Presentation Outline

- Project Overview/Schedule
- Resource Characterization
- Stratigraphic Test Results
- Reservoir Simulation
- Production Testing
- Conclusions / Future Plans
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Acknowledgements

The Mount Elbert Science Party

- Myung Lee – USGS
- John Miller - USGS
- Bill Waite – USGS
- Bill Winters – USGS
- Tom Lorenson – USGS
- Tanya Inks – Int. Services, Inc.
- Dennis Urban – BPXA
- Paul Hanson – BPXA
- Warren Agena - USGS
- Kelly Rose – DOE/NETL
- Eilis Rosenbaum – DOE/NETL
- Micaela Weeks – BPXA
- Larry Vendl – BPXA
- Danny Kara - BPXA
- Rick Colwell – OSU
- Marta Torres – OSU
- Steve Hancock (RPS)
- Tim Collett (USGS)
- Ray Boswell (DOE/NETL)
- Robert Hunter (ASRC/BP)
- The Crew of the Doyon 14
Gas Hydrate Resource Pyramid

In-Place Resource Distribution

- Arctic sandstones under existing infrastructure (~10’s of Tcf in place)
- Arctic sandstones away from infrastructure (100s of Tcf in place)
- Deep-water sandstones (~1000s of Tcf in place)
- Non-sandstone marine reservoirs with permeability (unknown)
- Massive surficial and shallow nodular hydrate (unknown)
- Marine reservoirs with limited permeability (100,000s Tcf in place)

- increasing in-place resource
- decreasing certainty in resource estimates
- decreasing reservoir quality
- increasing technical challenges
- decreasing ultimate % recoverable
Gas Hydrate Resource Pyramid

In-Place Resource Distribution

- Increasing in-place resource
- Decreasing certainty in resource estimates
- Decreasing reservoir quality
- Increasing technical challenges
- Decreasing ultimate % recoverable

Arctic sandstones under existing infrastructure (~10's of Tcf in place)

Arctic sandstones away from infrastructure (100's of Tcf in place)

Deep-water sandstones (~1000's of Tcf in place)

Non-sandstone marine reservoirs with permeability (unknown)

Massive surficial and shallow nodular hydrate (unknown)

Marine reservoirs with limited permeability (100,000's Tcf in place)
Cooperative Agreement Objectives

Characterize, quantify, and determine commercial viability of gas hydrates in the ANS field infrastructure areas

*How – Methods:*
- ✓ Prove exploration & reservoir models
- ✓ Describe & Quantify ANS resource
- ✓ Conduct long-term production test

*Why – Motivations:*
- ✓ Understand ANS hydrate productivity
- ✓ Demonstrate ANS hydrate resource
- ✓ Leverage to potential marine resource
- ✓ Synergies to other ANS gas resources
Cooperative Agreement Motivations

Opportunities

✓ Determine if long-term U.S. resource
✓ Collaborate with Federal & State R&D
✓ Mid-term possible fuel gas source?
✓ Long-term supplemental gas source?

Challenges

✓ Uncertain resource potential & risk
✓ Align with existing O&G operations
✓ Minimize impact to ANS development
✓ Manage stakeholder expectations
✓ Clarify goals, priorities, & timing
Assess Gas Hydrate Resource
• Jointly Decide Project Progression
• Use Alaska North Slope as Lab
• Require Clear Decision GATES
• Cost-shared/Yearly Appropriations
• Phases 1-2 (2003-2005)
  • Characterization & Modeling
• Phase 3a (2006-1Q2009)
  • Stratigraphic Test Ops/Analyses
• Phase 3b (2Q2009+)
  • Long-term Production Testing
## ANS Cooperative Research Program

### Assess Resource Potential in 3 Phases:

<table>
<thead>
<tr>
<th>Year</th>
<th>Phase</th>
<th>Major Task</th>
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<td><strong>Resource Characterization/Modeling</strong></td>
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<td><strong>Schematic Regional Modeling</strong></td>
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<td><strong>Acquire Stratigraphic Test Well Data</strong></td>
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<td><strong>Analyze Core, Logs, &amp; MDT test</strong></td>
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<td><strong>Acquire Additional Well Data</strong></td>
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<td><strong>Long-term Production Test</strong></td>
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<tr>
<td>2009+</td>
<td></td>
<td><strong>Determine Technical &amp; Commercial Viability</strong></td>
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<td>Planned</td>
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## ANS Cooperative Research Program

<table>
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<tr>
<th>Budget vs. Cost</th>
<th>Phase</th>
<th>Major Task</th>
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<td><strong>Resource Characterization/Modeling</strong></td>
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<td>$0.8MM/ $0.9MM</td>
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</table>
| $4.8MM/ $6.3MM  | 3a.   | **Acquire Stratigraphic Test Well Data**
                      |       | Analyze Core, Logs, & MDT test |
| >$10MM?         | 3b.   | **Acquire Additional Well Data**
                      |       | Long-term Production Test |
| TOTAL: $20MM+   |       | **Determine Technical & Commercial Viability** |
PREVIEW: 4 Long-term Production Test Sites

1. Mount Elbert 01
2. PBU L-106
3. PBU V-107
4. W Kuparuk 7-11-12

Sites:
- NW Eileen St-2
- W Kuparuk St 1
- W Sak 24
- KRU 1H-6
- KRU 1C-8
- KRU 1D-8
- Beechy St-1
- PBU V-107
- PBU L-106
- W Kuparuk 7-11-12
Parameters for a Successful Production Test

- Site with continuous, long-term access
  - Maximize likelihood for success
  - Conduct long-term test operations
  - Build on past success, learn from others

- Designed to determine the potential productivity of gas hydrate reservoirs
  - Validate simulations, test methods
  - Maximize knowledge, not just rate
  - Demonstrate technical recovery
  - Try multiple completions/stimulations

- Carefully manage risks
  - Maintain operationally simple
  - Meet all HSE requirements
  - Minimize impacts to existing operations
  - Optimize reservoir conditions
## Phase 3b Schedule

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<th>Timing</th>
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<td>1Q2009</td>
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<td>2Q2009</td>
<td>2. Select Production Test Site</td>
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<tr>
<td>3-4Q2009</td>
<td>3. Production Test Detailed Design, Well Package, Risk Assessment, Preparation</td>
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<tr>
<td>2010+ Planned</td>
<td>4. Acquire Additional Well Data Implement Long-term Production Test</td>
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- Determine Technical & Commercial Viability
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Study Area Location

Introduction

After Collett, 2004

Eileen Trend, PBU/KRU/MPU
33 TCF GIP, 0-12 TCF EUR

Tarn Trend

After Collett, 2004
Eileen/Tarn Gas Hydrate Trends

100 km

Tarn

Eileen

BGHSZ

BIBPF

TGHSZ
Introduction

Study Area Location

Milne Point 3D Survey

After Collett, 2004

Eileen Trend, PBU/KRU/MPU
33 TCF GIP, 0-12 TCF EUR

Tarn Trend

After Collett, 2004
14 Intra-Hydrate Prospects
Total GIP = 600 BCF
Largest Prospect
158 BCF GIP

Courtesy; Inks, T., Lee, M., Taylor, D., Agena, W., Collett, T. and Hunter, R., in press
Milne Point Unit Gas Hydrate Prospects

Stratigraphic Test
Mt Elbert Prospect
~90 BCF GIP

Courtesy; Inks, T., Lee, M., Taylor, D., Agena, W., Collett, T. and Hunter, R., in press
Mt. Elbert Prospect Seismic Amplitude

- 3-Way, Fault-Bounded Closure
- Drilling/Data: February 3-19, 2007
- Validated Seismic Interpretation
- Acquired 430’ Core
- Acquired Extensive OH Logs
  - GR/Res/N/D/ Dipole/ NMR / FMI
Mt. Elbert Prospect Seismic Amplitude

- 3-Way, Fault-Bounded Closure
- Drilling/Data: February 3-19, 200
- Validated Seismic Interpretation
- Acquired 430’ Core
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Gas Hydrate Stratigraphic Test “Firsts”

• 1st ANS open-hole multi-day data acquired
• 1st Significant ANS gas hydrate core
• 1st dual-packer, open-hole MDT program
• 1st MDT sampling of hydrate gas/water
• 1st formation temperature data with MDT
MPU Mount Elbert
Site Preparation

Ice Road

First #1
Ice Pad

Powerline Above Ground
Downhole Log Acquisition Program

- Excellent Hole Conditions
  - Use of chilled, oil-based drilling fluids

- Full Log Suite Obtained
  - Gamma Ray (lithology)
  - Resistivity (hydrocarbon)
  - Neutron and Density (porosity)
  - Acoustics (Hydrate Indicator- Dipole Sonic)
  - Magnetic Resonance (distribution, nature, and saturation of fluids)
**PREDICTION**

- Prospect within undrilled, 3-way fault-bounded trap
- Seismic attributes estimate reservoir thickness and saturation for Zones C & D
  - Upper “D” sand: 46’ thick with 68% Gas Hydrate Saturation
  - Lower “C” sand: 70’ thick with 85% Gas Hydrate Saturation
- Thickest previous total GH seen in MPU wells ~20 ft.

**RESULTS**

- Validated seismic methods
- Extensive Open-hole Logs
  - 430’ core, 261 subsamples
  - 100’ gas hydrate-bearing
- Comprehensive OH MDT

*Courtesy; Inks, T., Lee, M., Taylor, D., Agena, W., Collett, T. and Hunter, R., in press*
Gas Hydrate Prediction vs. Actual

GH Thickness
Pre-drill: 46 ft
Actual: ~44 ft

GH Saturation
Pre-drill: 68%
Actual: ~75%

GH Thickness
Pre-drill: 70 ft
Actual: ~43 ft (perched water)

GH Saturation
Pre-drill: 89%
Actual: ~75%
Core Sub-Sampling in the Cold Trailer

Core liner cut, core examined, described, sampled, & archived

Tim Collett
USGS

Core – Note rind of Oil-Based Mud

Tom Lorenson (USGS) & Rick Colwell (OSU)

Robert Hunter
ASRC
Core Program Summary

- Outstanding performance
  - Oil-based mud chilled to ~30° F
  - 23 cores, 504’ core, 85% recovery

- 261 subsamples collected onsite
  - 7 preserved in liquid nitrogen
  - 4 preserved in pressure vessels
  - 52 physical properties
  - 46 porewater geochemistry
  - 5 thermal properties
  - 86 microbiology
  - 46 organic geochemistry
  - 15 petrophysics

- Recipients: NETL, LBNL, PNNL, ORNL, CSM, NRCan, USGS, ConocoPhillips, OSU, OMNI Lab, UAF
Core Sedimentology

Shale Top-Seal
ME01 Core1 Sec3 4-8"

Zone D Pebble Conglomerate
ME01 Core2 Sec5 0-12"

ZONE D Gas Hydrate-bearing sand
ME01 Core3 Sec2 19-24"

ZONE C Gas Hydrate-bearing sand
ME01 Core7 Sec2 28-33"
Petrophysical Data from Core

SUMMARY OF ROUTINE CORE ANALYSES RESULTS
Vacuum Oven Dried at 140°F

BP Alaska
KT Elicent-01 Well
Alaska, USA
File: HH-36610

<table>
<thead>
<tr>
<th>Core Number</th>
<th>Sample Number</th>
<th>Sample Depth, feet</th>
<th>Net Containing Stress, psi</th>
<th>Median Grain Size, microns</th>
<th>Permeability, millidarcys</th>
<th>Porosity, percent</th>
<th>Grain Density, gm/cc</th>
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Average values: 43.87, 800, 871, 30.5, 34.8, 2.74
## Petrophysical Grain Size Data from Core

**BP Alaska**  
**MT. Elbert-01 Well**

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

### Laser Grain Size Summary

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<tr>
<th>Core Run</th>
<th>Depth, feet</th>
<th>ID Number</th>
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<th>Silt</th>
<th>Clay</th>
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<td>Crs %</td>
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### Zone D
- Sand > 50%
- Sand 20%-50%
- Sand < 20%

### Zone C
Note high pyrite in transgressive top of D (but not in C). Note also 10%+ feldspars in D sand except in cleanest sands at top of regressive section.

Sample Identity | CLAYS | CARBONATES | OTHER MINERALS | TOTALS
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<td>22-4-20-26B</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
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<tr>
<td>AVERAGE</td>
<td>3</td>
<td>2</td>
<td>11</td>
<td>2</td>
</tr>
</tbody>
</table>

**Notes:**
- *Tracking interbedded mudstones and interbeds: Approx. 10-30% clay and/or silt.
- May include the FeK-alpha.
Core Sampling
Onsite Pore-Water Geochemistry Lab

Core samples are squeezed to extract/examine pore water samples and analyzed for thermal properties.
Downhole Data Acquisition
Modular Dynamics Testing (MDT)

- Tests reservoir response to fluid withdrawal and pressure reduction
- Indication of reservoir quality and performance
- Tests conducted at four locations two per pay zone
- Critical data for reservoir simulation calibration and potential production test
Modular Dynamic Testing (MDT)

- Extensive and repeatable flow and pressure transient data obtained from 4 extended Dual-Packer OH MDT’s
  - Collected formation temperature data tracking cooling and warming events during flow and build-up periods – an industry first
- 4 gas samples obtained from each test interval
- Observed rapid cooling (and potential freezing of pore water) during gas hydrate dissociation/gas flow
- Produced free pore water from gas hydrate zone without causing gas hydrate dissociation
- 1 pore water sample obtained from D1 test interval
Presentation Outline

- Project Overview / Schedule
- Resource Characterization
- Stratigraphic Test Results
- Reservoir Simulation
  - Production Testing
  - Conclusions / Future Plans
Presentation Outline

• Project Overview / Schedule
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➢ Production Testing
• Conclusions / Future Plans
Presentation Outline

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- Resource Characterization
- Stratigraphic Test Results
- Reservoir Simulation
- Production Testing

➢ Conclusions / Future Plans
Mt Elbert Gas Hydrate
Well Summary

• Demonstrated safe data collection in shallow unconsolidated, GH-bearing sediments
  • good hole = outstanding core recovery and log suite
• Confirmed GH reservoir in close conformance to pre-drill predictions
  • ability to prospect for hydrate using G&G approach
  • improved confidence in broader ANS GH resource assessment
• Coring, Logging, Pressure Testing Program
  • fully integrated data and sample set
  • moveable fluids in fully-saturated reservoirs quantified and accessed
  • gas release via depressurization
• Acquisition and analysis of complete and integrated dataset for cost of ~$6.0 million
Project Phase 3b – beyond 2009+
Parameters for a Successful Production Test

• Site with continuous, long-term access
  • Maximize likelihood for success
  • Conduct long-term operations
  • Build on past success, learn from others

• Designed to determine the potential productivity of gas hydrate reservoirs
  • Validate simulations
  • Maximize knowledge, not just rate
  • Demonstrate technical recovery
  • Test multiple completion scenarios

• Carefully manage risks
  • Maintain operationally simple
  • Meet all HSE requirements
  • Minimize impacts to existing operations
  • Optimize reservoir conditions
Four areas under evaluation within Eileen trend for Production Test Site

Key Criteria
- Probability of Success
  - Reservoir presence and quality
- Temperature
- Nature of contacting units (pressure support?)
- Modeling results
- Operational flexibility (multiple zones)
- Ease of Access
- Logistics/Facilities
- Program Complexity
## Site Comparison and Risk Detail

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MPU/KRU option</th>
<th>PBU L option /down-dip</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MP E-pad</td>
<td>MP B-pad</td>
</tr>
<tr>
<td>Temp¹</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Ownership²</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Access³</td>
<td>M*</td>
<td>M*</td>
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<tr>
<td>Geo Risk⁴</td>
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<td>L</td>
</tr>
<tr>
<td>Data⁵</td>
<td>L</td>
<td>L</td>
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<tr>
<td>Well Risk⁶</td>
<td>L-M</td>
<td>L-M</td>
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<tr>
<td>Facilities⁷</td>
<td>L</td>
<td>L</td>
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<tr>
<td>Gas⁸</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Interference⁹</td>
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<tr>
<td>Water¹⁰</td>
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<td>L</td>
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<tr>
<td>Market¹¹</td>
<td>L?</td>
<td>L?</td>
</tr>
<tr>
<td>Options¹²</td>
<td>M-H</td>
<td>M-H</td>
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</table>
### General comparison of test site options

<table>
<thead>
<tr>
<th>Target</th>
<th>Depth</th>
<th>Contact</th>
<th>H (ft)</th>
<th>Sw/Swirr (%)</th>
<th>Phi (%)</th>
<th>K (mD)</th>
<th>T (°C)</th>
<th>Pressure gradient</th>
<th>Salinity (ppt)</th>
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</thead>
<tbody>
<tr>
<td><strong>Milne Point Unit – Mount Elbert Prospect</strong></td>
<td></td>
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<tr>
<td>C-sand 2132 Water</td>
<td>52</td>
<td>Water</td>
<td>52</td>
<td>35/25</td>
<td>35</td>
<td>1000</td>
<td>3.3 - 3.9</td>
<td>9792</td>
<td>5</td>
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<tr>
<td>D-sand 2014 Water?</td>
<td>47</td>
<td>Water?</td>
<td>47</td>
<td>35 -</td>
<td>40</td>
<td>1000</td>
<td>2.3 - 2.6</td>
<td>9792</td>
<td>5</td>
</tr>
<tr>
<td><strong>Prudhoe Bay Unit – L-pad vicinity</strong></td>
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<tr>
<td>C2-sand 2318 Shale</td>
<td>62</td>
<td>Shale</td>
<td>62</td>
<td>25</td>
<td>40</td>
<td>1000</td>
<td>5.0 - 6.5</td>
<td>9792</td>
<td>5</td>
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<tr>
<td>C1-sand 2226 Shale</td>
<td>56</td>
<td>Shale</td>
<td>56</td>
<td>25</td>
<td>40</td>
<td>1000</td>
<td>5.0 - 6.5</td>
<td>9792</td>
<td>5</td>
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<tr>
<td>D-sand 2060 Shale</td>
<td>50</td>
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<td>E-sand 1915 Shale</td>
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<tr>
<td><strong>Prudhoe Bay Unit Down-Dip from L-pad</strong></td>
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<tr>
<td>C-sand 2500 ? 60*</td>
<td>25</td>
<td>60*</td>
<td></td>
<td>40</td>
<td>40</td>
<td>1000</td>
<td>~12</td>
<td>9792</td>
<td>5</td>
</tr>
<tr>
<td><strong>Kuparuk River Unit – West Sak 24 vicinity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-sand 2260 Shale?</td>
<td>40</td>
<td>Shale?</td>
<td>40</td>
<td>35</td>
<td>40</td>
<td>1000</td>
<td>2.0 - 3.0</td>
<td>9792</td>
<td>5</td>
</tr>
</tbody>
</table>

*KRU and MPU units are very similar, both colder and are treated as one scenario for modeling*

- MPU/KRU-like reservoirs
- PBU L-pad-like reservoirs
- Warmer reservoirs such as those that occur down-dip of the PBU L-Pad area
Milne Point (or Kuparuk River) unit option

**Favorable**
- Low geologic risk
- Ease of access to land and facilities

**Unfavorable**
- High risk of poor test results
  - Low formation temperature (2-3 C)
  - Lower zone (at least) likely in contact with free water
- No surface location for vertical well
  - must drill directionally
- Fewer options –2 possible zones
- Lateral extent unclear
**Prudhoe Bay down-dip option**

**Favorable**
- Temperatures as high as 12°C
- Most favorable simulation results

**Unfavorable**
- Much higher geologic risk
  - very few nearby well penetrations
  - uncertainty as to reservoir presence and fill
  - Potentially limited reservoir options
- No viable surface site infrastructure or facilities
  - Extended reach well or near permanent gravel pad at prohibitive cost
W. Prudhoe L-pad vicinity option

**Favorable**
- **Acceptable technical risk**
  - Moderate temperature (3-6 C)
  - Expect at least scalable production rates
  - Can drill vertically
  - Multiple zones each ~15m thick

- **Acceptable geologic risk**
  - Close offset to high-quality log suites
  - Clean, fully saturated sands
  - Recent 3D data in hands of industry partners

**Unfavorable**
- **Complex contractual arrangement**
  - Would require approval of all Stakeholders
The Team

INDUSTRY
- BP Exploration Alaska
- Arctic Slope Regional Corporation
- Ryder Scott Company
- RPS - APA Energy
- Interpretation Services, Inc.
- Doyon Drilling, Inc.
- ReedHycalog (Corion)
- Drill Cool Systems, Inc.
- Omni Laboratories
- Schlumberger
- MI Swaco

GOVERNMENT
- US Geological Survey
- Department of Energy

ACADEMIA
- U. Alaska-Fairbanks
- U. Arizona
- Oregon State University
• Backup Misc.
Contribution to R&D Community

Results, Reporting, Publications, Presentations

• DOE Reports: 15 major DOE Technical Reports, 4Q02-2Q08
  • 1 Topical Report on Drilling and Data Acquisition Planning, 6/05
    • Published 2005 Regional Modeling in June 2006 Q Report

• DOE Advisory Committee / other Government presentations

• Present project updates - technical conferences/public meetings
  • Annual AAPG Meeting Oral/Poster Sessions 2002 – 2008
  • 2002-04: >20 external presentations
  • 2005-08: ~20 external presentations
  • M.S. Thesis: 3 + 2 pending UA and 5 + 1 pending UAF
  • >30 professional publications

• Participate openly in Model Comparison Studies: 2005 – 2008

• Industry-standard input - Operations designs and production test
OUR PROPOSED TIME SCHEDULE IS AS FOLLOWS:
First submission deadline to guest editors: March 1, 2009.
Completion of initial reviews: May 1, 2009.
Completion of review-revision process: July 1, 2009.
Hardcopy: Jan-Feb, 2010.
THEMATIC VOLUME PROPOSAL

Introductory Materials (Hunter, ed.)

1. R. Hunter (ASRC Energy): Research overview and Stratigraphic Test
2. M. Lee (USGS): 3D seismic analysis of Mount Elbert prospect
3. T. Collett (USGS): Regional geologic framework
4. R. Boswell (DOE): Geologic controls of gas hydrate, Milne Point
5. S. Wilson (RyderScott Co.) Regional production modeling

Coring Program (Boswell, ed.)

6. K. Rose (DOE): Core operations and sedimentology
7. B. Winters (USGS): Physical and grain-size properties
8. B. Winters (USGS): Geotechnical behavior
9. T. Lorenson (USGS): Gas geochemistry
11. F. Colwell (Oregon St. U.): Microbial community diversity
12. T. Kneafsey (LBNL): Core disturbance and handling
13. L. Stern (USGS): SEM and XRD imaging and characterization
14. H. Lu (Natural Resources Canada): Characteristics of gas hydrate
THEMATIC VOLUME PROPOSAL

Well Logging Program (Collett, ed.)
17. M. Lee (USGS): Data analysis
18. Y. Sun (Texas A&M): High-resolution dielectric properties
19-21: TBD: Advanced log analyses

MDT Program (Anderson, ed.)
23. M. Pooladi-Darvish (U. Calgary): MDT data - implications
24. M. Kurihara (Japan Oil Eng.: MDT/Mallik data findings

Production Modeling (Anderson, ed.)
25. B. Anderson (West Va. U.): Regional production modeling overview
26. J. Rutqvist (LBNL): Geo-mechanics during production testing
27. G. Moridis (LBNL): Evaluation of gas production testing
Proactions & Reactions
Project Management Challenges

- **Gates / Phases / Decisions**
  - **2001 – Present:** Industry / Government Alignment
    - Underestimated time needed to maintain/grow alignment
  - **2002 – 2004:** Reservoir Description & Modeling
    - Recommended MPU field area Field Operations
    - Regional Eileen trend resource potential not evident
    - Led to 2005 Redirection → Regional Development Model
    - Maintained & Increased Industry support for Operations
  - **2006-07:** Field Operations Approved / Executed
    - 2006 → Third-party delays with Drilling Rig
      - Optimized Safety, Drilling, & Data Acquisition program
    - 2007 → Budget Overruns ~$1.1MM
      - Documented Costs → Strong Industry & DOE Commitment
      - Demonstrated ability to Implement Operations / Acquire Data
Methane Hydrate Resource
Petroleum System Components

- **Source** – Thermogenic - Biogenic
- **Migration** – Fault Systems
- **Reservoir** – Sub-Permafrost Shallow Sands
- **Trap** – Complex Structural and Stratigraphic through 4D
- **Seal** – Can Self-Seal
- **Stability** – Pressure/Temperature
- **Gas/Water** – Clathrate Structure