Alaska Natural Gas Hydrate Production Test: Accomplishments To-Date and Science In Progress

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U.S. Department of Energy
National Energy Technology Laboratory
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Presentation Outline

- Project overview – Structure and objectives
- Alaska production testing: Accomplishments
  - Test site review, selection, and characterization
  - Field test technical planning support
  - Geophysical monitoring program
  - Hydrate-01 Stratigraphic Test Well results
- Alaska production test: What's next
  - Field activities currently in-progress
  - Test and monitoring plans
- Project Summary

Project Overview

Completed project: DE-FE0022898

Alaska Natural Gas Hydrate Production Testing, Test Site Selection, Characterization, and Testing Operations

Funding:

DOE $230,700

USGS $1,890,000 (Cost Share)

Performance Dates:

09/01/2014 – 01/15/2021

Now under way: 89243321SFE000024

Alaska Gas Hydrate Production Field Experiment: Reservoir Response Test Planning, Operations, and Results Analysis Support

Funding (through 2023):

DOE $182,114

USGS $636,000 (Cost Share)

Performance Dates:

09/01/2021 – 08/30/2026

DOE Project Manager

Rick Baker

USGS Involved Scientists

Tim Collett (PI), Seth Haines, Rita Zyrianova, Sam Heller, Craig Markey

Project Overview

Goals and Objectives

This is a cooperative research effort, with the USGS providing technical support in a partnership with DOE and the Japan Oil, Gas and Metals National Corporation (JOGMEC).

Objectives of DOE-USGS Interagency Agreements (IA):

- Provide geologic and geophysical technical support to identify and characterize possible gas hydrate production test sites on the Alaska North Slope

- Develop plans for an extended gas hydrate production testing program

- Provide direct technical support for the field production testing phase of the project and the analysis of the geologic and production test data acquired during the field test

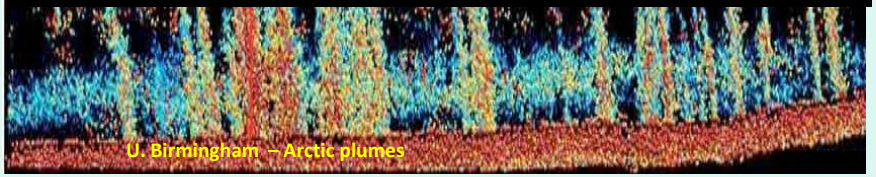
Gas hydrate research motivations

Geohazards

1. Hazards for sea-floor structures?
2. "Conventional" well drilling/production in areas of gas hydrate?
3. Can hydrate destabilization cause sea-floor instability?

Global Environmental

1. Hydrate linkages to biological communities?
2. What role does destabilized hydrate play in the carbon cycle over long time-scales?
3. What is the near-term response of hydrate to global climate change?

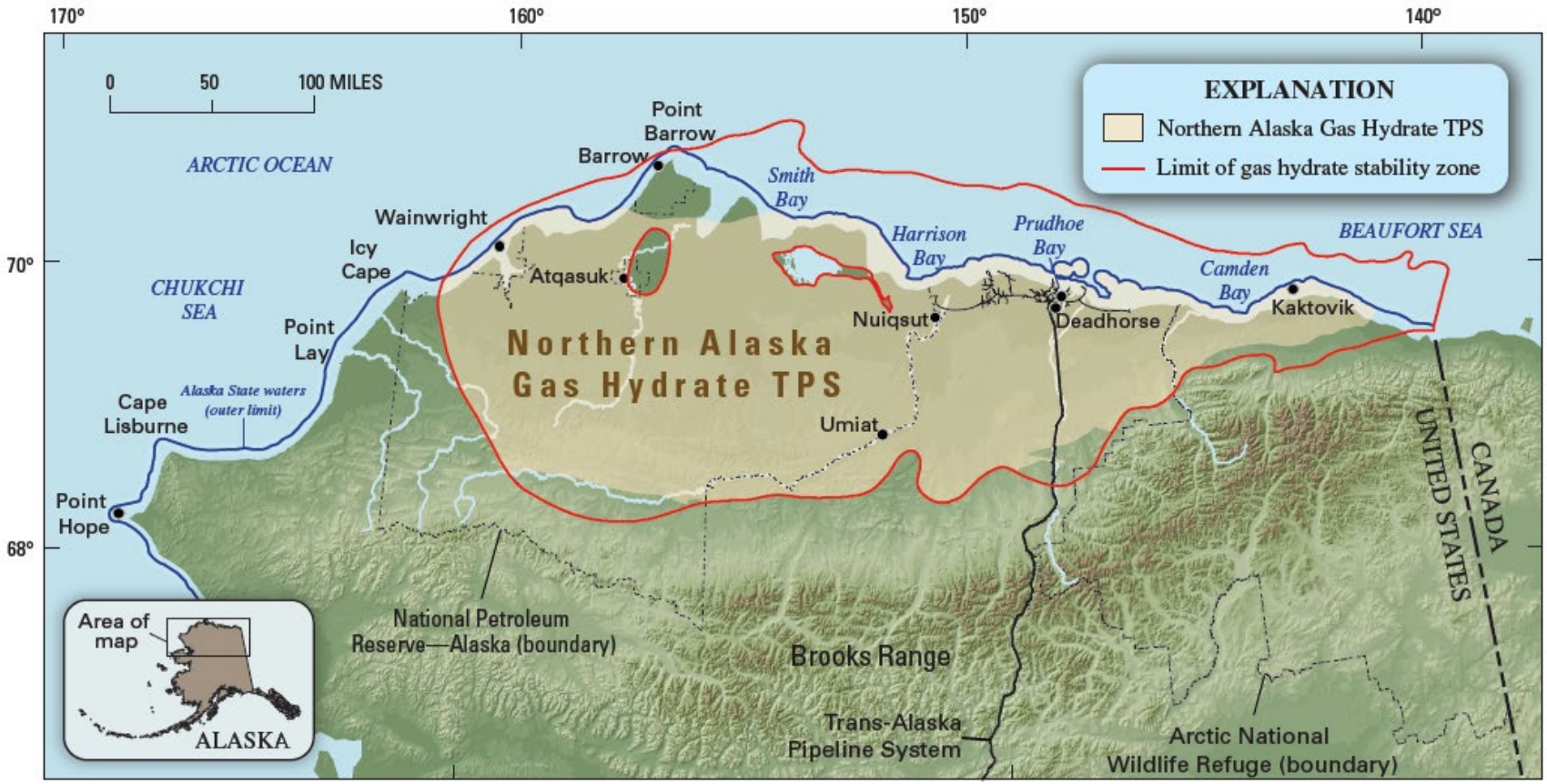


Energy Resource Potential

1. What types of deposits are most promising?
2. How can they be found?
3. How can production be best accomplished?
4. What are the environmental impacts and how can they best be minimized?

USGS Alaska North Slope gas hydrate research

Gas Hydrate Assessments & Production Studies



1983-2020: USGS Alaska North Slope Gas Hydrate Assessment Project

2007: BPXA Mount Elbert Gas Hydrate Stratigraphic Test

2011-2012: ConocoPhillips CO_2 Displacement Test

2018-2024: Alaska North Slope Extended GH Production Test

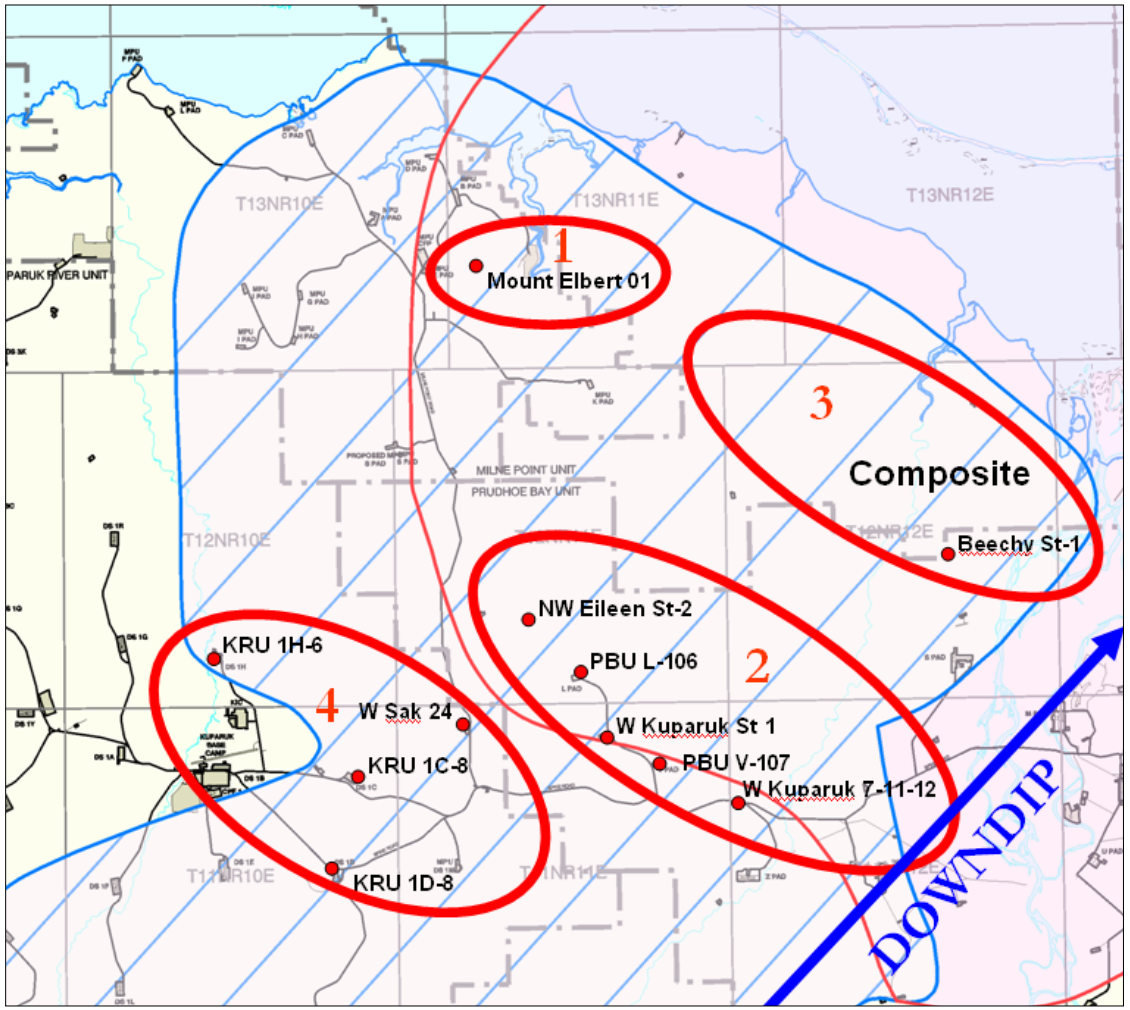
USGS science for a changing world

Long-term testing site selection

Four Areas Were Initially Considered – PBU KRU MPU

Key criteria

- **Probability for test success**
  - Reservoir presence & quality
  - Temperature
  - Nature of contacting units (pressure support?)
  - Modeling results
  - Operational flexibility (multiple zones)
- **Ease of Access**
- **Logistics/Facilities**
- **Program Complexity**



Alaska North Slope

Site Review of Prudhoe Bay Unit 7-11-12

Key criteria

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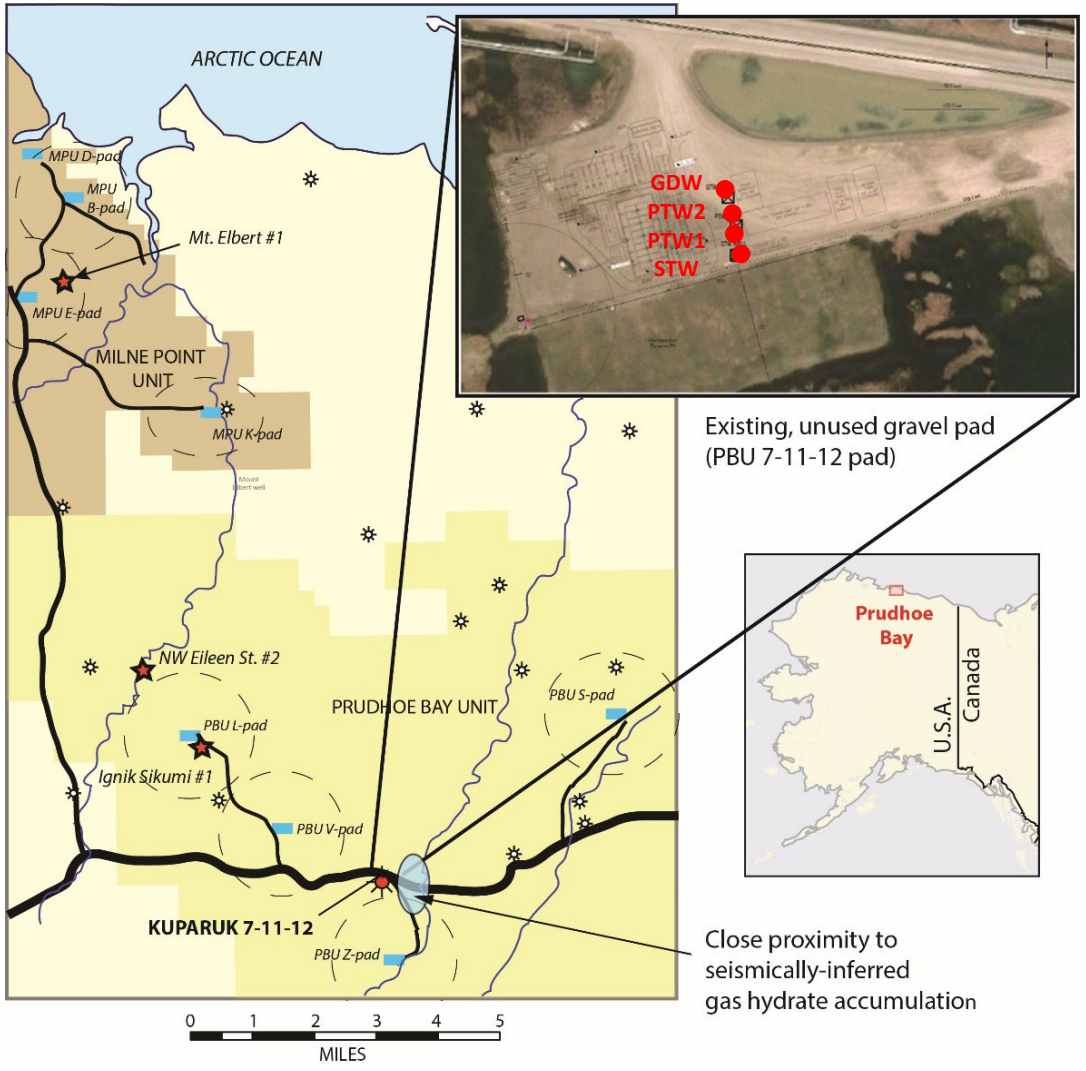


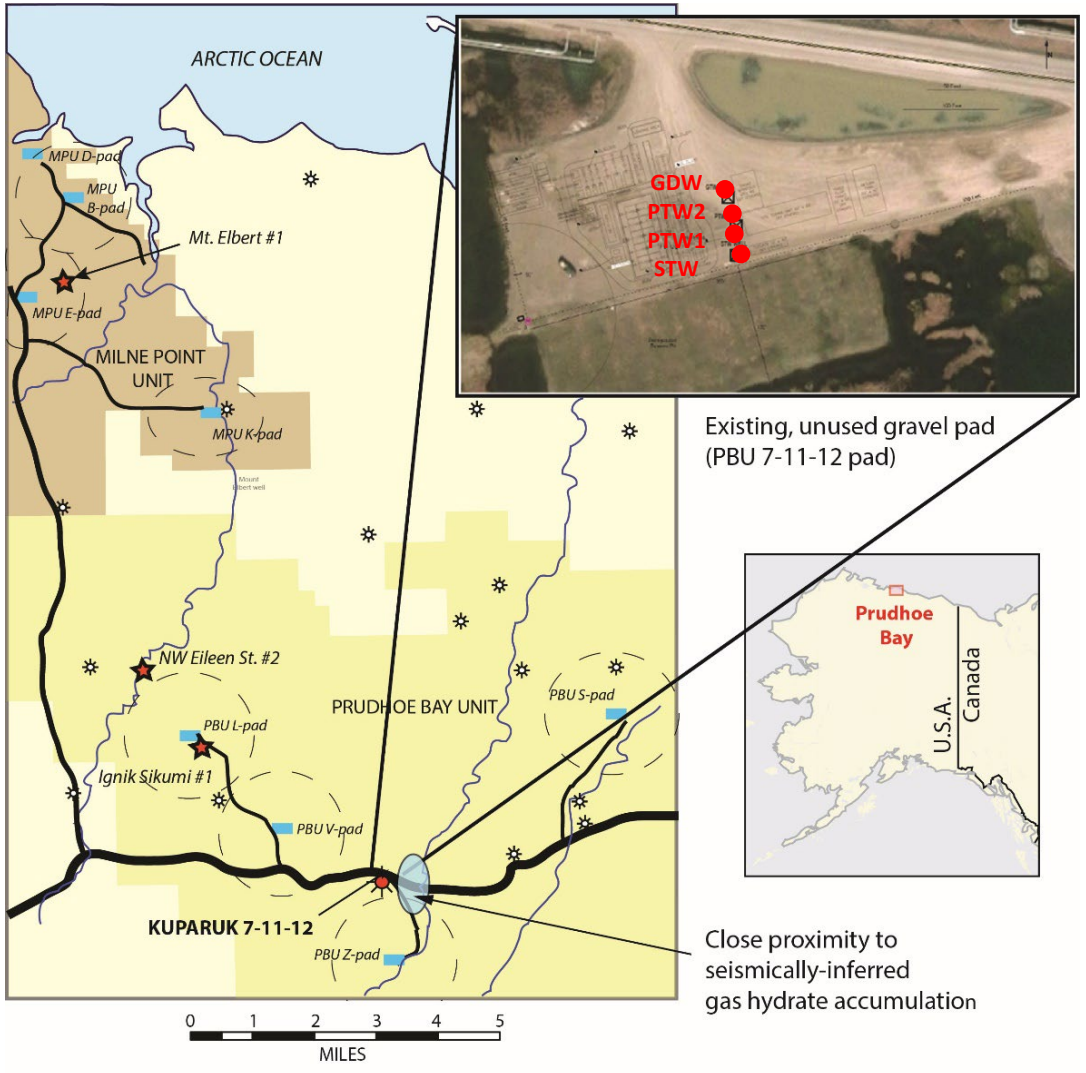
Alaska North Slope

Site Review of Prudhoe Bay Unit 7-11-12

Key steps

- Site studies
  - Geophysical studies
  - Modeling
  - Logistical and organizational questions

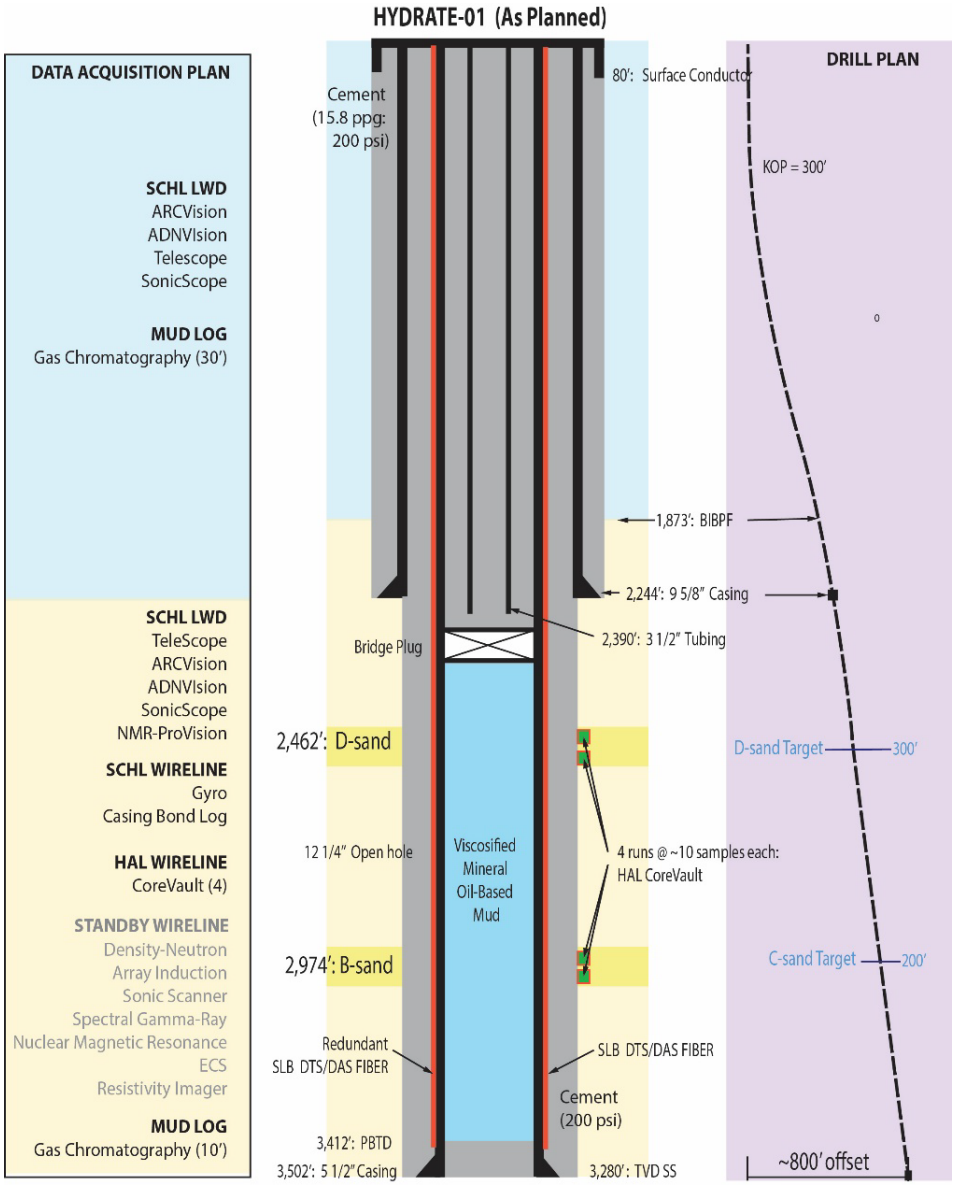
➢ Drill stratigraphic test well to verify interpretations



PBU Hydrate-01 Stratigraphic Test Well

Well Design and Operations

- BPXA gained partner alignment to operate STW (warm up of rig for the impending PBU 2019 drilling season)
- Program was designed to acquire only essential data
  - Full logging suite to confirm reservoir occurrence and characteristics
  - Side wall pressure cores to provide data to support planning of test well completion
  - Installed fiber optic cables for
    - Vertical seismic profiling
    - Monitoring during future operations



PBU Hydrate-01 Stratigraphic Test Well
Data Acquisition Results

Drilling/wellbore quality (to allow reliable data collection)

- FULLY ACHIEVED: both targets penetrated within provided target. Mud temperature maintained within set limits (as modified). No incidents of induced GH dissociation; hole in gauge.

Logging-while-drilling (data to confirm/characterize reservoir condition)

- FULLY ACHIEVED: outstanding quality data with all tools!
- **NOTE**: Sonic data – muted reservoir response in lower portion of B target. Verified proper tool response through two additional MAD passes across the reservoir.

Contingency Wireline data

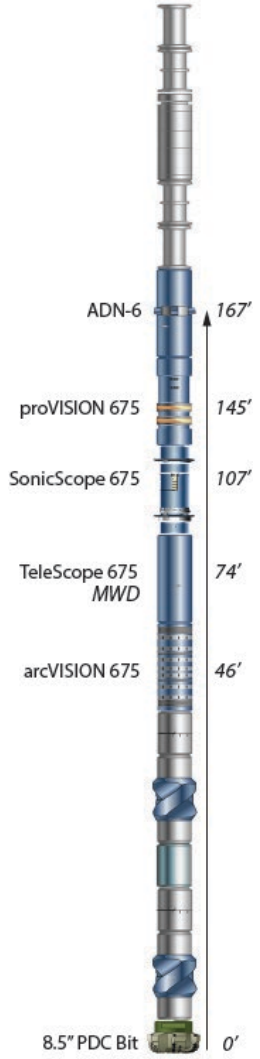
- DEFERRED PER PLAN: Not required due to high quality of LWD data.

Sidewall pressure cores (grain size analyses & test well completion design)

- FULLY ACHIEVED: 34 samples recovered spanning full extent of both reservoirs.
- **NOTE**: Obtained additional petrophysical data from the highest quality cores.

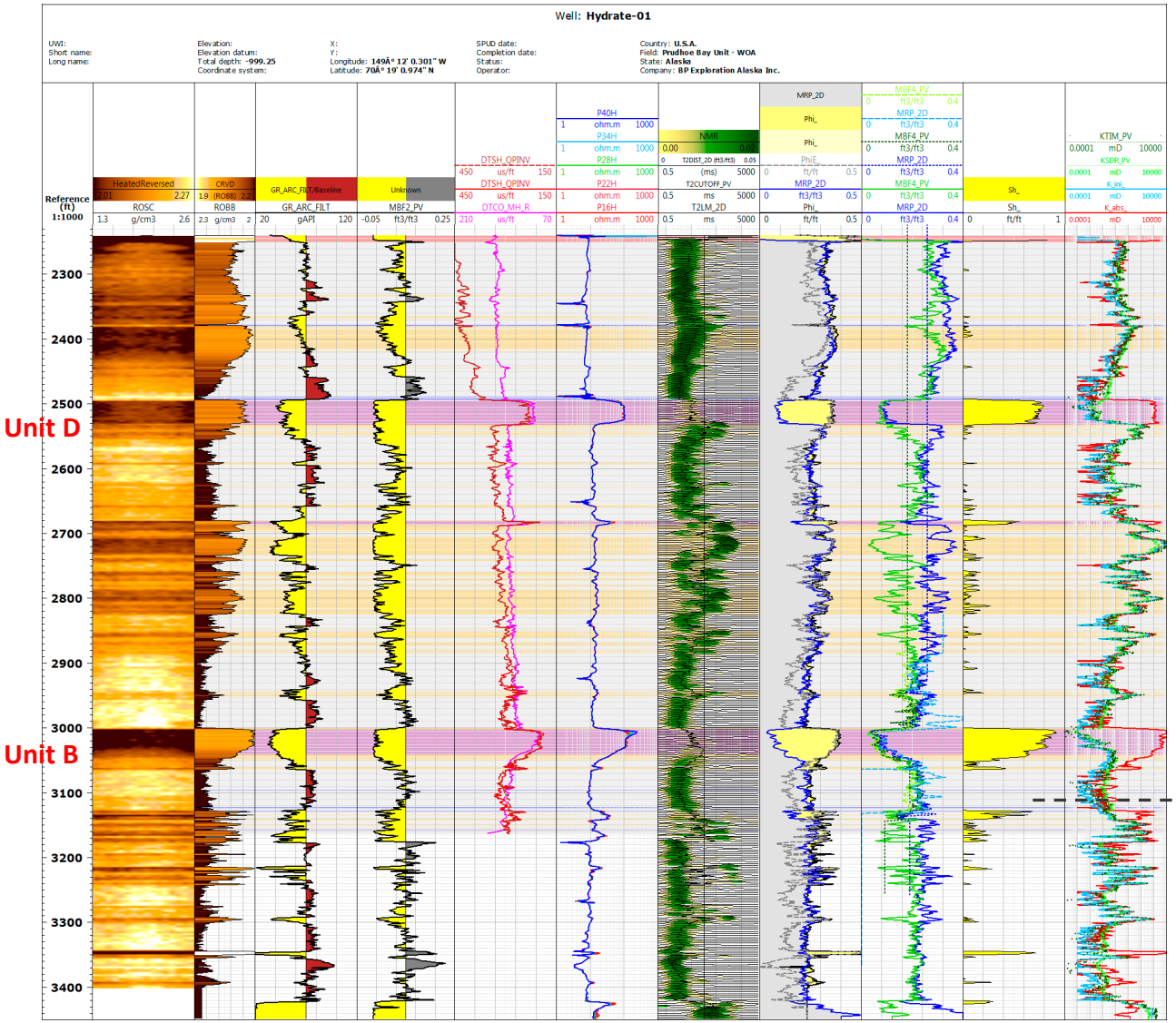
Fiber Optic cable installation (to enable use of STW as monitoring well)

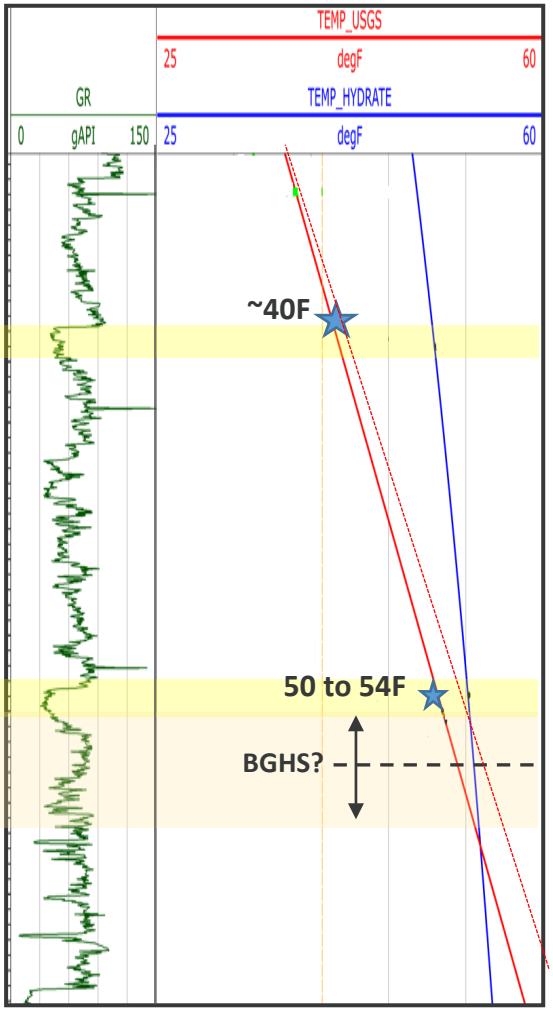
- FULLY ACHIEVED: Two (one as backup) distributed temperature/acoustic sensor cable packages were installed on outside of casing and successfully tested.



Bottom-hole assembly for main hole (from Schlumberger)

PBU Hydrate-01 Stratigraphic Test Well

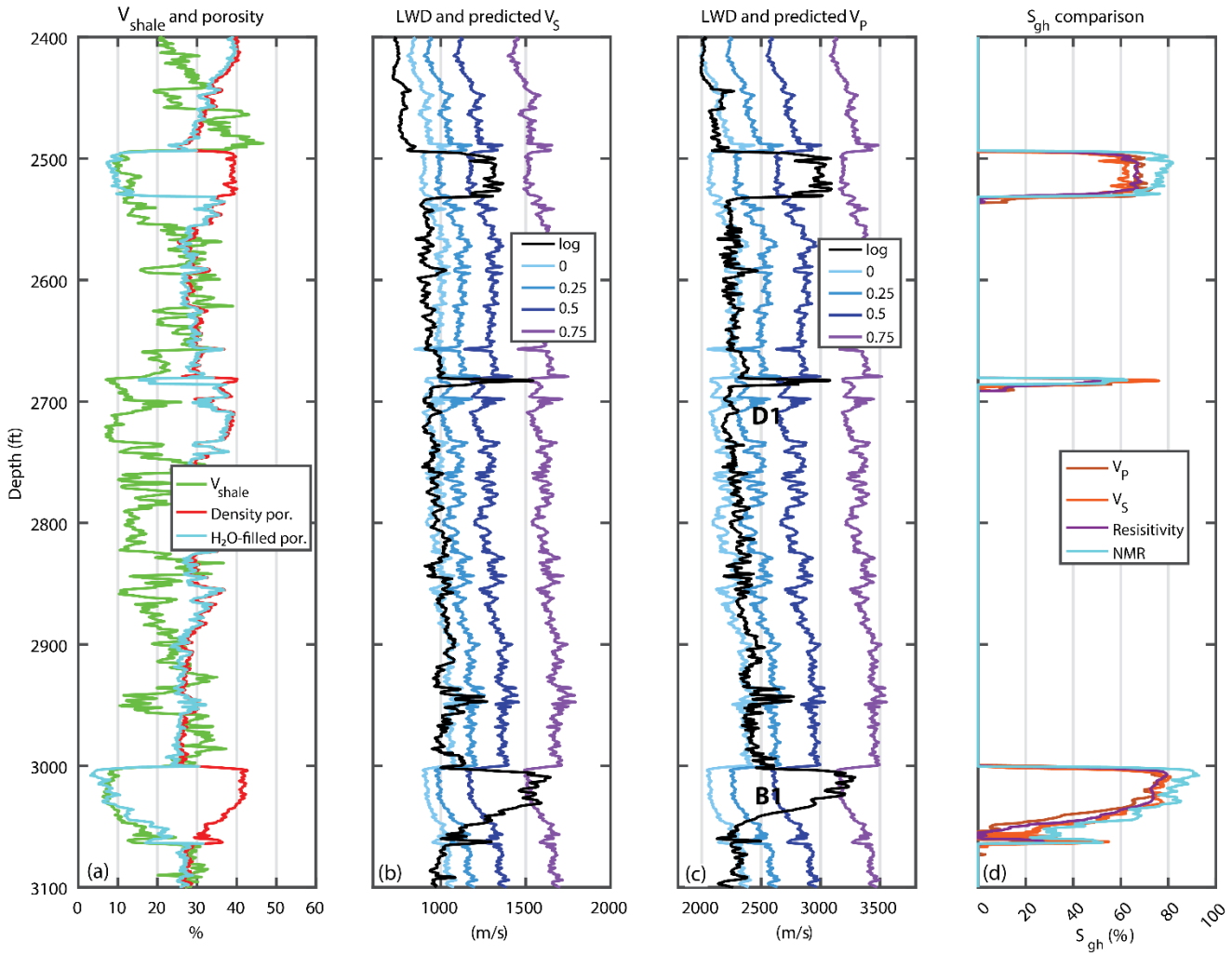




Modified from Boswell et al., 2020 - ICGH10

PBU Hydrate-01 Stratigraphic Test Well

Well Log S_{gh} estimation



Gas hydrate saturations (S_{gh}) from sonic and other log data.

a. LWD derived shale volume (V_{sh}) and porosity logs

b. LWD-measured V_P (black line) and model predicted V_P for S_{gh} values

c. LWD-measured V_P (black line) and model predicted V_P for S_{gh} values

d. Predicted V_S and V_P Gas hydrate saturations (S_{gh})

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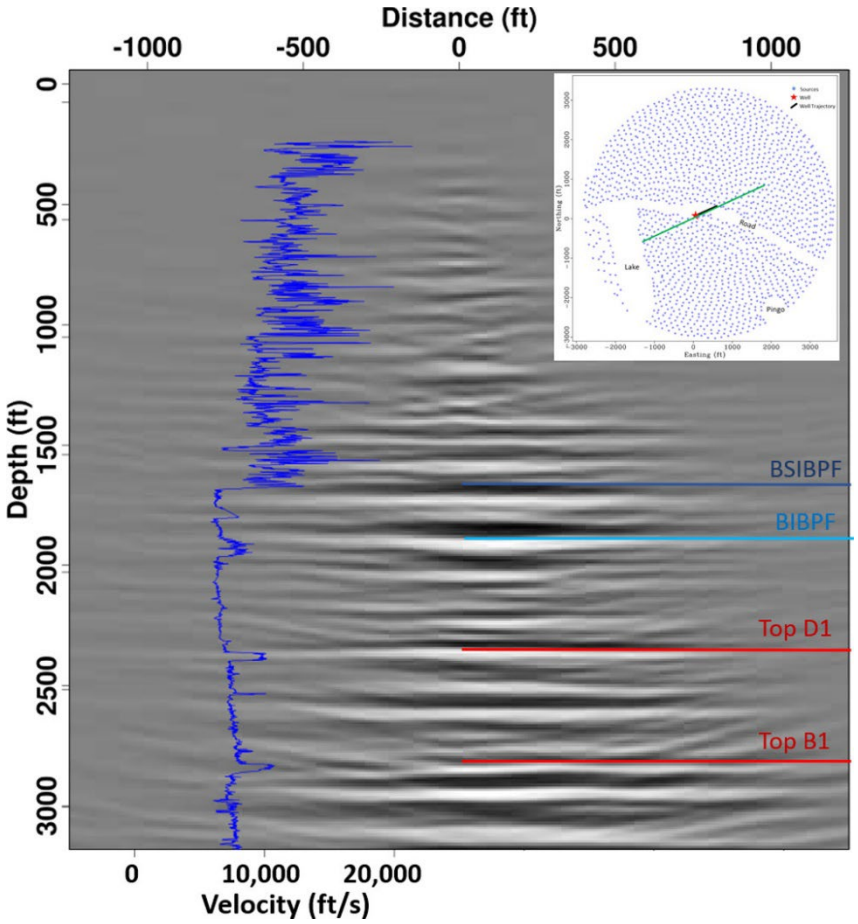
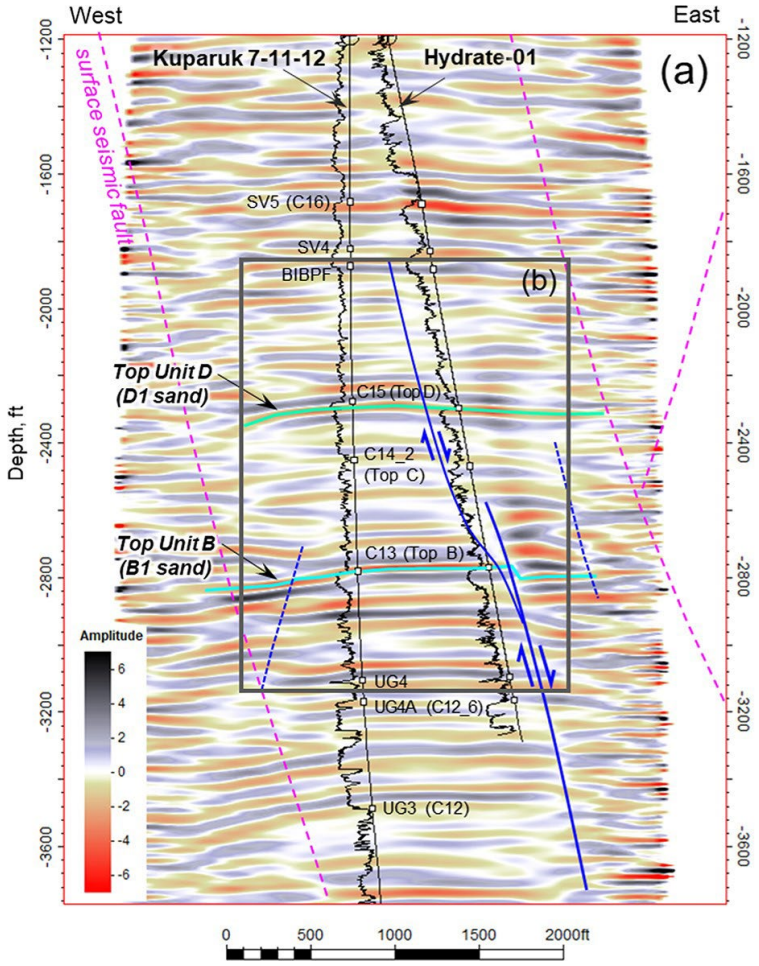
Haines et al., 2022 – Energy & Fuels

PBU Hydrate-01 Stratigraphic Test Well

3D VSP data acquired with distributed acoustic sensor (DAS)



Reverse time migration image of DAS VSP data.
Young et al., 2022 – Energy & Fuels

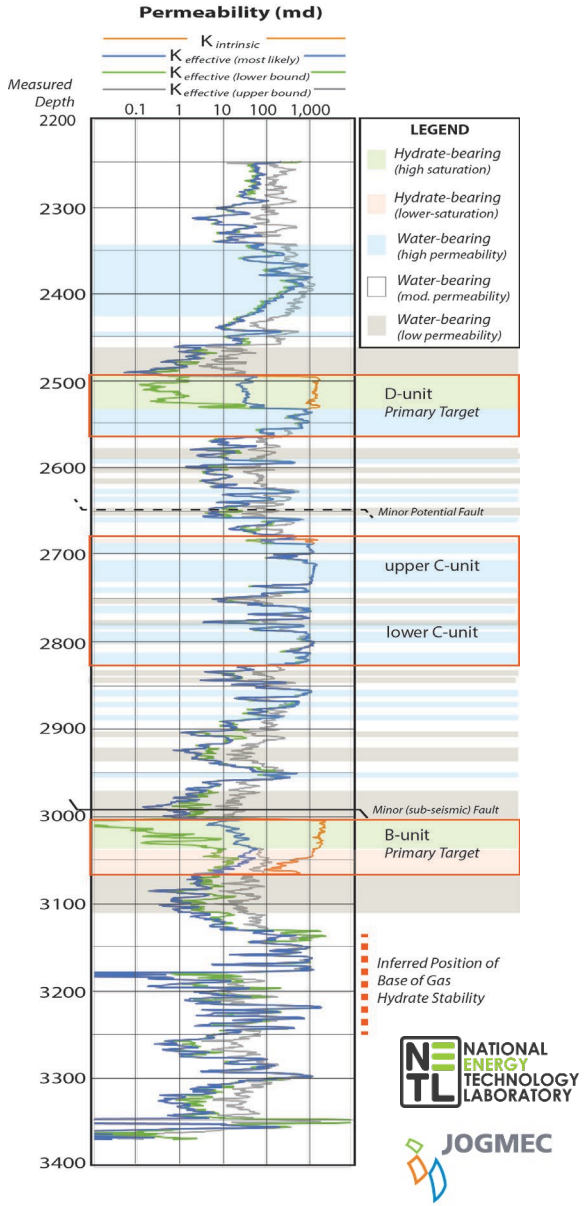


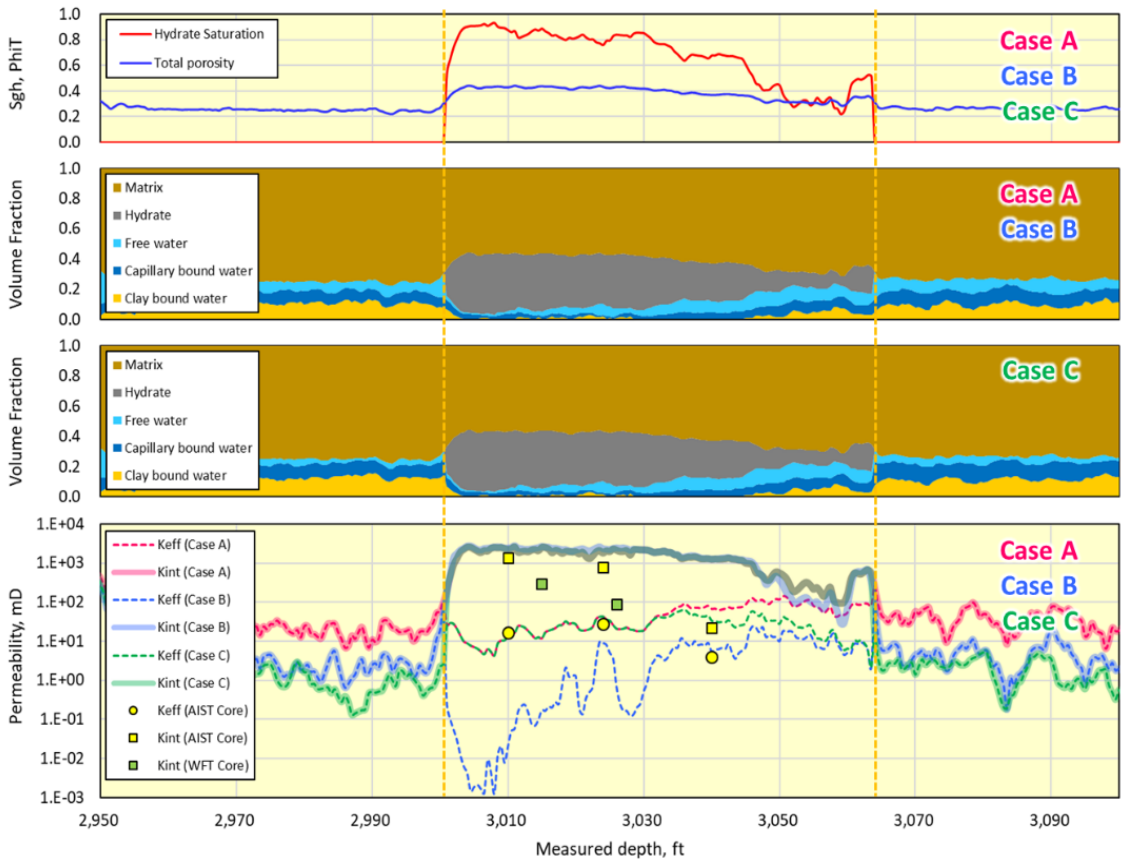
Mapping statigraphic and structural features in the DAS VSP data.
Tamaki et al., 2022 – Energy & Fuels

Gas Hydrate Production Modeling

Reservoir Properties

Boswell et al., 2020 - ICGH10
Myshakin et al., 2020 - ICGH10





Three modeling cases to constrain gas and water rates

- Conservative case (CASE B) based on NMR- Ks
- Aggressive case (CASE A) core-corrected (entire section)
- Most Likely case (CASE C) core-corrected (main reservoir)

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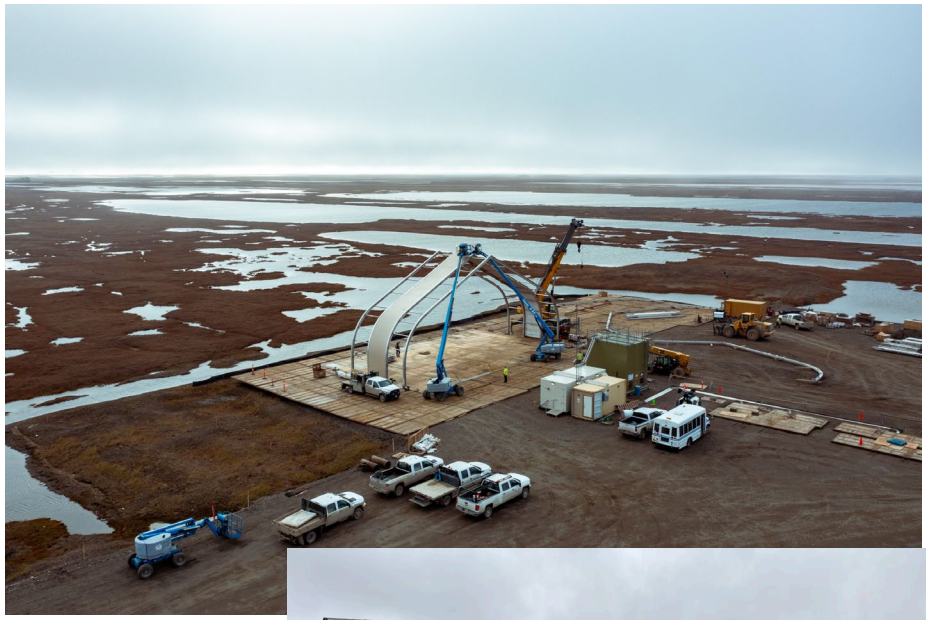
JOGMEC

Moving ahead toward production testing

September 2022: Site preparation



Moving forward toward production testing

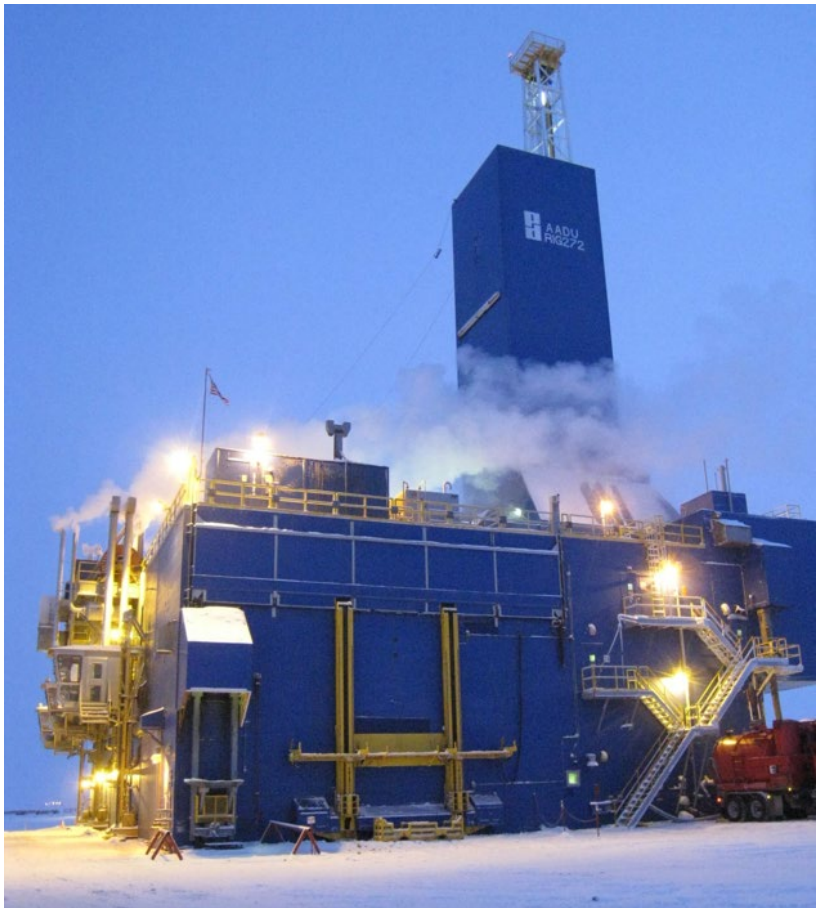
Oct. 2022 through Jan. 2023: Drilling three additional wells

Geodata Well (GDW): Currently in progress
- Extensive borehole log suite
- Pressure core in reservoirs and seals
- Fiber optic cables for monitoring

Production Test Well 2 (PTW2)
- Borehole logs
- Fiber optic cables for monitoring

Production Test Well 1 (PTW1)
- Borehole logs
- Fiber optic cables for monitoring
- Completion for production test

Spring 2023: Commence production testing



Hydrate-01 drilling, December 2018

Alaska Gas Hydrate Production Field Experiment

Extended Gas Hydrate Production Testing

Reservoir response testing

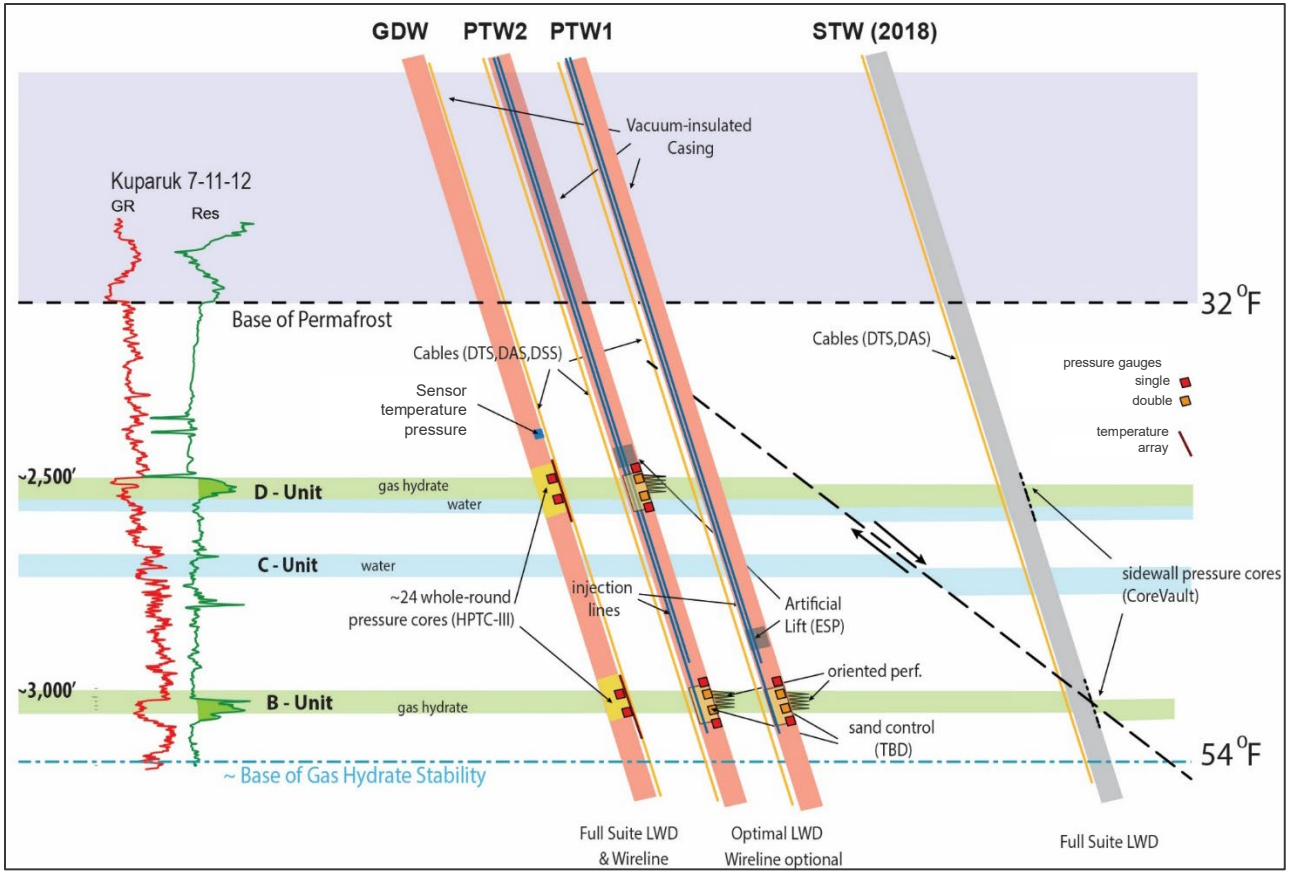
Extended-duration pressure draw-down in B reservoir at PTW1

Monitoring:

- Produced fluids from PTW1
- Temperature, pressure, strain in other wells
- Geophysical monitoring

Adjust production testing program as warranted

Duration: Approximately 9 months, according to current plans



STW = Stratigraphic Test Well
GDW = Geoscience Data Well
PTW1 = Production Test Well 1
PTW2 = Production Test Well 2

Science and Operational Plan

1. Well Delivery: Engineering Planning and Operations

2. PTWs Completion and Production Testing Program

- -PTWs Completions
- -Surface Facilities
- -Production Testing Planning and Design
- -Testing Operations
- -Testing Results Analysis

3. Well-Based Data Acquisition and Analysis

- -Mud Logging Program
- -Downhole LWD/Wireline Logging Program
- -Pressure Coring Operations
- -Coring Plan
- -Well Site Core Flow and Analysis
- -Post Well Site Core Shipping, Processing and Analysis

4. GDW and PTWs Monitoring Program

- -DTS/DAS/DSS and Gauge Based P&T Systems and Surface Monitoring Systems
- -4D VSP/CWT Geophysical Data Acquisition: Test Site Characterization and Production Monitoring

Anticipated outcomes

Broadly:

- Significantly improved understanding of the response of a gas hydrate reservoir to extended pressure draw-down
- What happens when we try to produce gas hydrate?

More specifically:

- Core data and reservoir logs to understand initial reservoir conditions and gas hydrate occurrence
- Highly detailed (in time and space) pressure, temperature, and strain data to understand changes due to pressure draw-down
- Geophysical monitoring data to understand spatial extent of reservoir changes

Hydrate-01 drilling, December 2018

Anticipated outcomes

Technology development

- Modeling capabilities and model calibration
- Monitoring techniques
  - Fiber optic data, combined with other sensors/data
  - Temperature, strain, acoustics
  - Vertical seismic profiling
  - Cross-well seismic tomography
- All of this is applicable to
  - Other gas hydrate systems/studies,
  - Other applications such as geologic carbon storage

Summary

- Cooperative effort, with significant technical and financial contributions from all parties.
- Objective is to conduct an extended duration production test of a promising gas hydrate reservoir
- A multi-year site-selection process led to the Kuparuk 7-11-12 site on the Alaska North Slope
- The 2018 stratigraphic test well confirmed reservoir suitability and provided data to help plan the test
- Drilling is currently under way on the first of three additional planned wells
- Production test is planned to run from spring 2023 to December 2023
- We are excited for the characterization and monitoring data, and the insights to be gained

- Financial support to data acquisition includes the U. S. Department of Energy National Energy Technology Laboratory (NETL), the U. S. Geological Survey Energy Resources Program, and the Ministry of Economy, Trade and Industry (METI) Japan and MH21 - S R&D consortium.