOE

DOE sedimentologist Kelly Rose imitated detailed core sedimentology studies in mid-March 2008.

4.2.3 Log Data Analyses

4.2.3.1 Mudlog Data

Final digital mudlog data was provided during the reporting period and is available on the project internal ftp site.

4.2.3.2 Logging-While Drilling Data

Digital Logging-While-Drilling data was provided during the reporting period and is available on the project-internal ftp site. The data may require reformatting.

4.2.3.3 Wireline Log Data

Schlumberger completed processing of wireline data during the reporting period. The delayed finalization of this data led to delays in planned special log analysis studies. This data is available on the project-internal ftp site. The data on this site are under evaluation and plans include distribution to specialists at Texas A&M University, Lamont-Dougherty Earth Observatory (LDEO), and Schlumberger for further analyses. Data files will be used in support of core and other log data studies and are normalized to a 6-inch sample interval standard.

4.2.3.3.1 Electromagnetic Propagation Tool (EPT), Texas A & M University, PI Dr. Yuefeng Sun and Co-PI David Goldberg, LDEO

Dr. Sun analyzed the Electromagnetic Propagation Tool (EPT) log data for the 2002 Mallik gas hydrate program and is recommended to collaborate with LaMont-Dougherty Earth Laboratory (LDEO) log analyst, Dave Goldberg, to analyze the EPT log data for the 2007 MPU Mount Elbert-01 gas hydrate stratigraphic test well, using methods developed from the Mallik research.

This research work is to study the in-situ dielectric properties of gas hydrate formation in the Mt. Elbert-01 Stratigraphic Test Well. The major objectives of this study are:

1. Analyze the electromagnetic propagation tool (EPT) data acquired in the gas-hydrate-bearing section of the Mt. Elbert-01 Stratigraphic Test Well for high-resolution estimation of the gas hydrate amount.
2. Perform comparative study of the EPT log results with the analysis of the oil-based formation micro-imager (OBMI) conducted by Dr. Dave Goldberg at Columbia University, in order to correlate the high-resolution internal structures revealed by the EPT log with their possible micro-resistivity responses on the OBMI log.
3. Interpret the high-resolution internal structures revealed by the EPT log in terms of lithologic variations in the gas hydrate-bearing section using the detailed core scans acquired by Peter Schultheiss at Geotek and other sedimentological studies of the gas hydrate core samples.
4. Prepare a report documenting the findings of the EPT analyses and comparative studies (OBMI and core scans).

The first-time successful measurement of in-situ dielectric properties of natural gas hydrates in the Mallik 5L-38 well in the Mackenzie Delta, Canada, has demonstrated that dielectric logging tool could result in accurate high-resolution (cm-scale) estimates of gas hydrate saturation (Sun and Goldberg, 2005). The Mallik study also concluded that dielectric measurement could be the only geophysical method that can be used to distinguish gas hydrates from ice in permafrost-bearing zones. Rigorous analysis of the EPT log data from the MtEblert-01 gas hydrate well in comparison with the results from the Mallik 5L-38 well could further improve our scientific understanding and knowledge of the relationship between dielectric response and natural gas hydrate in arctic regions. The EPT tool is very sensitive to the borehole conditions; the MtElbert-01 gas hydrate stratigraphic test well could become the second historical well to document reliably the in-situ dielectric properties of natural gas hydrates.

Analysis of the EPT log data acquired in the Mallik 5L-38 well reveals the formation heterogeneities of the gas hydrate-bearing zone drilled in the Mallik well. These heterogeneities are not apparent on other logs of lower resolution. These heterogeneities should also exist in the gas hydrate reservoir away from the drill hole. The presence of a large extent of reservoir heterogeneity could affect gas hydrate saturation estimates. More importantly, the existence of these heterogeneities due to inter-bedded silt/clay and their dynamic instability caused by temperature and pressure changes during production may affect the temporal change of formation permeability and production performance. This proposed work is thus to provide high-resolution gas hydrate estimates for better assessing reservoir heterogeneity and reservoir quality. The result may further be used to understand the role played by the fine-scale clays and silts in gas hydrate formation and dissociation processes.

The studies will include:

1. High-resolution Estimation of Gas Hydrate Amount

In this proposed work, the method of high-resolution EPT log analysis developed during the Mallik gas hydrate project (Sun and Goldberg, 2005) will be used to analyze the EPT log data obtained in the Mt. Elbert-01 well. In addition to the EPT log data, high-resolution density log data will also be required for the proposed analysis.

We assume that the porous media consist of only three components, namely, solid grain, hydrate, and water. We will use the following equations (Sun and Goldberg, 2005) to calculate both gas hydrate saturation and porosity:

$$r = (1-f)\,r_s + fS_h\,r_h + f(1-S_h)\,r_w$$

(1)

$$\sqrt{e_r} = (1-f)\sqrt{e_{rs}} + fS_h\sqrt{e_{rh}} + f(1-S_h)\sqrt{e_{rw}}$$

where f is the porosity of the total pore space, S_h is the hydrate saturation or the hydrate volume fraction, r_s, r_h, and r_w are the density of solid grain, gas hydrate, and water, respectively, e_{rs}, e_{rh}, and e_{rw} are the dielectric constant of solid grain, gas hydrate, and water, respectively. The dielectric constant of water used here, e_{rw} = 80 (?), is approximated according to the t_{po} method for 3^{o}C (onsite results, MountElbert-01) in the hydrate zones in the Mt. Elbert-01 well [Schlumberger, 1989]. The dielectric constant of gas hydrate at the 1.1 GHz tool frequency, is assumed to be similar to ice, e_{rh} = 3, based on the laboratory results reported by Wright et al. [2002]. The average of the dielectric constants of quartz and illite minerals e_{rs} = 5 is assumed [Ellis, 1987]. We also use r_w = 1.0 g/cc, r_h = 0.92 g/cc, and r_s = 2.65 g/cc [Collett and Lewis, 2005]. Given these intrinsic dielectric and density parameters of individual components, equation (1) can be solved to calculate simultaneously both the hydrate saturation and porosity of the hydrate-bearing formation from the dielectric and density logs. In the GHz frequency range, the total propagation time is mainly controlled by the dielectric properties of the matter and less affected by attenuation. In the gas hydrate zone studied in Mallik 5L-38 well, the average correction on propagation time caused by attenuation ranges only from 0 to 10% (Sun and Goldberg, 2005).

Analysis of the EPT data in the Mallik 5L-38 well also concluded that the measured electromagnetic propagation time was much more accurate and stable than the measured electromagnetic attenuation in the Mallik 5L-38 well. It is highly desirable to conduct detailed analysis of the EPT tool response in the MtEblert-01 gas hydrate well to investigate if the new tool has improved the attenuation measurement.

High-resolution estimation of gas hydrate saturation in the Mallik 5L-38 well was made possible by combining the dielectric constant calculated from the propagation time measured by the EPT tool with the high-resolution density log data, without using the less accurate attenuation data. Nevertheless, accurate attenuation measurement is important in order to evaluate quantitatively the upscaling of electrical resistivity from the standard DC resistivity log to the GHz EPT response for gas hydrate amount estimation. Equally or more importantly, accurate measurement of both dielectric constant and resistivity could provide us theoretically a superior means to characterize the dynamics of natural gas hydrates and to quantify the recovery factor and production efficiency. If the theory can be further proved and tested in the laboratory using both synthetic hydrates and gas hydrate cores recovered from the MtElbert-01 gas hydrate well, dielectric measurement of varying frequency could be used as a viable high-resolution tool to monitor the dissociation process of natural gas hydrate and therefore a tool for gas hydrate production monitoring. Nevertheless due to budget constraint, these theoretical and laboratory studies will not be pursued in this proposed work.

2. Comparison with OBMI image logs

After EPT data analysis, the principal investigator will work closely with Dr. Dave Goldberg at LDEO/Columbia University for a comparative study of the EPT log results with the analysis of the oil-based formation micro-imager (OBMI). This integrated analysis may enable us to correlate the high-resolution internal structures revealed by the EPT log with their possible micro-resistivity responses on the OBMI log.

3. Integrated analysis and interpretation of EPT log for high-resolution lithology characterization

Detailed interpretation of the high-resolution internal structures revealed by the EPT log in terms of lithology variations in the gas hydrate-bearing zones in the Mallik 5L-38 well was not possible. This Mt. Elbert research project provides us with an unique opportunity to ground-truth the lithology and physical properties of these possible internal heterogeneities of gas hydrate formation using the detailed core scans acquired by Peter Schultheiss at Geotek and other sedimentological studies or core descriptions of the gas hydrate core samples.

4. Report documenting EPT analyses and comparative studies

Preliminary studies indicate excellent high-resolution EPT log quality. The EPT log appears to indicate some thin-bedded gas hydrate-bearing sands not observed by the NMR logging tool. The EPT tool responses show similar trends with CMR and density logs, but with much higher vertical resolution (<5 cm). The electromagnetic measurements reveal the fine structures of hydrate formation and can be used to obtain high-resolution estimates of hydrate concentration, where hole conditions are good.

Future work planned includes determining the physical properties of the OBM used, including density and dielectric constant. Also, determine the mobility of invaded fluid (OBM) in hydrate-bearing formation. Assess in-situ internal structure of hydrate formation and its significance to hydrate formation and dissociation processes, combining core image analysis, geology, and petrophysical analysis. Work may also include a detailed study comparison to the Mallik well.

4.2.3.3.2 Modular Dynamics Testing (MDT) Analyses

MDT modeling has revealed that wellbore or tool storage is necessary to history-match the pressure curves. Fluid segregation in this annular space plays a key role in the general shape of the recovery curves. No models explicitly represent open space and the overall history-match parameters may reflect this error. It is also possible that formation kinetics may affect the shape of the pressure recovery curve.

4.2.3.3.2.1 MDT Tool Storage Calibration Experiment, CSM, PI Michael Batzle

A CSM lab study to analyze the effects of Modular Dynamics Testing (MDT) tool gas storage effects during MDT testing at the Mount Elbert-01 site was proposed in 2007 as a result of uncertainty in MDT data interpretation and associated reservoir modeling studies. The laboratory test is designed to attempt to prove the hypothesis that a small closed chamber, alternately draining and re-filling with both gas and liquid will create a multi-step build-up response like that seen in the Mt. Elbert-01 C2 test sequence. The test should be performed in as simple a manner as possible, while preserving the basic physics of the MDT system and the ability to measure and capture the relevant pressure, volume and flow rate information. If pressure responses show promise of matching actual data from and reservoir modeling of the Mt. Elbert C2 test sequence, adjust input flow rates to determine the best gas and liquid rate inputs to match the actual data.

The Mt. Elbert C2 MDT test sequence showed a strange character where later build-up responses were "flattened" compared to the first build-up. On-site interpretation of this behavior predicted that it might be a "skin" or surface restriction. Later reservoir simulation work could not match this character using hydrate re-formation or increasing skin factors. Only after incorporating a discrete wellbore, with a void space and falling fluid levels down to the exit port, did the simulation studies arrive at an adequate match. Although there is not enough information to definitively prove that wellbore effects are the reason for the strange response, it is now widely viewed to be the reason by those using mathematical models. To test this hypothesis, an alternate method is proposed that will test the physical system and eliminate any issues that might be causing a false positive result from all the simulation studies.

This test could be performed using equipment available at the School of Mines, by the laboratory technician, and by students who would be recruited from upper level Petroleum Engineering courses. The work could also be coordinated by a graduate student in the Geophysics department. The exact specification of the equipment to be used is not yet determined but several options fall within the overall scope envisioned. In one case, a clear pressure vessel could be used to represent the wellbore void space, with a fine adjustment needle valve used to meter small amounts of water and gas out of the void space to match the actual MDT flow rates in aggregate. A second vessel providing a constant pressure source of fluids would be connected to the surrogate wellbore with a second set of valves feeding gas and water at a constant pressure. The rates at which these fluids feed into the wellbore is an unknown, but can be adjusted to match the early pressure build-up response, and loosely constrained by the "known" volumes removed from the wellbore. Many other layout and scaling options are possible, all of which will provide a valid test of the hypothesis. This experiment was to occur in December 2007, but was delayed by laboratory remodeling. The experiment should proceed by mid-2008 with report to follow.

4.2.4 Reservoir Characterization

4.2.4.1 University of Arizona (UA), PI Dr. Robert Casavant

BP notified the University of Arizona (UA) in December 2007 of plans to terminate the BP-UA reservoir characterization studies. BP issued a formal letter in early January 2008 to terminate this contract. UA initiated this work under contract in 2002 and has operated under a no-cost extension for this work since 2005. Remaining obligated funds will likely be used in final report preparation.

4.2.4.2 U.S. Geological Survey (USGS), PI Dr. Timothy Collett

Additional resource characterization work was completed during the reporting period in support of reservoir modeling studies and potential production test site evaluations within the Eileen trend. These USGS studies were presented during the March 2008 Mount Elbert data analyses and production test workshop held at the USGS Federal Center.

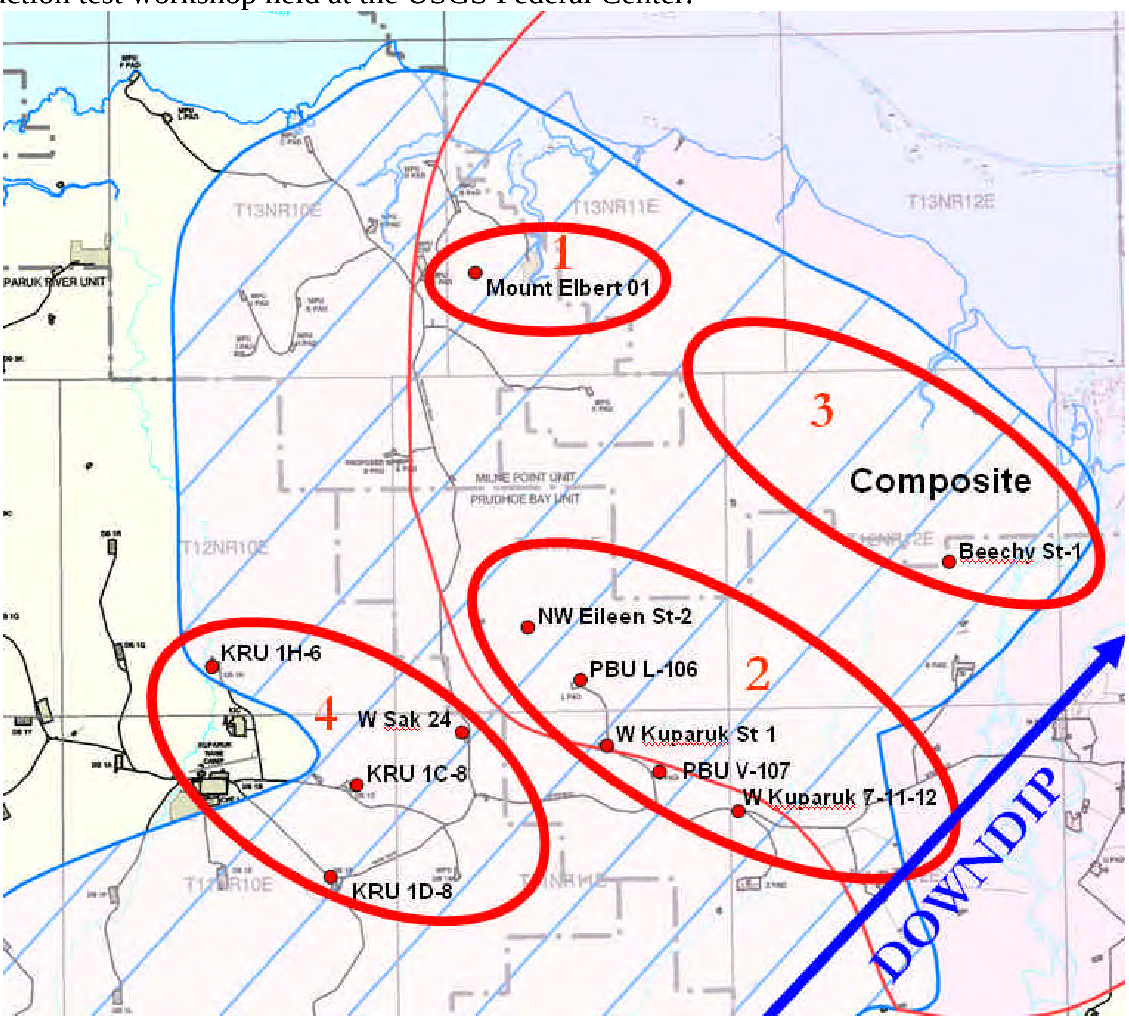

Figure 25: Map of composite lateral extent of Sagavanirktok gas hydrate bearing zones A, B, C, D, E, and F (blue with stripes) with 4 reservoir characterization areas.

Figure 25 illustrates the lateral extent of gas hydrate bearing zones shown with Alaska North Slope field gravel roads and pads infrastructure and several key gas hydrate-bearing well penetrations. Four areas (Figure 25) were evaluated for gas hydrate-bearing reservoir properties. Areas one, two, and three were selected as input to three primary reservoir model simulations as discussed in section 4.2.5.

4.2.4.2.1 Area 1, MPU Mount Elbert-01 Reservoir Characterization

Figure 26 summarizes the Mount Elbert-01 log data between the base permafrost and the base gas hydrate stability zone. Sagavanirktok zones E, D, and C are gas hydrate-bearing. Notably, the reservoir-quality sands of Zone C are not fully charged, possibly due to a reservoir charge or seal limit. Zones A and B contain no gas hydrate.

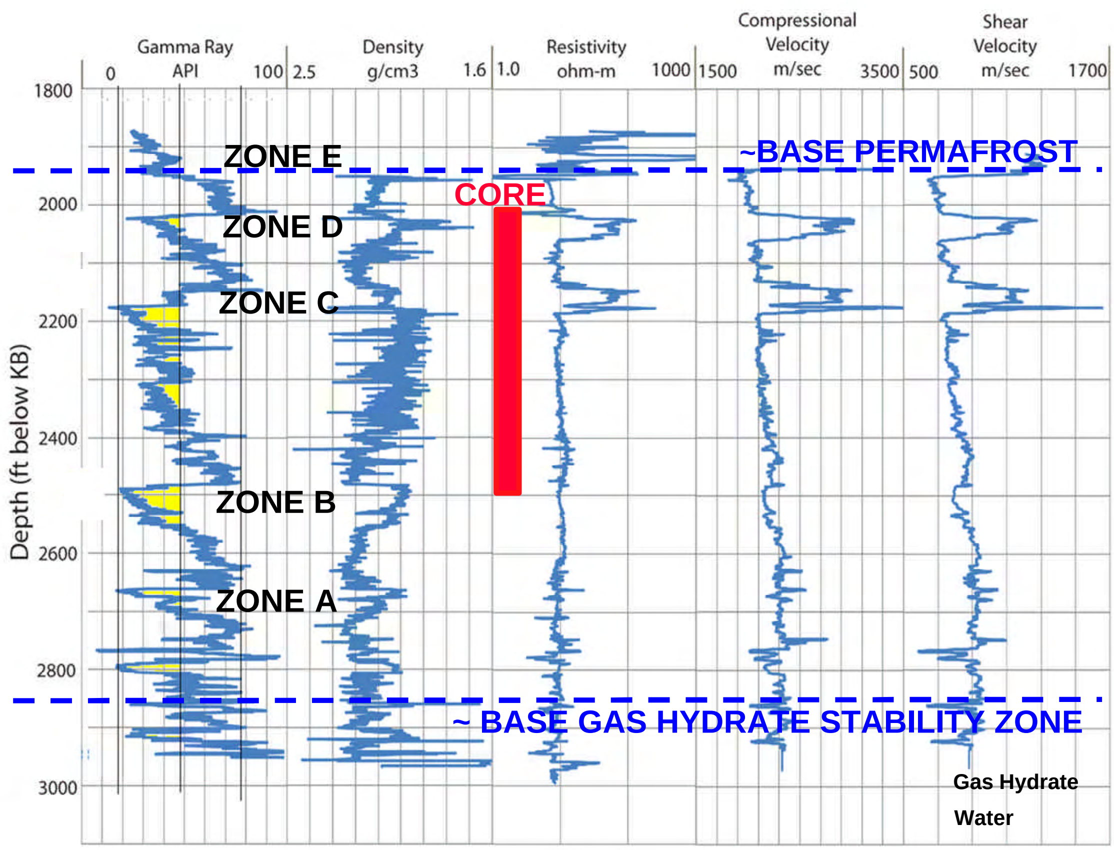

Figure 26: Mount Elbert-01 log data summary between base permafrost and base gas hydrate stability zone

Table 9 summarizes the gas hydrate-bearing zone reservoir properties at the Mount Elbert-01 site. Figure 27 illustrates a schematic cross-section tie of the Mount Elbert-01 well and gas hydrate bearing zones into the PBU L-106 Area 2.

4.2.4.2.2 Areas 2 and 3, PBU L-106-and "Downdip" Reservoir Characterization

Based on regional mapping, correlations, and log data, the PBU L-106 area contains thicker total gas hydrate bearing zones within warmer reservoirs (Figure 27, Table 10). Only Zone C reservoir properties were provided for reservoir modeling (Table 10). At L-106, Zone C contains an additional hydrate-bearing reservoir sand; however, this sand may be of limited lateral extent (Figure 27). If projected downdip (Figure 25) into Area 3, the reservoir temperature would increase to nearly 12°C just above the gas hydrate stability field base (Table 10 and Figure 28).

Reservoir Property:	**Mount Elbert Zone D**	**Mount Elbert Zone C**
Reservoir Model	**Problem 7a**	
Hydrate-bearing Reservoir (feet)	47 (2014 – 2061 feet RKB)	52 (2132 – 2184 feet RKB)
Upper Contact	Shale contact	Shale contact
Lower Contact	Shale contact	Water Contact/perched water
Gas Hydrate Saturation	65% average	65% average
Porosity	40%	35%
Intrinsic Permeability	1,000mD (NMR log)	1,000 mD (NMR log)
Hydrate-bearing Permeability	0.12 md (MDT model)	0.12 mD (MDT model)
Reservoir Temperature	2.3-2.6°C (MPU D-02 basis)	3.3-3.9°C (MPU D-02 basis)
Hydrostatic Pressure	6.7 MPa	7.1 MPa
Pore Water Salinity	5 ppt	5 ppt

Table 9: Reservoir properties of gas hydrate-bearing zones C and D at Mount Elbert-01

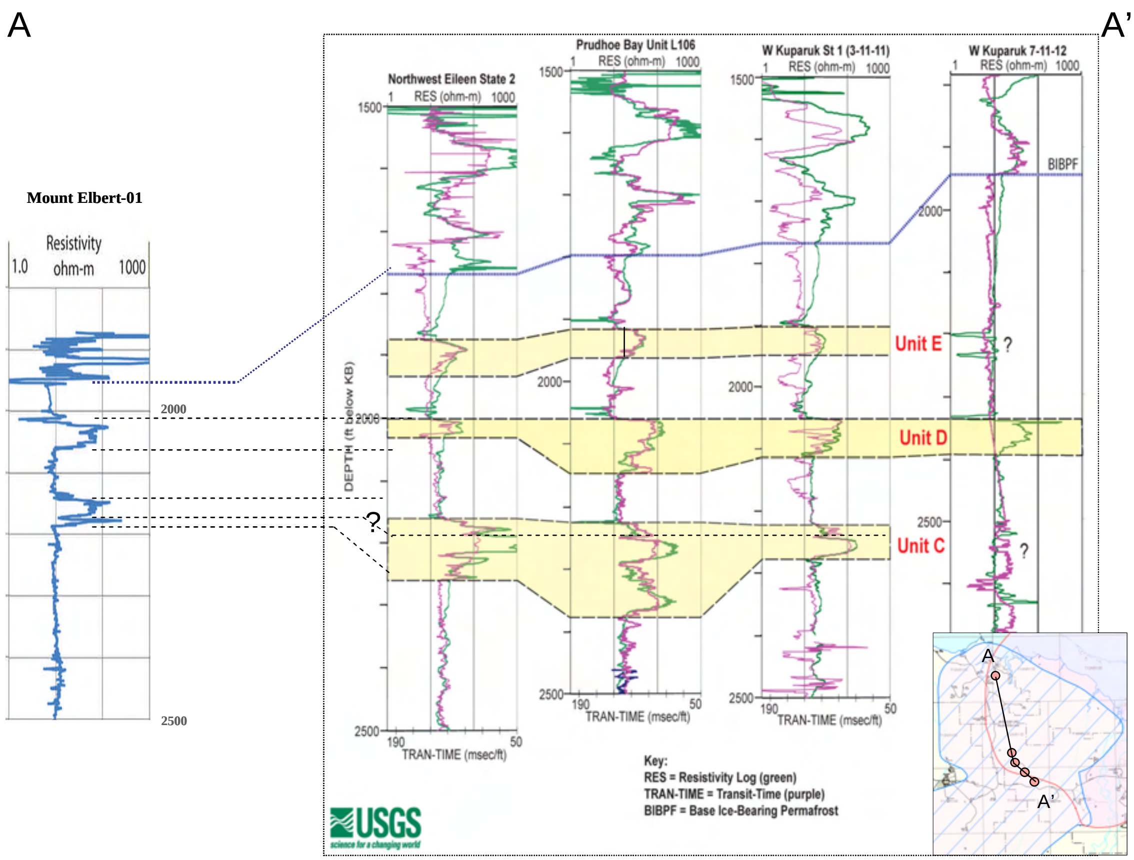

Figure 27: Schematic cross-section tie from Mount Elbert-01 Area 1 to L-106 Area 2 (R. Boswell modified from T. Collett)

It is important to note that Area 3 has no well penetrations of gas hydrate-bearing zones D or C and that this area is not accessible within the current infrastructure road and pad system.

Reservoir Property:	**L-106 Zone C1 & C2**	**"L-106 Downdip" Zone C**
Reservoir Model	**Problem 7B**	**Problem 7C**
Hydrate-bearing Reservoir (feet)	62 (C1) & 56 (C2) = 118	120 at ~2,500 feet TVDss
Upper Contact	Shale contact	Shale contact
Lower Contact	Shale contact	Shale contact
Gas Hydrate Saturation	75% average	75% average
Porosity	40%	40%
Intrinsic Permeability	1,000mD	1,000 mD
Hydrate-bearing Permeability	0.12 md (MDT model)	0.12 mD (MDT model)
Reservoir Temperature	5.0-6.5°C (MPU D-02 basis)	10-12°C (MPU D-02 basis)
Hydrostatic Pressure	7.3-7.7 MPa	8-9 MPa
Pore Water Salinity	5 ppt	5 ppt

Table 10: L-106 Area 2 and Area 3 reservoir properties comparison

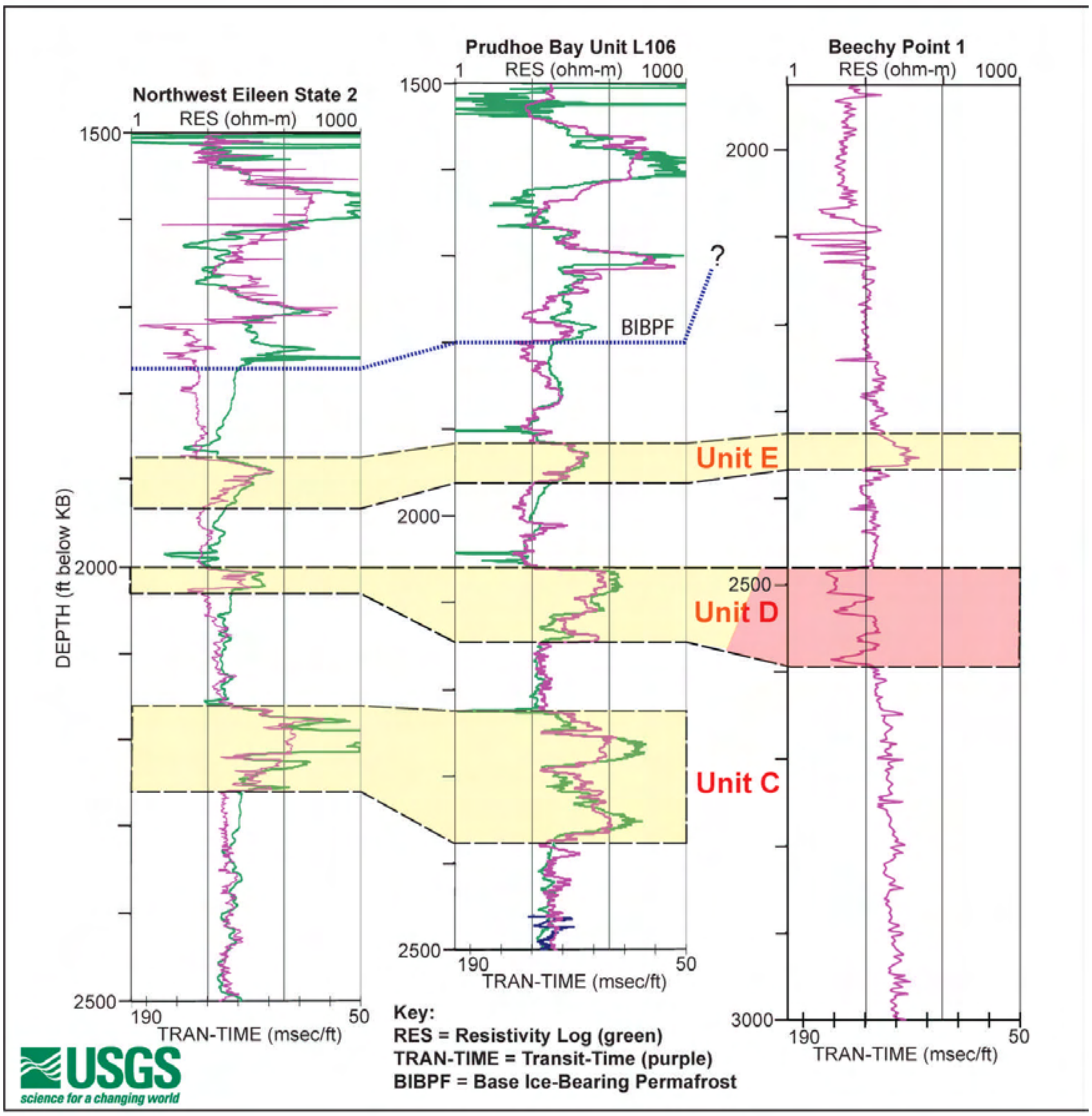

Figure 28: Cross section from PBU L-106 Area 2 to "Downdip" Area 3

4.2.4.2.3 Area 4, KRU WSak-24-area Reservoir Characterization

Area four was essentially equivalent to reservoir and temperature properties in Zone D of area one, so was not independently modeled. Table 11 compares the WSak-24 reservoir properties of Zone B to those of Mount Elbert Zone D. Note that the similar thicknesses, reservoir properties, and temperatures preclude the need to model the reservoir in Area 4. Also note that the colder temperatures are due to a deeper base-permafrost in this area (Figure 29).

Reservoir Property:	**Mount Elbert Zone D**	**KRU West Sak 24 Zone B**
Reservoir Model	**Problem 7a**	~ equivalent to Problem 7a
Hydrate-bearing Reservoir (feet)	47 (2014 – 2061 feet RKB)	40 (2260 – 2300 feet RKB)
Upper Contact	Shale contact	Shale contact
Lower Contact	Shale contact	Shale contact
Gas Hydrate Saturation	65% average	65% average
Porosity	40%	40%
Intrinsic Permeability	1,000mD (NMR log)	1,000mD
Hydrate-bearing Permeability	0.12 md (MDT model)	0.12 md (MDT model)
Reservoir Temperature	2.3-2.6^{o}C (MPU D-02 basis)	2.0-3.0^{o}C (MPU D-02 basis)
Hydrostatic Pressure	6.7 MPa	7.4-7.6 MPa
Pore Water Salinity	5 ppt	5 ppt

Table 11: Area 1 and Area 4 reservoir properties comparison

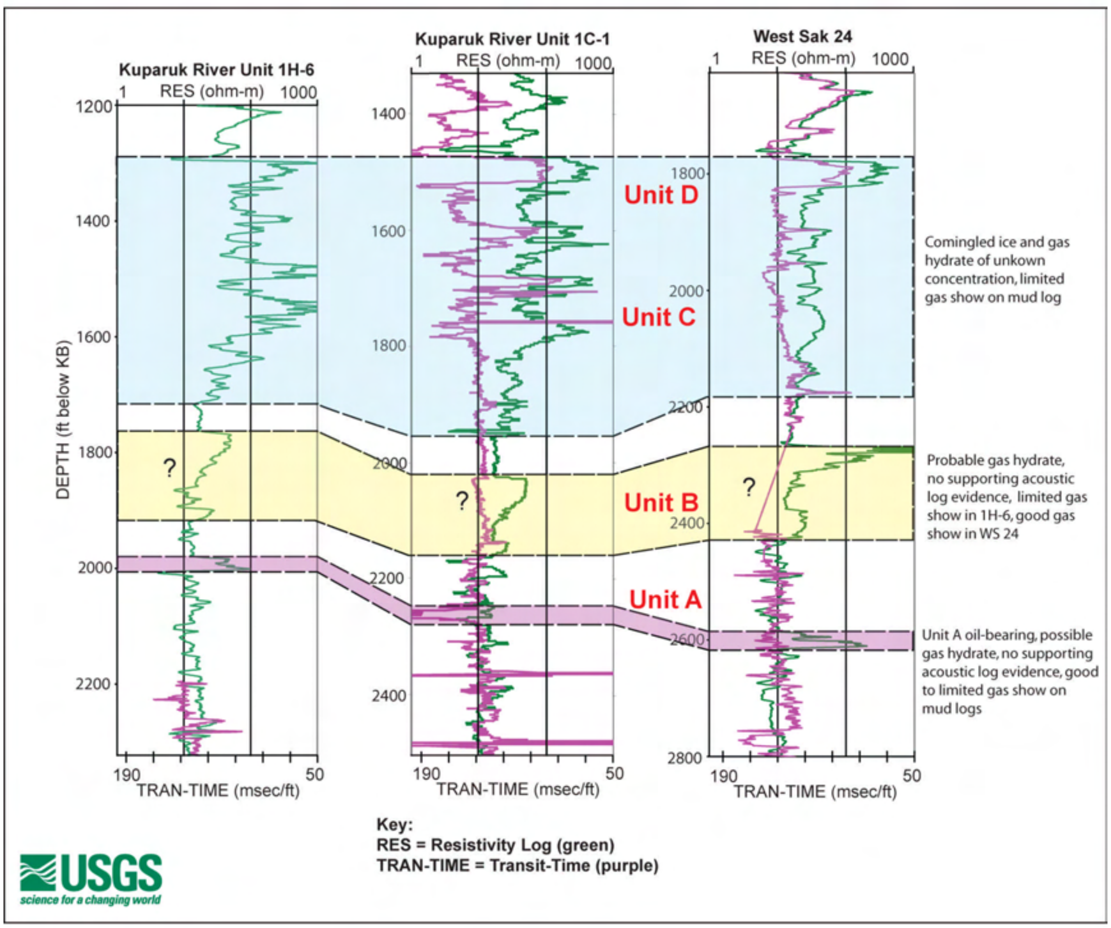

Figure 29: Cross section within KRU Area 4

4.2.5 Reservoir Modeling

4.2.5.1 Reservoir Model Comparison Team

Note that with the exception of RyderScott Co. and Fekete, funding for the reservoir model comparison team is separate from this project. Therefore, only general conclusions of this modeling are presented here at this time; the full report is in-press.

As indicated in Tables 9-11, three reservoir models were constructed to compare and contrast Areas 1-3 as discussed above. These reservoir models included:

1. Milne Point Unit - Mount Elbert-01 (Problem 7A)
2. Prudhoe Bay Unit L-106 (Problem 7B) and
3. Prudhoe Bay Unit L-106 "DOWN-DIP" (Problem 7C)

All participating simulators show remarkable agreement for gas production rates, character, and times. As expected, the warmer and deeper hydrates are modeled as more productive with higher overall initial and sustained rates as well as less time required to initiate hydrate dissociation. There is still much to be learned from validating the reservoir simulations to core and log data.

4.2.5.2 Fekete Engineering, PI Dr. Mehran Pooladi-Darvish, Co-PI Huifang Hong

The University of Calgary through the leadership of Dr. Pooladi-Darvish developed initial studies to adapt the oil phase of the Canadian Modeling Group (CMG) STARS model to simulate gas hydrate dissociation during field-scale production. A contract was executed with Fekete to involve both Dr. Pooladi-Darvish and Huifang Hong, (MSc. U. Calgary gas hydrate reservoir simulation) in recognition of their expertise. The funding allowed Fekete to participate in the Reservoir Modeling Comparison Team studies. The Fekete reports documenting these studies will be available at a later time and are best viewed in comparison to the in-press results of the Reservoir Modeling Comparison Team.

4.3 Project Reporting

- Wrote, received BP approval, and submitted project summary abstract for 4/08 AAPG
- Prepared and submitted 3Q07 financial and technical progress reports
- Distributed core analyses preliminary results and plans to BP for distribution to State
    - Reviewed and input additional core data to project ftp site
- Prepared and presented project and stratigraphic test summary presentation for Arctic Energy Summit (AES) international conference in Anchorage
- Wrote "Alaska Gas Hydrate Research and Stratigraphic Test Preliminary Results" 12 page article for inclusion in AES proceedings volume; Appendix A of 3Q07 Progress Report
- Edited AES text and figures and submitted to March 2008 World Gas Conference publication
- Prepared and presented project and stratigraphic test summary presentation to AGS/GSA luncheon meeting; coordinated presentation with DOE hydrate program summary
- Prepared project review summary with detailed presenter notes for guest presenter (Kirk Osadez, GSC) to present to November Calgary Far North Oil and Gas Conference
- Reviewed and provided input to project presentations and in-press publications
    - Reviewed Hedberg publication abstract and figures
    - Reviewed and finalized World Gas publication

- Reviewed DOE Fire/Ice article
- Reviewed initial CSM manuscript on potential gas hydrate production economics
- Reviewed SPE draft publication on resource modeling and production
- Reviewed, responded, and mitigated concerns to gas hydrate news publications

5.0 STATUS REPORT

5.1 Cost Status

Project cost auditing of the Mount Elbert-01 gas hydrate Stratigraphic Test was completed and documented in the 3Q07 Progress Report. This information was used to prepare contract Amendment 18. Outstanding invoices for Mount Elbert-01 well operations and data acquisition have been paid with the exception of one additional invoice received during the reporting period for drillpipe inspection for the pipe used during coring operations. This invoice was split between an MPU exploration well and the Mount Elbert-01 well that both used the drillpipe; costs allocated to this project were $5,740.79.

Table 12 summarizes project cost status through end-1Q08. Table 13 augments this information and estimates remaining project funds at this time. Project cost-share needs to be updated with in-kind data, staff, and cash contributions for Phase 3a work.

Total Invoices through end 1Q08	$8,191,255.35	Processed invoices reimbursed
Total Invoices 1Q08 – endMay08	$677,089.18	Includes April 10, 2008 reimbursement
Total Processed Invoices	**$8,868,344.53**	
US Treasury Account Balance	**$951,071.47**	

Table 12: Project cost status summary through end 1Q-08

Estimated Outstanding Invoices	$101,171.59	Post April 10, 2008
Additional Anticipated Invoices	$120,142.97	Through end-June 2008
US Treasury Account Balance	**$951,071.47**	(Table 12)
Estimated Current Remaining Funds	**$729,756.91**	Funds obligated in amendments 18-20

Table 13: Current remaining project funds estimate

5.2 Project Task Schedules and Milestones

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

Note that scope-of-work in contract amendments 1-8 for Phase 1.

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

Identification Number	Description	Planned Completion Date	Actual Completion Date	Comments
Task 1.0	Research Management Plan	12/02 – 12/04	12/02 and Ongoing	Subcontracts Completed
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	See Technical Progress Reports
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	Ongoing	See Technical Progress Reports
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	See Technical Progress Reports
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Advances	Ongoing		See Technical Progress Reports
Task 6.0	Reservoir and Fluids Characterization Study	12/04	1/08; awaiting final report	Interim Results presented, 2004 Hedberg Conference
Subtask 6.1	Characterization and Visualization	12/04	1/08; awaiting final report	Interim Results presented, 2004 Hedberg Conference
Subtask 6.2	Seismic Attributes and Calibration	12/04	1/08; awaiting final report	Interim Results presented, 2004 Hedberg Conference
Subtask 6.3	Petrophysics and Artificial Neural Net	12/04	1/08; awaiting final report	Interim Results presented, 2004 Hedberg Conference
Task 7.0	Laboratory Studies for Drilling, Completion, Production Support	6/04	6/04	
Subtask 7.1	Characterize Gas Hydrate Equilibrium	6/04	6/04	Results presented, 2004 Hedberg Conference
Subtask 7.2	Measure Gas-Water Relative Permeabilities	6/04	6/04	Results presented, 2004 Hedberg Conference
Task 8.0	Evaluate Drilling Fluids	12/04		
Subtask 8.1	Design Mud System	11/03		
Subtask 8.2	Assess Formation Damage	9/05	Into Phase 2	
Task 9.0	Design Cement Program	12/04		
Task 10.0	Study Coring Technology	2/04	2/04	
Task 11.0	Reservoir Modeling	12/04	Ongoing task	Interim Results presented, 2004 Hedberg Conference
Task 12.0	Select Drilling Location and Candidate	9/05		Topical Report submitted, June 2005
Task 13.0	Project Commerciality & Phase 2 Progression Assessment	9/05	Redesigned 2005 Phase 2	BPXA and DOE decision

* Date dependent upon industry partner agreement for seismic data release

5.2.2 U.S. Department of Energy Milestone Log, Phase 2, 2005-2006

Note that scope-of-work in contract Amendment 9 for Phase 2.

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

Identification Number	Description	Planned Completion Date	Actual Completion Date	Comments
Task 1.0	Research Management Plan	1/05 – 1/06	Ongoing	Subcontracts Completed
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	See Technical Progress Reports
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	Ongoing	See Technical Progress Reports
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	See Technical Progress Reports
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Development and Advances	Ongoing		See Technical Progress/Topical Reports
Task 6.0	Reservoir and Fluids Characterization Study	12/06	1/08; awaiting final report	
Subtask 6.1	Structural Characterization	12/06	1/08; awaiting final report	
Subtask 6.2	Resource Visualization	12/06	1/08; awaiting final report	
Subtask 6.3	Stratigraphic Reservoir Model	12/06	1/08; awaiting final report	
Task 7.0	Laboratory Studies for Drilling, Completion, Production Support	12/06		Some Hiatus; Phase 2-3a design, studies, & decision
Subtask 7.1	Design Mud System	12/05		
Subtask 7.2	Assess Formation Damage	1/06		
Subtask 7.3	Measure Petrophysical and Other Physical Properties	9/06	Phase 3a	No Samples Acquired; await Phase 3a acquisition
Task 8.0	Design Completion / Production Test for Gas Hydrate Well	4/06	Mt Elbert-01 strat test only	Design of Phase 3a Strat Test operation Complete
Task 9.0	Field Operations and Data Acquisition Program Planning	4/06	Mt Elbert-01 strat test only	Planning for Potential operations underway
Task 10.0	Reservoir Modeling and Project Commercial Evaluation	1/06		Regional Resource Review & Development Planning
Subtask 10.1	Task 5-6 Reservoir models	Ongoing		
Subtask 10.2	Hydrate Production Feasibility	1/06		
Subtask 10.3	Project Commerciality & Phase 3a Progression Assessment	1/06		January 2006 approval for Phase 3a Stratigraphic Test

* Date dependent upon industry partner agreement for seismic data release

5.2.3 U.S. Department of Energy Milestone Log, Phase 3a, 2006-2008

Phase 3a scope-of-work from contract Amendment 11 with additional detail provided in support of Amendments 18 and 20.

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 – 10/08	Ongoing	Subcontracts Completed
Task 2.0	Provide Technical Data and Expertise	MPU: 12/02 PBU: * KRU: *	MPU: 12/02 PBU: * KRU: *	See Technical Progress Reports
Task 3.0	Wells of Opportunity Data Acquisition	Ongoing	As-identified	See Technical Progress Reports
Task 4.0	Research Collaboration Link	Ongoing	Ongoing	See Technical Progress Reports
Subtask 4.1	Research Continuity	Ongoing	Ongoing	
Task 5.0	Logging and Seismic Technology Development and Advances	Ongoing	As-needed	See Technical Progress/Topical Reports
Task 6.0	Reservoir and Fluids Characterization Study	12/07	1/08; awaiting final report	University of Arizona contract terminated 12/07
Subtask 6.1	Structural Characterization	12/07	As above	Contract terminated
Subtask 6.2	Resource Visualization	12/07	As above	Contract terminated
Subtask 6.3	Stratigraphic Reservoir Model	12/07	As above	Contract terminated
Task 7.0	Laboratory Studies for Drilling, Completion, Production Support	9/08		University of Alaska Fairbanks contract to DOE Arctic Energy Office
Subtask 7.1	Design Mud System	9/07		
Subtask 7.2	Assess Formation Damage	9/07		
Subtask 7.3	Measure Petrophysical and Other Physical Properties	9/07		
AEO Task 1	Relative Permeability Studies	9/08		
AEO Task 2	Minipermeameter Studies	6/08		
Task 8.0	Implement completion/production Test for gas hydrate well	3/07	3/07	Stratigraphic Test Well Drilled February 3-19, 2007
Task 9.0	Reservoir Modeling and Project Commercial Evaluation	9/08	Ongoing	Regional Resource Review & Development Planning
Subtask 9.1	Task 5-6 Reservoir models	9/08	As-needed	
Subtask 9.2	Project Commerciality & Phase 3b Production Test Decision	9/08		Phase 3a analyses and Phase 3b planning/design

* Date dependent upon industry partner agreement for seismic data release

5.2.4 U.S. Department of Energy Milestone Plans

(DOE F4600.3)

DOE F 4600.3#

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

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

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

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

DOE F 4600.3#

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

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

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

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

DOE F 4600.3#

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

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

6. Identification Task Number	7. Planning Category (Work Breakdown Structure Tasks)	8. Program/Project Duration (Phases 3a-3b, 2007-2008) ←Phase 3a Strat Test→←3a Analyses/Audit → 3bPlanning→←3a Analyses, 3b Decisioning→3b Planning→ J F M A M J J A S O N D J F M A M J J A S O N D	9. Comments (Primary work Performer)
Task 1.0	Contracts and Research Management Planning	!>>>>>>!>>>--->>>>>--->>>>>>>>>>>>>>>>>>!------------------!--------->>!>>>>>>>>	BPXA, AES
Task 2.0	Technical Data and Expertise	!->>>>>>----->>>>------->>>>>>>>>-------!--->>>>>>>>-------!>>>>>>>>-->!>>>>>>>--	BPXA, AES
Task 3.0	Wells of Opportunity - Data	!------------>>>>>----------------->>>>---!----->>>>>>>>>>>>>!>-----------!>>>>>>>>	BPXA, AES
Task 4.0	Research Collaboration Link	!>>>>>>>>>>>>>>>>>>----------->>>>>>>>>>!>>>>>>>>>>>>>>>>>>>!>>>>>>>>>>>!>>>>>>>>	BPXA, USGS, AES, UAF
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	Drill/Analyze Strat Test Evaluate/Design Production Test & Phase 3b progression	! -->>>>>>>>>>>>->>>----->>>>>>>>>>>>!>>>>>>>>>>>>>>>>>>>!>>>>>>>>>>>!>>>>>>>>	APA, BPXA, AES, UAF
Task 9.0	Reservoir Modeling and Commercial Evaluation	!---->>>>>>>>>>>>>>>->>>>>>>>>>>>>>>>>>>>!>>>>>>>>>>>>>>>>>>>!>>>>>>>>>>>!>>>>>>>>	RS, AES, BPXA, UAF

10. Remarks * Schedule shows Phases 3a-3b (3b not approved-indicated in red) from 2007 projected through end-2008. Phase 3a stratigraphic test deferred until early 2007 by 3rd party rig delay. Explanation of Symbols: >> Major Task Work; -- Minor Task Work; ! Milestone. Significant technical work and milestones presented in Technical Progress and Topical Reports. Note that 2009 Drilling Schedule apparently fully dedicated; 2010 Implementation possible.

5.3 4Q07 – 1Q08 Reporting Period Significant Accomplishments

Updated project schedule for work authorized in amendments 18 and 20. Continued analyses of Stratigraphic Test data culminating in March project workshop attended by approximately 30 leading scientists. Continued planning and design of potential production test operations.

5.4 Actual or Anticipated problems, delays, and resolution

Contract amendments 18-20 were completed in December 2007 and March 2008, respectively, to fund Phase 3a data acquisition cost overruns, better define operations liabilities and extend Phase 3a data analyses and Phase 3b planning activities through end-September 2008. Additional funds authorized in amendments 18 and 20 enable completion of Phase 3a data analyses and initiation of Phase 3b planning activities.

5.5 Project Research Products, Collaborations, and Technology Transfer

5.5.1 Project Research Collaborations and Networks

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

1. **Reservoir Model Comparison studies:** DOE NETL and West Virginia University (Dr. Brian Anderson) coordination of reservoir modeling significantly increased collaborative reservoir modeling efforts with Japan, Lawrence Berkeley National Lab (LBNL), Pacific Northwest National Lab (PNNL), and University of Calgary and Fekete. This important work has continued into simulation of field-scale gas hydrate bearing reservoirs, to history matching of the Mount Elbert-01 stratigraphic test MDT data, and to evaluation of ANS potential production test options. These studies have facilitated an improved understanding of how these different gas hydrate reservoir models handle the basic physics of gas hydrate dissociation processes within gas hydrate-bearing formations. Significant 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 (University of Akron), Brian Anderson (West Virginia University), Scott Wilson (Ryder Scott Company, Consultant to BP-DOE project), Mehran Pooladi-Darvish and Huifang Hong (University of Calgary and Fekete), Timothy Collett (U.S. Geological Survey), and Robert Hunter (ASRC Energy Services; BP Exploration (Alaska), Inc.).
2. **DE-FC26-01NT41248:** This UAF/PNNL/BPXA study investigated the effectiveness of CO_2 as a potential enhanced recovery mechanism for gas dissociation from methane hydrate. DOE supported this associated project research which may help facilitate a possible future field test of this technology.
3. **UAF/Argonne National Lab project:** This associated project was approved for funding by the Arctic Energy and Technology Development Lab (AETDL) / Arctic Energy Office (AEO), forwarded to NETL for review, and was funded in mid-2004. The project is designed to determine the efficacy of Ceramicrete cold temperature cement for possible future gas hydrate drilling and completion operations. Evaluating the stability and use of

an alternative cold temperature cement may enhance the ability to maintain the low temperatures of the gas hydrate stability field during drilling and completion operations and help ensure safer and more cost-effective operations. In early 2006, the Ceramicrete material was approved for field testing at the BJ Services yard in Texas (primary contact Lee Dillenbeck). Although Ceramicrete was not yet field tested in time to be evaluated for use in 2007 Alaska operations, successful future yard testing of the material may enable limited testing in Alaska project operations. However, this project does not appear to have significantly progressed during 2006 through 2008.

4. **Precision Combustion, Inc. (PCI) – DOE collaborative research project:** Potential synergies from this DOE-supported research project with the BPXA – DOE gas hydrate research program were recognized in December 2003 by Edie Allison (DOE). Communications with Precision Combustion researchers indicate possible synergies, particularly regarding potential in-situ reservoir heating. Successful modeling and lab work could potentially proceed into field applications in future gas hydrate operations. BPXA provided a letter in April 2004 in support of progression of PCI's project into their phase 2: prototype tool design and possible surface testing. If the BP/DOE project proceeds into Phase 3b operations, a thermal component of production testing may be recommended and a delivery mechanism could potentially incorporate this technology.
5. **McGee-McMillan, Inc.** – Dr. Bruce McGee leads application of downhole thermal electromagnetic production stimulation for a pilot viscous oil project at Fort McMurray, Canada. Discussions with Dr. McGee have continued from 2004 through present; potential adaptation of this downhole technology for an Alaska North Slope production test is under investigation.
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. JOGMEC successfully accomplished short-term gas hydrate production test operations in 2007-2008 at the Mallik field site in Canada's MacKenzie Delta.
7. **India gas hydrate research:** India's Institute of Oil and Gas Production Technology (IOGPT) indicates a continued interest in the BPXA – DOE research. Dr. Tim Collett, partner in the BPXA-DOE research team, and Ray Boswell, DOE gas hydrate program, led and participated in, respectively, certain aspects of the data acquisition at multiple offshore India field sites. India sent a technical observer to view ANS Phase 3a operations and data acquisition.
8. **Korea gas hydrate research:** Korea is developing a gas hydrate research program. Korea has discussed Alaska gas hydrate research with DOE and USGS. BPXA has not initiated direct contact with Korea, but referred 2007 correspondence to DOE and USGS. Korea gas hydrate program representatives visited UAF in fall 2007.
9. **China gas hydrate research:** China is also developing a significant gas hydrate research program. BPXA has not initiated contact with China, but DOE is collaborating in certain gas hydrate research studies in China.
10. **U.S. Department of Interior, USGS, BLM, State of Alaska DGGS:** An additional collaborative research project under the Department of Interior (DOI) may provide

significant benefits to this project. The BLM, USGS, and the State of Alaska recognize that gas hydrate is potentially a large untapped ANS onshore energy resource. To develop a more complete regional understanding of this potential energy resource, the BLM, USGS and State of Alaska Division of Geological and Geophysical Surveys (DGGS) have an Assistance Agreement to assess regional gas hydrate energy resource potential in northern Alaska. This agreement combines the resource assessment responsibilities of the USGS and the DGGS with the surface management and permitting responsibilities of the BLM. Information generated from this agreement will help guide these agencies to promote responsible development if this potential arctic energy resource becomes proven. The DOI project has worked with the BPXA – DOE project to assess the regional recoverable resource potential of onshore natural gas hydrate and associated free-gas accumulations in northern Alaska, initially within current industry infrastructure.

5.5.2 Project Research Technologies/Techniques/Other Products

Multiple technologies are under evaluation in association with this project. With research progression into Phase 3 operations, technologies under evaluation include gas hydrate production techniques such as thermal and/or chemical stimulation to enhance gas dissociation during future Phase 3b production testing, if approved. Recent advances in electromagnetic thermal stimulation techniques may benefit potential future production test operations. Coiled-tubing unit-supported completions may offer sufficient flexibility to support various completion options during potential future production test operations.

5.5.3 Project Research Inventions/Patent Applications

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

5.5.4 Project Research Publications

5.5.4.1 General Project References

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5.5.4.2 University of Arizona Research Publications and Presentations

5.5.4.2.1 Professional Presentations

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5.5.4.2.2 Professional Posters

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5.5.4.2.3 Professional Publications

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5.5.4.2.5 Artificial Neural Network References

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5.5.4.3 Gas Hydrate Phase Behavior and Relative Permeability References

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5.5.4.8 Short Courses

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5.5.4.9 Websites

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

6.0 CONCLUSIONS

The first ANS dedicated gas hydrate coring and production testing well, NW Eileen State-02, was drilled in 1972 within the Eileen trend. Since that time, ANS gas hydrates have been known primarily as shallow a drilling hazard to deeper well targets. 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 investigate the resource potential of the potentially large (33 to 100 TCF in-place) unconventional ANS methane hydrate accumulations beneath or near existing production infrastructure. Studies show this in-place resource is compartmentalized both stratigraphically and structurally within the petroleum system.

The BPXA – DOE cooperative research agreement 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 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 serious attempts to understand the potential production 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. This evidence was improved by the short-term Mallik production testing accomplished by JOGMEC in 2007-2008 which validates reservoir modeling efforts. However, long-term production testing could resolve many remaining uncertainties.

The potential to induce gas hydrate dissociation across a broad regional contact from adjacent free gas depressurization may have been observed at Messoyakha field production in Russia (Collett and Ginsberg, 1998) and at East Barrow gas field in Alaska (Singh, et al., in-press). Reservoir modeling also demonstrates this potential as documented in the March 2003 Quarterly report, in the December 2003 Quarterly report, and others.

The possibility to induce in-situ gas hydrate dissociation through producing mobile connate waters from within an under-saturated gas hydrate-bearing reservoir was postulated by Howe, Wilson, and Hunter, et. al. (2004). This potential to induce a depressurization drive within an intra-hydrate accumulation emphasizes the importance of saturation and permeability as key variables which, when better understood, could help mitigate productivity uncertainty. A schematic potential development screening study was undertaken to set ranges on potential recoverable resources given various possible production scenarios of the ANS Eileen gas hydrate trend, which may contain up to 33 TCF gas-in-place. Type-well production rates modeled at 0.4-2 MMSCF/d yield potential future peak field-wide development forecast rates of up to 350-450 MMSCF/d and cumulative production of 0-12 TCF gas. Individual wells would exhibit a long production character with flat declines, potentially analogous to Coalbed Methane production.

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

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

7.0 LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Denotation
2D	Two Dimensional (seismic or reservoir data)
3D	Three Dimensional (seismic or reservoir data)
AAPG	American Association of Petroleum Geologists
AAT	Alaska Arctic Terrane (plate tectonics)
AGS	Alaska Geological Society
AETDL	Alaska Energy Technology Development Laboratory
ADEC	Alaska Department of Environmental Conservation
ANL	Argonne National Laboratory
ANN	Artificial Neural Network
ANS	Alaska North Slope
AOGCC	Alaska Oil and Gas Conservation Commission
AOI	Area of Interest
AVO	Amplitude versus Offset (seismic data analysis technique)
ASTM	American Society for Testing and Materials
BGHSZ	Base of Gas Hydrate Stability Zone
BHA	Bottom Hole Assembly; equipment at bottom hole during drilling operations
BIBPF	Base of Ice-Bearing Permafrost
BLM	U.S. Bureau of Land Management
BMSL	Base Mean Sea Level
BP	BP or BPXA
BPXA	BP Exploration (Alaska), Inc.
CMR	Combinable Magnetic Resonance log (wireline logging tool – see also NMR)

CP	ConocoPhillips
CRA	Cooperative Research Agreement (commonly in reference to BP/DOE project)
CSM	Colorado School of Mines
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DGGS	Alaska Division of Geological and Geophysical Surveys
DNR	Alaska Department of Natural Resources
EM	Electromagnetic (referencing potential in-situ thermal stimulation technology)
EPT	Electromagnetic Propagation Tool for geophysical wireline logging
ERD	Extended Reach Drilling (commonly horizontal and/or multilateral drilling)
FBHP	Flowing Bottom-Hole Pressure (during MDT wireline production testing)
FEL	Front-End Loading, reference to effective pre-project operations planning
FG	Free Gas (commonly referenced in association with and below gas hydrate)
GEOS	UA Department of Geology and Geophysics
GH	Gas Hydrate
GIP	Gas-in-Place
GMC	Geological Materials Center, State of Alaska in Eagle River, Alaska
GOM	Gulf of Mexico (typically referring to Chevron Gas Hydrate project JIP)
GR	Gamma Ray (well log)
GSC	Geological Survey of Canada
GTL	Gas to Liquid
GSA	Geophysical Society of Alaska
HP	Hewlett Packard
HSE	Health, Safety, and Environment (typically pertaining to field operations)
JBN	Johnson-Bossler-Naumann method (of gas-water relative permeabilities)
JIP	Joint Industry Participating (group/agreement), ex. Chevron GOM project
JNOC	Japan National Oil Corporation
JOGMEC	Japan Oil, Gas, and Metals National Corporation (reorganized from JNOC 1/04)
JSA/JRA	Job Safety Assessment/Job Risk Assessment; part of BP HSE operations protocol
KRU	Kuparuk River Unit
LBNL	Lawrence Berkeley National Laboratory
LDD	Generic term referencing Logging During Drilling (also LWD and MWD)
LDEO	Lamont-Dougherty Earth Observatory
LNG	Liquefied Natural Gas
MDT	Modular Dynamics Testing wireline tool for downhole production testing data
MGE	UA Department of Mining and Geological Engineering
MOBM	Mineral Oil-Based Mud drilling fluid used to improve safety and data acquisition
MPU	Milne Point Unit
MSFL	Micro-spherically focused log (wireline log indication of formation permeability)
NETL	National Energy Technology Laboratory
NMR	Natural Magnetic Resonance (wireline or LDD tool – see also CMR)
NRC	National Research Council of Canada
OBM	Oil Based Mud, drilling fluid
ONGC	Oil and Natural Gas Corporation Limited (India)
PBU	Prudhoe Bay Unit
PNNL	Pacific Northwest National Laboratory

POOH	Pull out of Hole; pulling drillpipe or wireline from borehole during operations
POS	Pump-out Sub (pertaining to MDT tool)
SCAL	Special Core Analyses, references analyses beyond basic porosity/permeability
SPE	Society of Petroleum Engineers
TCF	Trillion Cubic Feet of Gas at Standard Conditions
TCM	Trillion Cubic Meters of Gas at Standard Conditions
T-D	Time-Depth (referencing time to depth conversion of seismic data)
UA	University of Arizona (or Arizona Board of Regents)
UAF	University of Alaska, Fairbanks
USGS	United States Geological Survey
USDOE	United States Department of Energy
Vp	Velocity of primary seismic wave component
Vs	Velocity of shear seismic wave component (commonly useful to identify GH)
VSP	Vertical Seismic Profile
WOO	Well-of-Opportunity

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