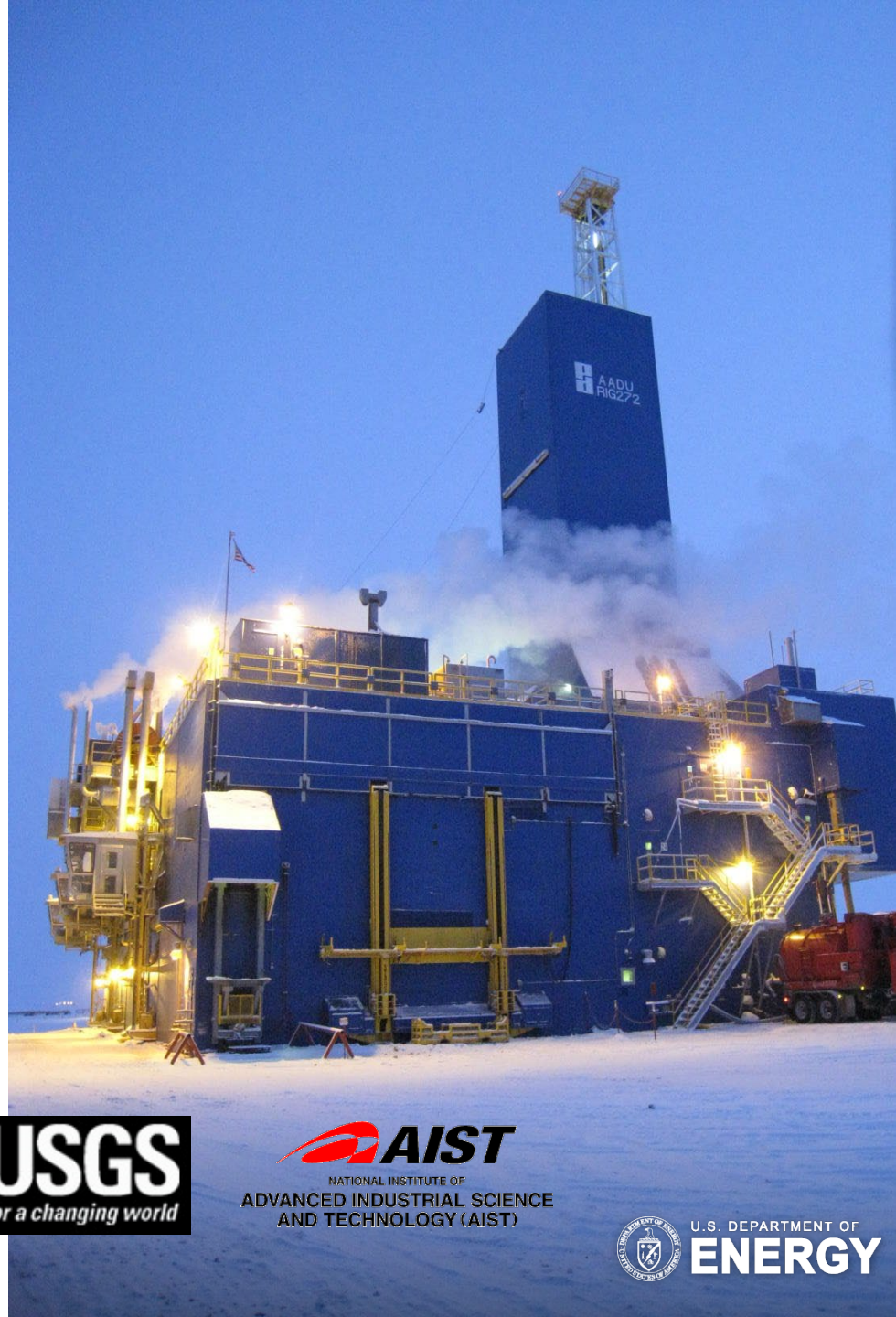
Alaska North Slope Project Status

Ray Boswell,
Nori Okinaka, Tim Collett

And other members of the
ANS project R&D Committee

MHFAC Meeting; Houston TX, April 23, 2019



NATIONAL ENERGY TECHNOLOGY LABORATORY

JOGMEC

USGS science for a changing world

AIST
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

U.S. DEPARTMENT OF ENERGY

Project Structure

NETL ← CRADA (Cooperative Research & Development Agreement) → JOGMEC

CRADA currently defines outline of project scope related with STW drilling and associated tasks, data sharing, publication, IP, etc.

Steering Committee

Authorize implementation plan at each stage gate

Tim Reinhardt (Director of Supply and Delivery, Office of Fossil Energy, DOE)
Koji Yamamoto (Group Leader of Methane Hydrate R&D Group, JOGMEC)
Toshikazu Ebato (Executive Vice President, JOGMEC)
Brian Anderson (Director of NETL)

Site Representatives

Discuss and solve site matters.
Ray Boswell (NETL), Tim Collett (USGS), Scott Marsteller (NETL)
Nori Okinaka, Motoi Wakatsuki (JOGMEC)

R&D Committee

Provide technical advice to develop implementation plan.
Nori Okinaka (JOGMEC)
Ray Boswell (NETL)
Tim Collett (USGS)
Many other per topic

Administrative Coordinators

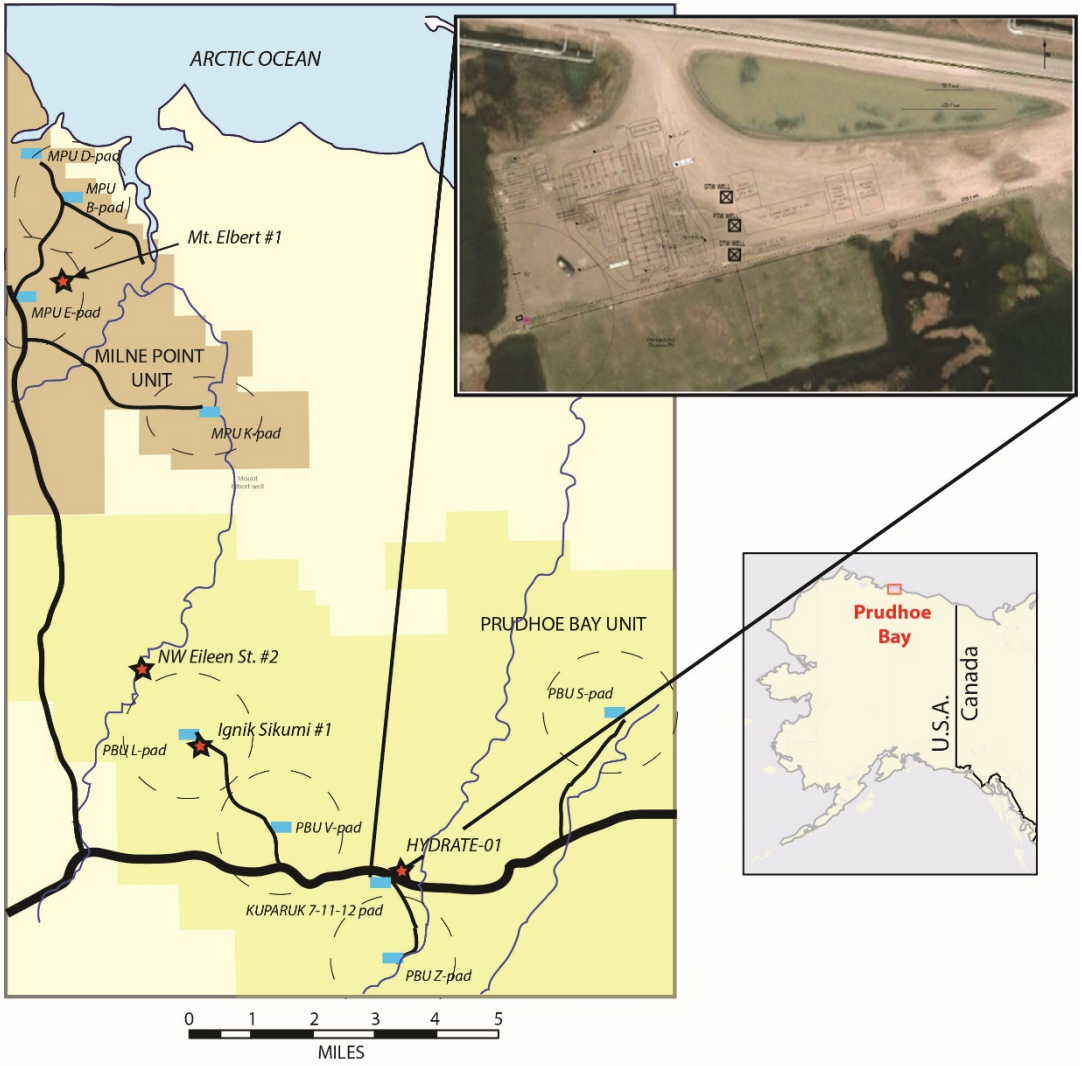
Provide advice regarding contract execution and budget expenditure.
Nori Okinaka (JOGMEC)
Don Hafer (NETL)

Decision Making Mechanism

PBU Hydrate-01

Western PBU

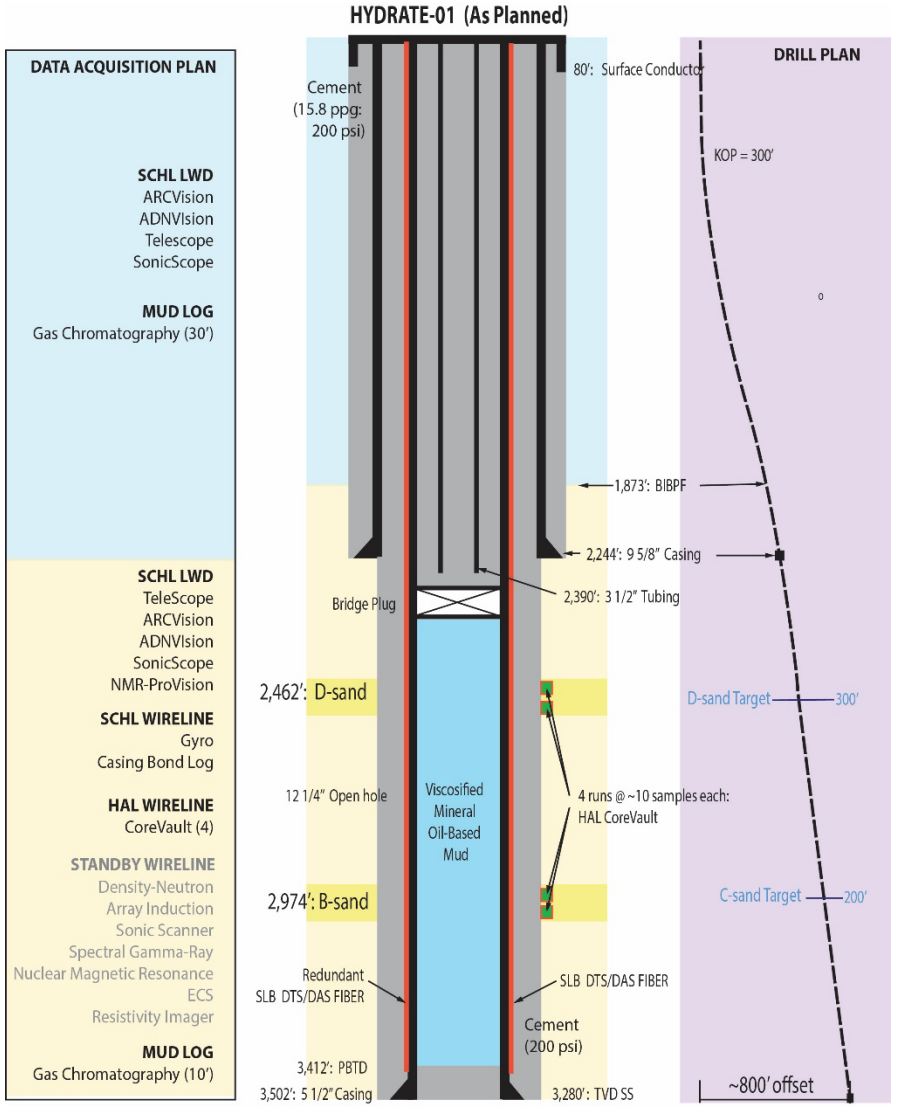
- Site selected by project team: good potential in two sands (well log & seismic) accessible from an unused gravel pad on year-round road.
- Geologic risk remained, in particular with deeper sand
- BP gained partner alignment to operate STW as part of warm up the Parker 272 rig for the impending PBU 2019 drilling season



PBU Hydrate-01

Well design

- Deviated to east to isolate from earlier wells and to access most prospective location in the structure.
- Program was designed to acquire those data <u>needed</u> to confirm the site.
  - Full logging suite to confirm reservoir occurrence and characteristic
  - Side wall pressure cores to provide data to support planning of test well completion
  - Installed FO cables to allow STW to serve as a monitoring well for future operations.



Easily Correlated Short Step-out

Outstanding data quality through target section

Unit D

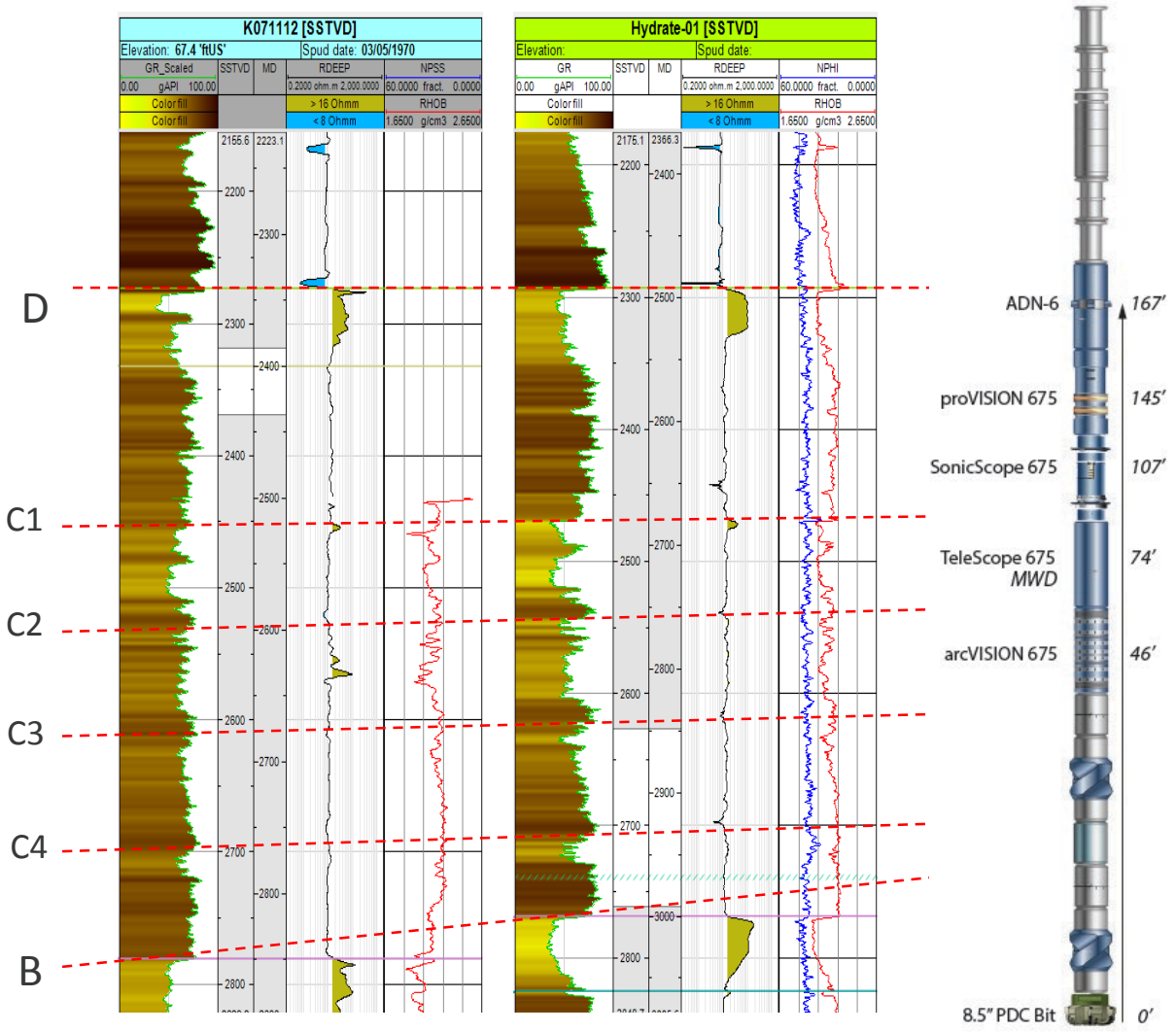
- In better condition (no intervening shale break; cleaner top)

Unit C

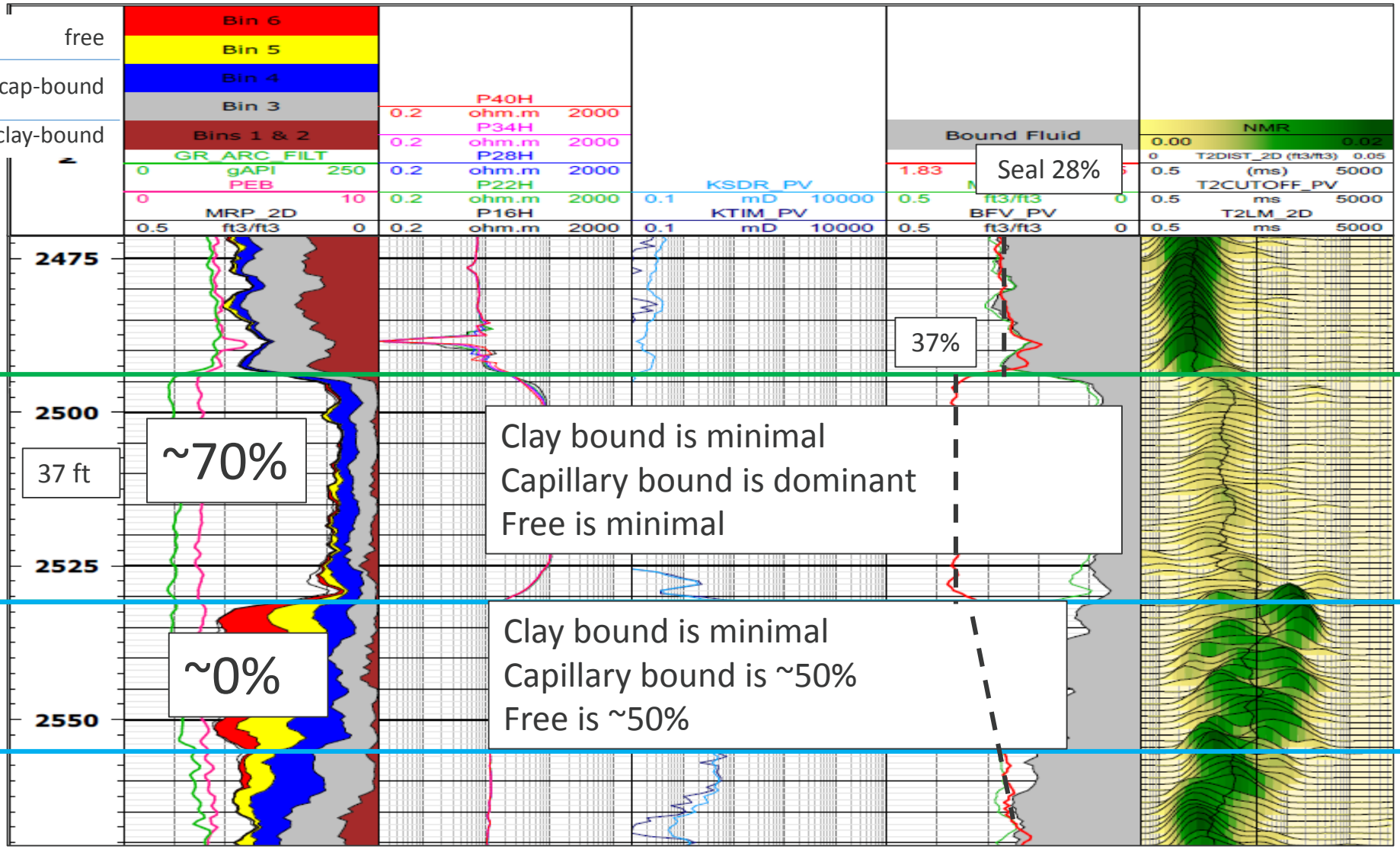
- Virtually identical.

Unit B

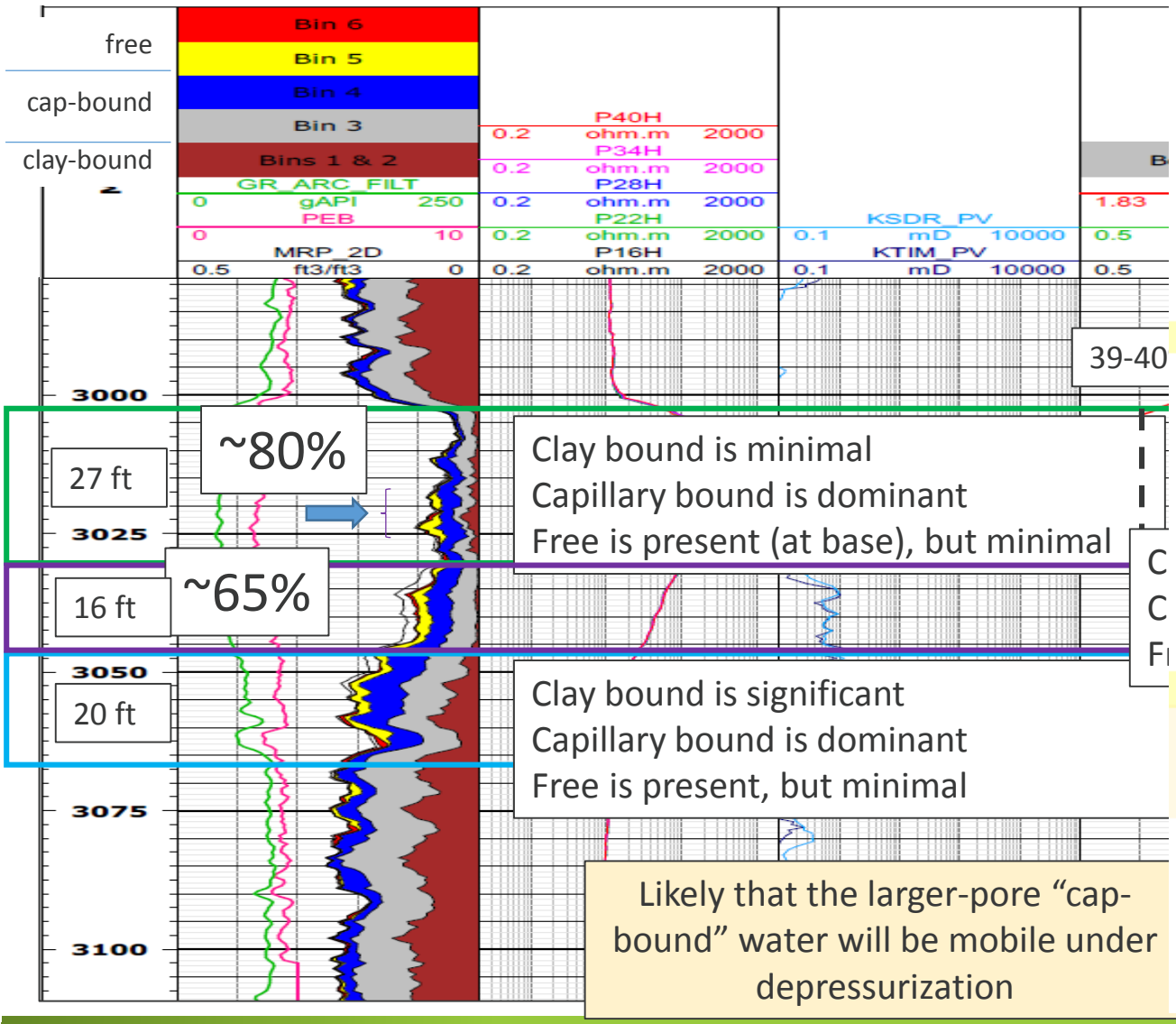
- In better condition (lower GR); more uniform RES and DEN); clear GH indicators (SON)

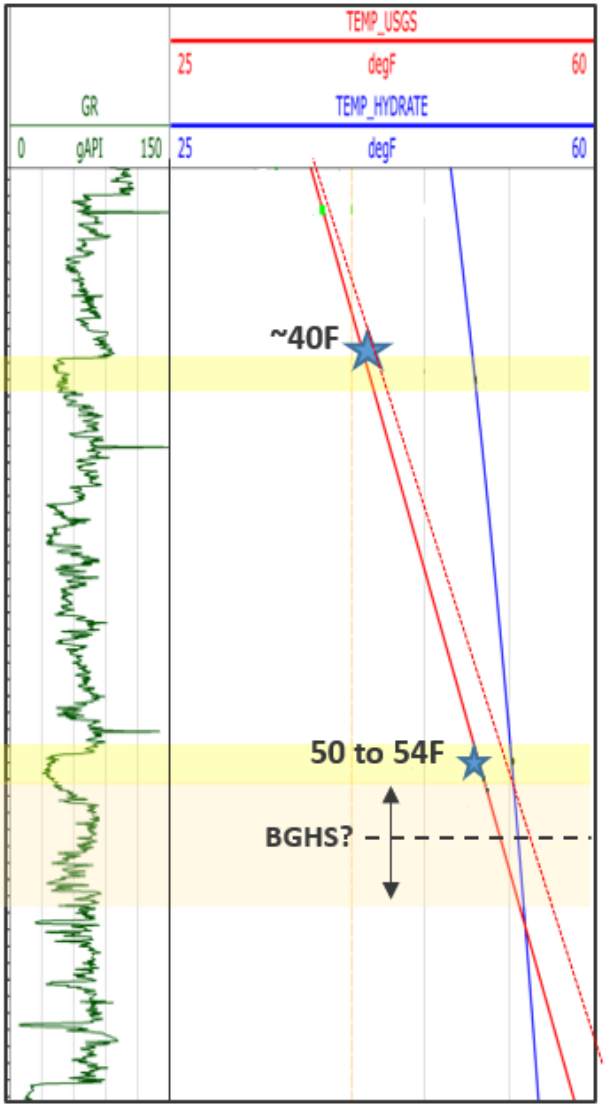


Log Data: Unit D



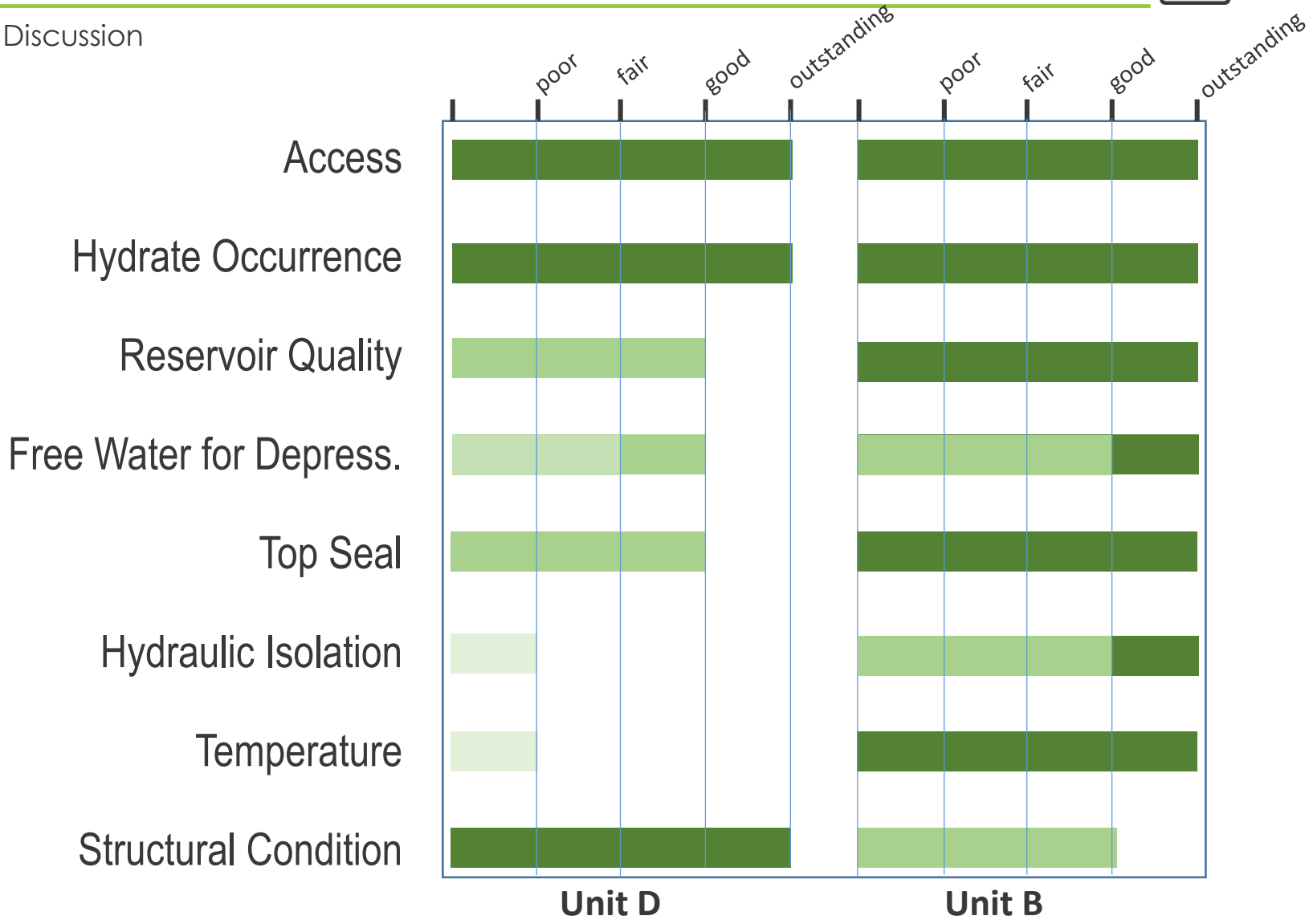
Log Data: Unit B





Summary: Suitability for Testing

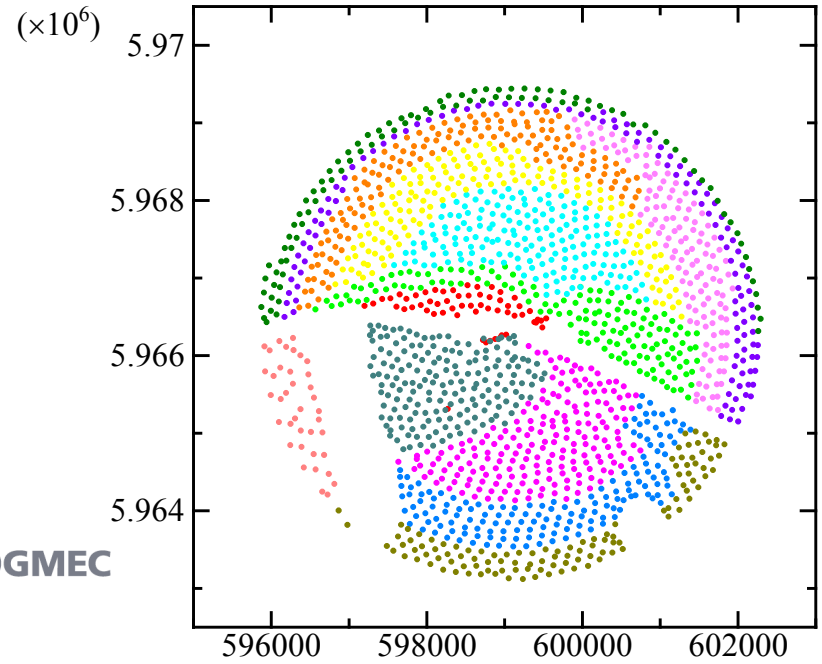
For Discussion



DAS-3DVSP

March 3-15, 2019: Largest Known DAS-VSP acquisition

- Utilizing FO DAS cables installed in STW
- Goal is to confirm local structural and stratigraphic heterogeneity and phase distribution to refine placement of GDW and PTW
- Provide baseline for potential future 3DVSPs during and/or after testing
- Despite weather challenges - acquired 1,701 of 1,740 (98%) planned shot points
- ALSO: Baseline surveys for elevation (subsidence) ongoing (Oct, Nov, Apr)



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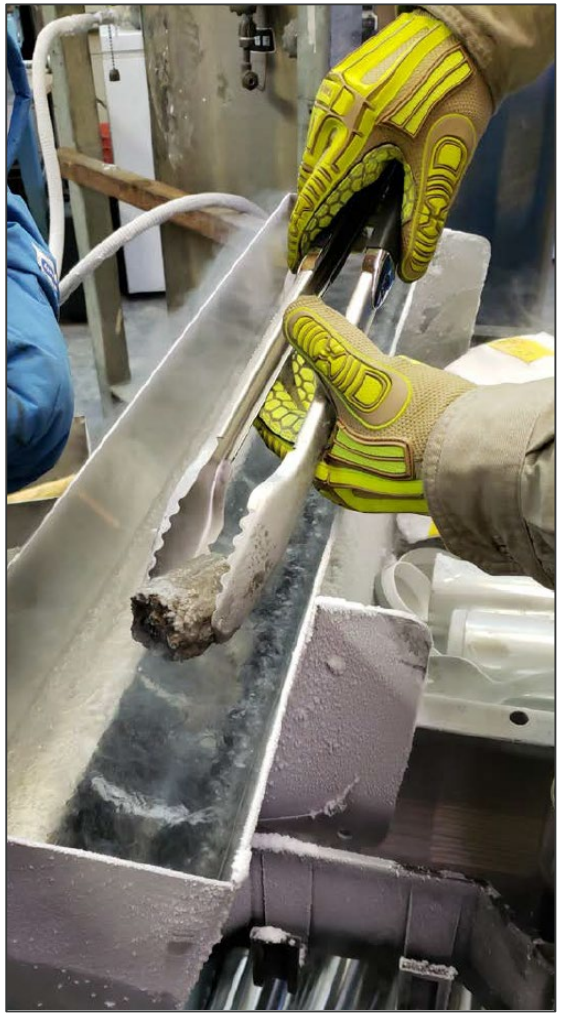
Review of STW Successes

All Science Objectives Achieved

- Safe operations!
- Communication between teams at the wellsite and in Anchorage
- Directional drilling: targets hit
- Main hole: Hole quality/mud temperature control
- Outstanding LWD data quality
- Pressure sidewall samples acquired in both reservoirs
- Dual fiber-optic cables installed and tested fully-functional



Review of STW Issues

Lessons-learned reviews ongoing

Move-in/Rig Up

- Well spud delayed by various issues.

Surface Hole LWD

- Minor delays consistent with any rig warm up

Run Surface Casing

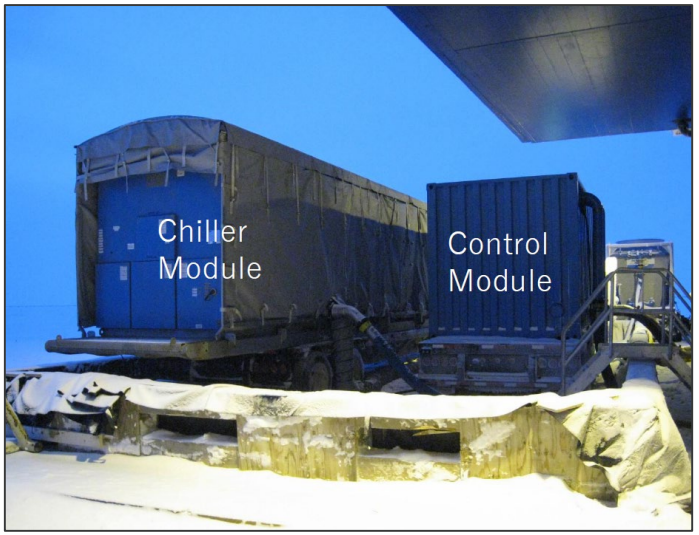
- Complications in getting casing to bottom and in setting surface cement. Fully resolved.

Main Hole LWD

- Additional time required to troubleshoot Mud temperature control systems.

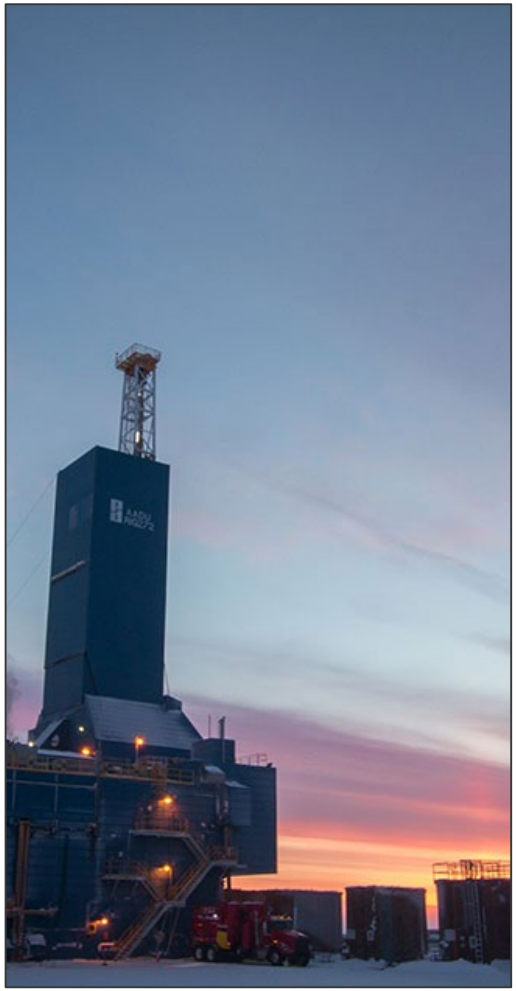
Completion and Move-out

- Various minor delays in final casing tests.



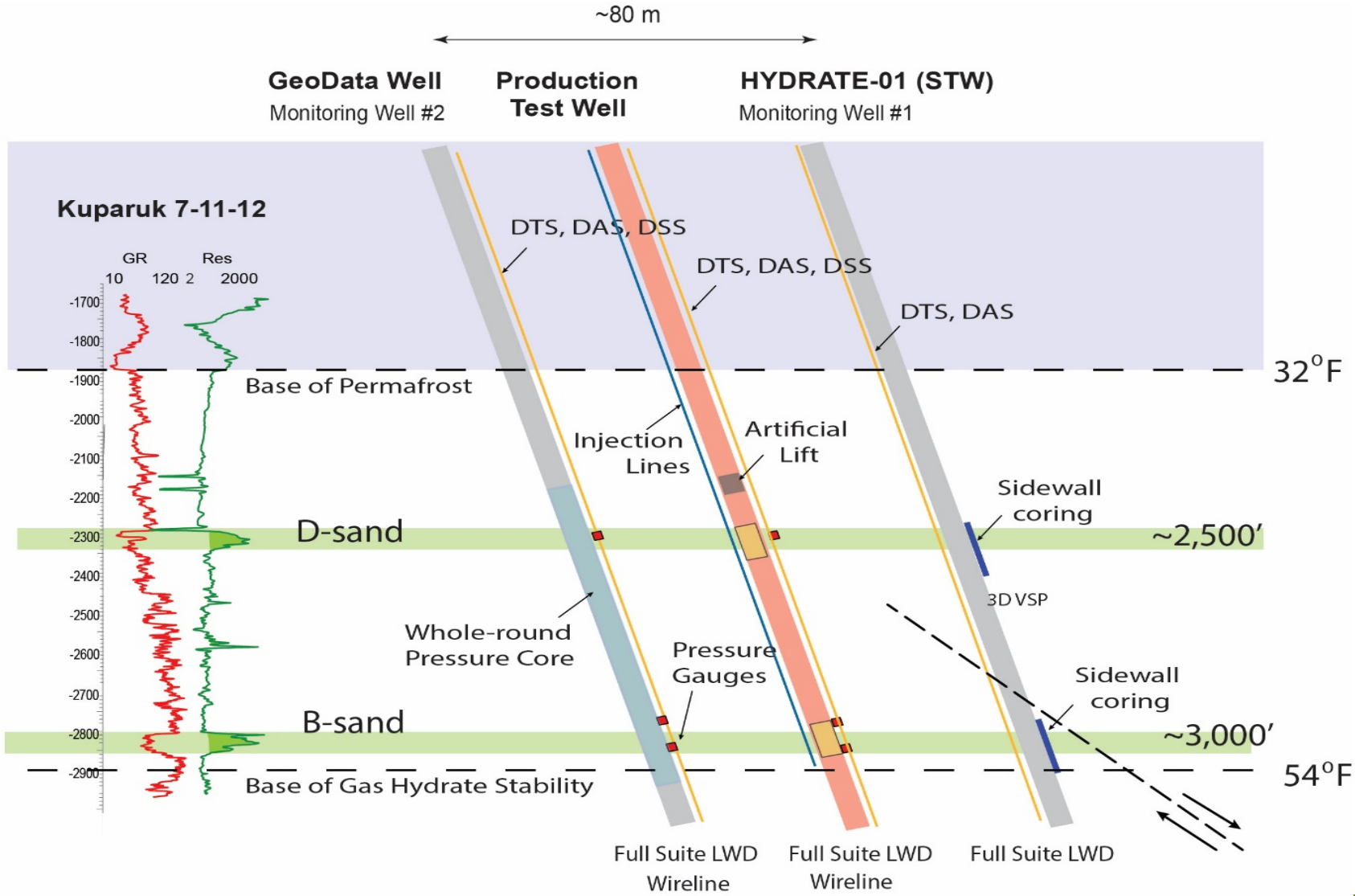
Project Status

Status as of April, 2019



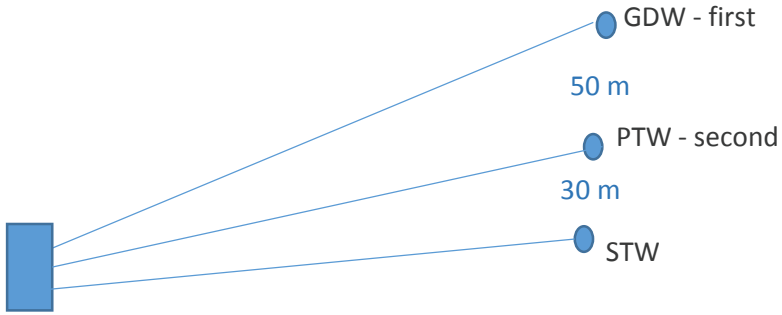
- Initial Stratigraphic Test drilled in partnership with PRA (via Drilling Services Agreement with BP) has confirmed site feasibility from a geologic standpoint
- PBU WIOs have indicated good faith effort to work with SOA to enable a Third Party to conduct further field phases. Operator will not be a PBU WIO.
- Test design must be "standalone"; designed to operate independently with no support from the PBU Operator or facilities.
- An RFI was released with intent to determine if such third parties exist.
- Project Steering Committee to meet shortly to authorize continuation into next phases.

Overview of ANS Testing Plan: Wells



GDW and PTW: Drilling Design

Feb 2019 RDC Decisions and Recommendations



Drilling Order

- Drill the GDW with B ~80 m north of the STW
- Drill PTW to BHL between the GDW and STW.
- Use the STW/GDW data to finalize PTW plan
- Well locations/drilling order contingent pending any insight 1) on directional tolerances and assured anti-collision for drilling the PTW and 2) from additional seismic evaluation using PBU 3D data and/or project-generated DAS-VSP data.
- Allow 3 months prior to start of PTW operations (to ensure temperature equilibration in both wells).

Site Characterization

- Develop collaborative plan for DAS-VSP data evaluation and integration.
- Focus evaluation on delineation of faults, lateral stratigraphic heterogeneity, and lateral pore-fill heterogeneity.

GDW and PTW: Drilling

Feb 2019 RDC Decisions and Recommendations

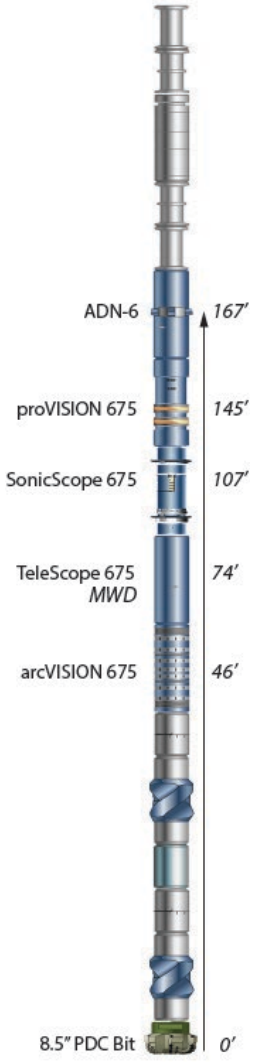
Items for inclusion in next field operations

- Complete study of drilling mud/shale interactions
- Comprehensive pre-drill mud and drill system temperature modeling
- Improved real-time mud temperature monitoring
- Review mud chilling approach.
- Address lessons learned on surface casing cementing
- Ensure adequate contingency supplies and varieties of cement
- Consider Gyro-while-Drilling.

Items for study by the project owners

- Resolve requirements for long-lead items (cables, clamps, etc.).
- Examine cement bond using data from FO cables
- Constrain STW BHL (difference between LWD and WLL gyro surveys).

GDW and PTW: Data Acquisition



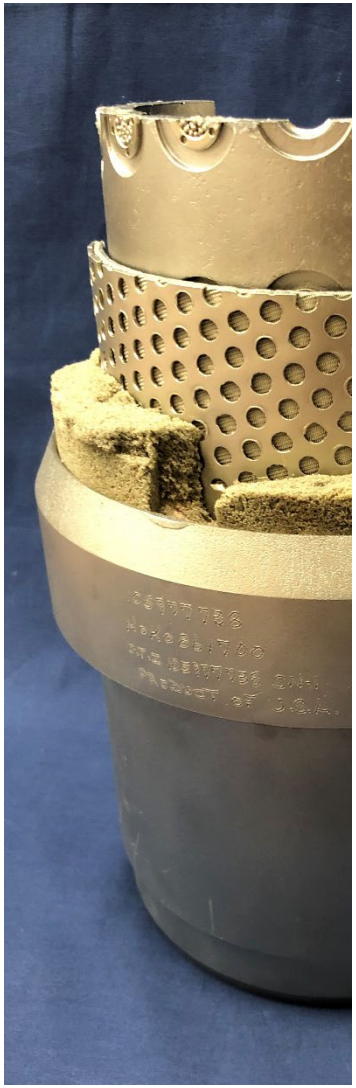
Items for inclusion in next field operations

- **GDW LWD (to coring point):** TeleScope; arcVISION; adnVISION; SonicScope; PowerDrive.
- **Utilize HPTC in GDW.** Stage PCATS on location. 250' of cores in B and D, their seals. No conventional coring.
- **GDW WLL:** Not contingent. PEX; RtScanner; SonicScanner; CMR/MRScanner; HNGS; QuantaGeo; ECS
- **GDW:** Left in accessible state for production logging: Gyro; IsolationScanner; RST
- **PTW Surface LWD:** Simplify to PowerDrive; MWD; GR (maximize hole quality - assuming data success in the GDW)
- **PTW Main LWD:** As GDW, with WLL (as GDW) contingent on data quality.
- **Install DTS/DAS/DSS in both wells**, with pressure-gauges behind casing, and high-res temperature sensors.
- **GDW-PTW Mud-logging** as STW with addition of isotubes.

Items for study by the project owners

- **Advanced NMR/CMR analyses** (basis for T2 assignments (lab/modeling) to free and bound in B and D sands).
- **Detailed review of SonicScope data** for saturation calculation, geomechanics, others…
- **Conduct advanced analyses of resistivity data** for saturation and density data for porosities
- **Review technical feasibility of cross-hole tomography from GDW**
- **Develop p-core distribution plan** including AIST, NETL, and USGS laboratories (eval. UT/GT labs for capabilities).
- **Evaluate options for MDT-XPT in GDW** (currently not in the base plan).
- **Develop site layout** to confirm feasibility (particular wrt pressure-coring systems).

PTW: Test Design



For inclusion in the next field operation

- Implement staged depressurization approach (>GHS, <GHS, -2.0 mPa steps to op limit).
- Evaluate deviations from desired reservoir response and implement intervention protocols

Items for study by the project owners

- Develop simulation input models using STW data.
- Optimized sand control
- Optimized hydraulic isolation
- Optimized artificial lift
- A well completion design that allows rigless move from B sand to D sand as feasible
- A well completion design with pre-set systems for wellbore remediation/reservoir stimulation
- Optimized planned/emergency shut-in/restart procedures
- Assess ability to control mobile water through partial zone completion (Unit D).
- Finalize plan and frequency for time-series VSP.

GeoForm Image Courtesy BHGE. This was used for Japan's 2nd offshore production test in 2017

Surface Facilities Design

Items for inclusion in next field operations

1. Lease of skid mounted equipment, etc. based on provided information by project owners
2. Ensure accurate measurement of liquid, gas, solids volumes particularly at low rates.
3. Standard on-site systems for real-time gas, water, solids chemistry.
4. On-site gas disposal; solid disposal at PBU G&I; Liquid disposal via trucking to PBU injectors.
5. Coordination of simultaneous operations with BP and future development plans in Prudhoe Bay.

Items for study by the project owners

1. Basis, requirements, specifications of facilities as developed through the modeling and engineering effort…currently max. rates as 1.4 MMscf/d and 3,000 bbl/d max.
2. Resolve flaring and air-permit issues
3. Integrate ongoing surface subsidence monitoring program with the GDW and PTW subsidence monitoring program.

PTW & SF: Intervention Plan

Ongoing

Flow Assurance: Shut-in & remediate

Gas Rate (low, declining, erratic, persistently flat)

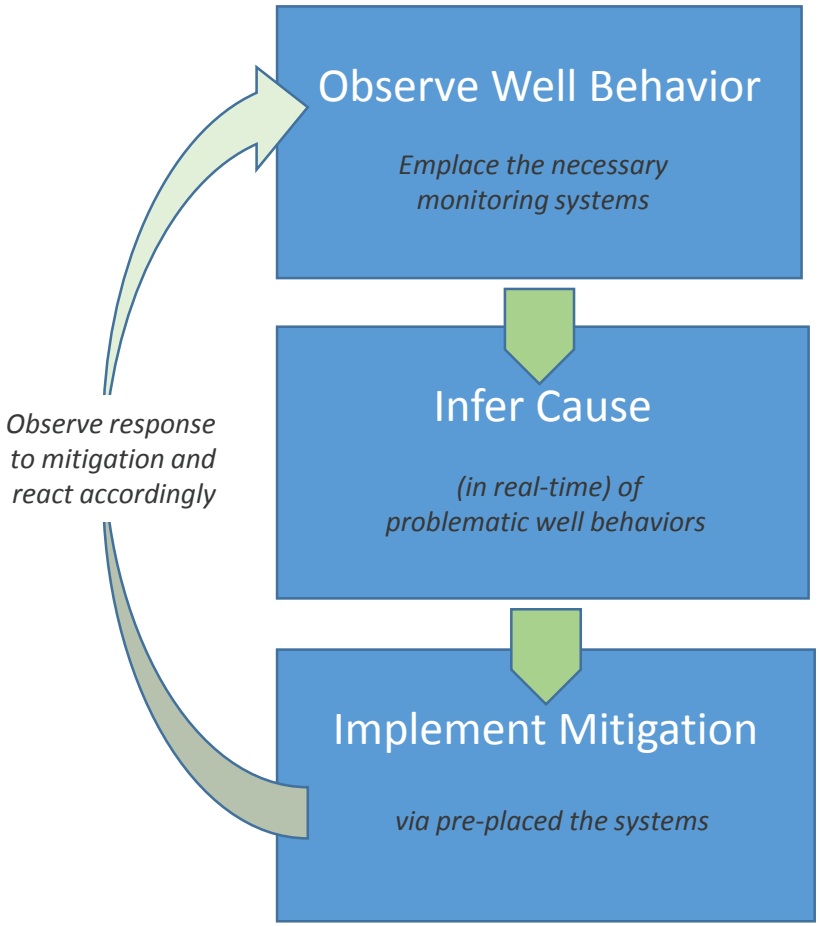
- Hydrate formation → P drop and monitor
- Ice formation→ P drop and monitor: hot methanol
- Sand/fines blockage → P cycling: acid?: re-perf
- Gas-Water block→ P cycling
- Reservoir Limitation → stimulation… TBD
- Equipment failure → shut in and repair

Excessive Sand

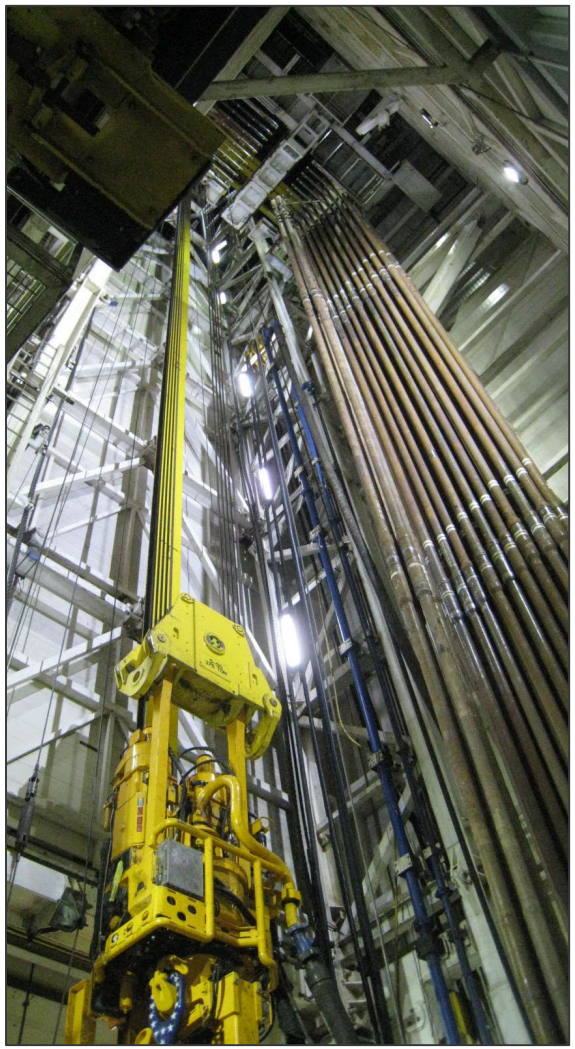
- Systems failure → patience, move to D

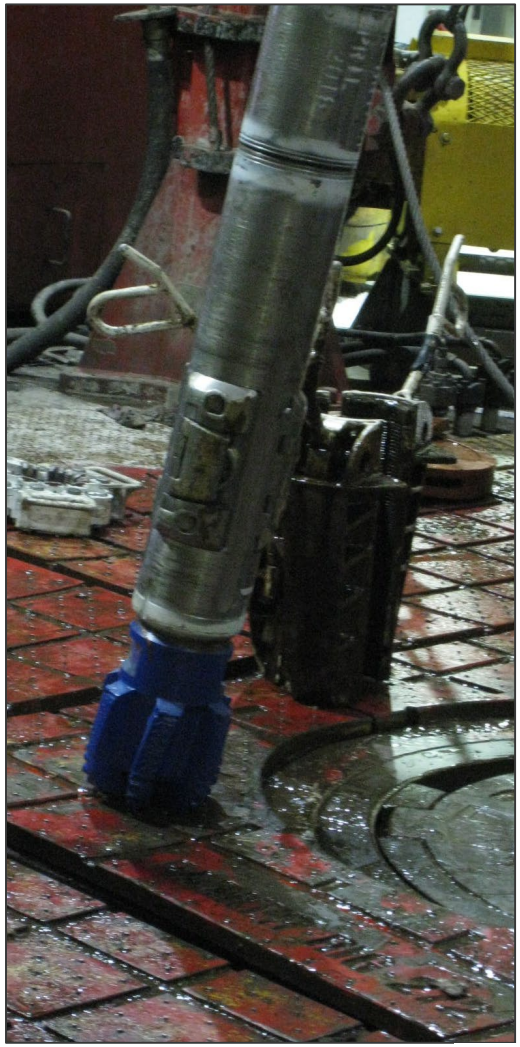
Excessive Water (ensure adequate onsite storage)

- Reservoir → P drop; P cycling, move to D



THANK YOU





RDC ATTENDEES
(alphabetical)

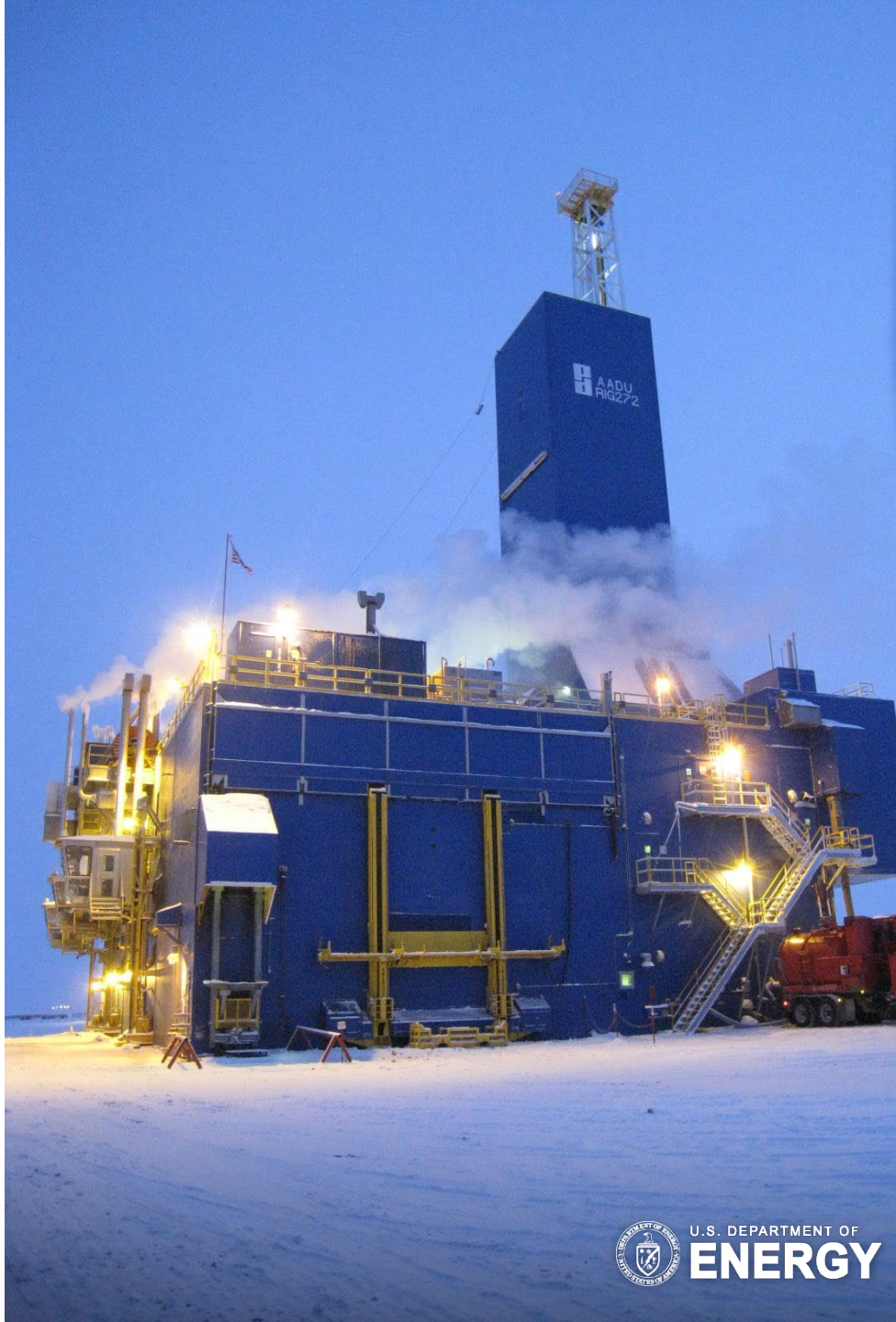
Boswell, Ray (DOE-NETL)
Collett, Tim (USGS)
Haines, Seth (USGS)
Hasegawa, Toshikazyu (TOYO)
Imasato, Yutaka (TOYO)
Intihar, Gabby (DOE-HQ)
Kawaguchi, Kyojiro (TOYO)
Kumagai, Kenichi (JOGMEC)
Lewis, Krissy (USGS)
Lei, Liang (DOE-NETL)
Lim, Teck Kean (TOYO)
McGuire, Tom (DOE-NETL)
Myshakin, Eugene (DOE-NETL)
Okinaka, Nori (JOGMEC)
Otsuki, Satoshi (JOGMEC)
Reinhardt, Tim (DOE-HQ)
Sato, Daichi (JOGMEC)
Seol, Yongkoo (DOE-NETL)
Suzuki, Kiyofumi (JOGMEC)
Wakatsuki, Motoi (JOGMEC)
Yamamoto, Koji (JOGMEC)
Yoneda, Jun (AIST)
Zyrianova, Marguerite (USGS)

Gulf of Mexico Project Status

Ray Boswell,
Peter Flemings, Rick Baker

And other contributors to the
UT-Austin GOM2-2 Drilling Project

MHFAC Meeting; Houston TX, April 23, 2019

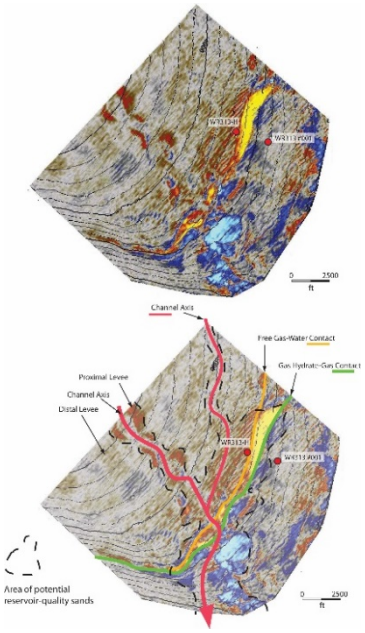


NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY

GOM GH R&D Overview

- Continuation of efforts initiated with the GOM JIP in 2001 to characterize all aspects of GOM gas hydrate systems.
- Extensive interagency collaboration
- International collaboration (particularly with respect to core-device development)
- Field Programs in 2005 and 2009 confirmed GH occurrence and collected extensive well log data
- Project developed with UT Austin in 2014 to continue the effort including the acquisition of pressure core samples
- Successful test of coring tools and evaluation of GC955 site in 2017
- Proposed scientific drilling (60-day expedition) under the auspices of IODP have proven not feasible in the Gulf of Mexico.
- Current effort is to develop a plan to maximize scientific insight from an ~30 day expedition

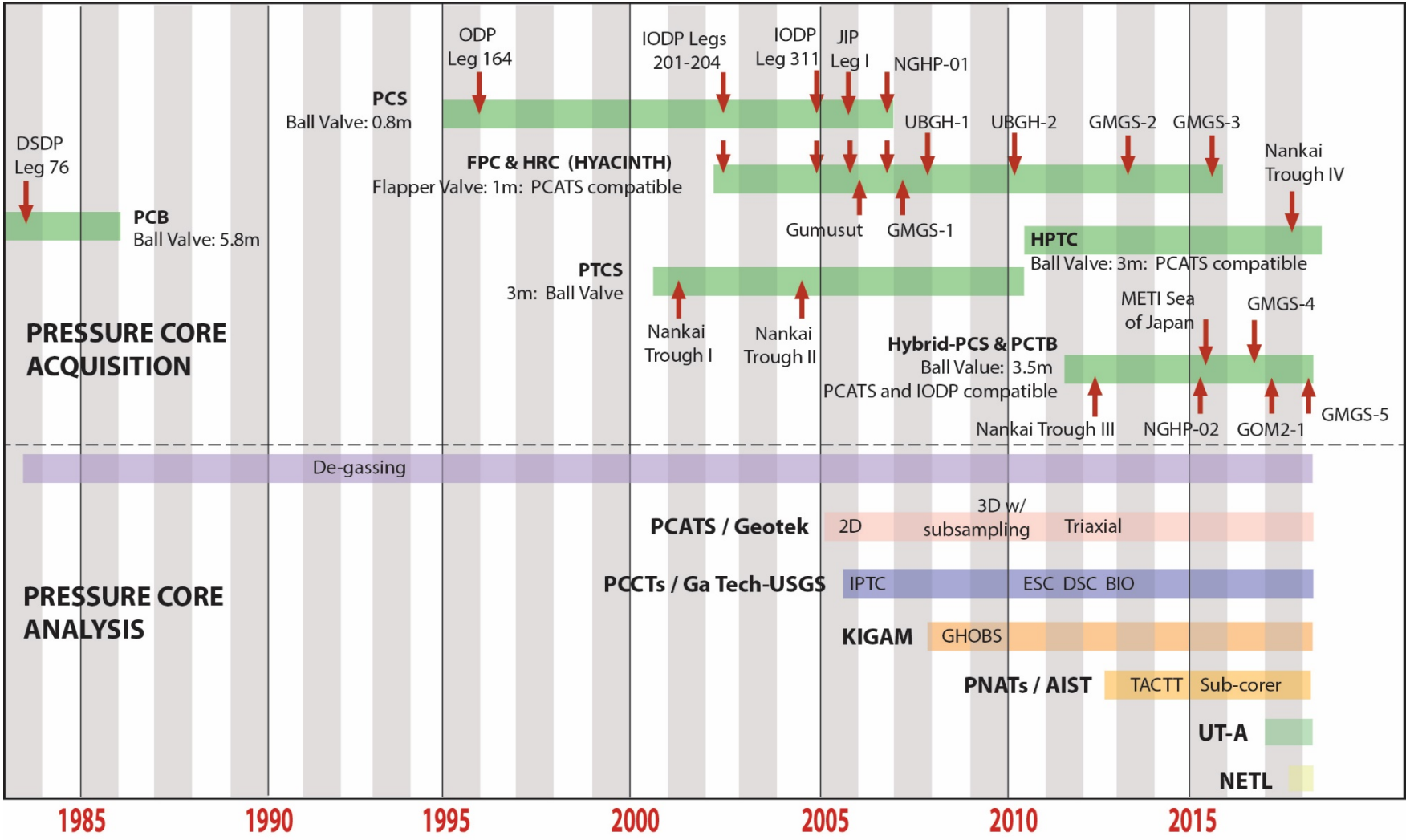


Exp-1: Post-Expedition Science Team

19 organizations: 42 scientists: 29 students

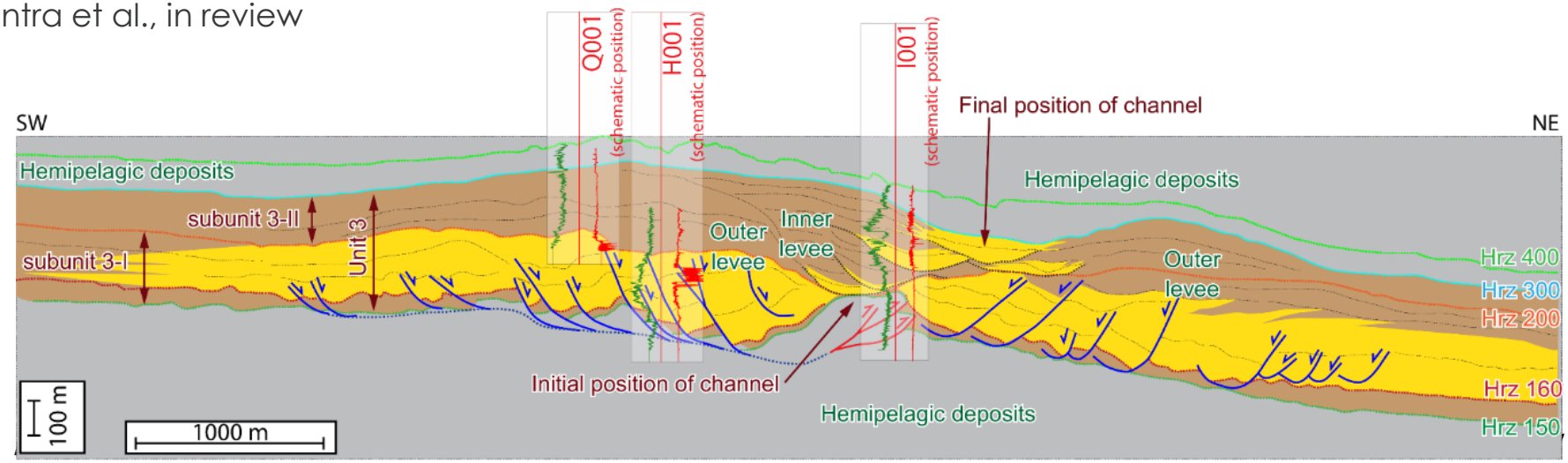
- **U. Texas-Austin** (Flemings, Phillips, Polito, Santra, Meazell, Petrou, Myer, Murphy, Lin, Daigle, DiCarlo, Espinoza, You, Dong, others)
- **Geotek** (Schultheiss, Holland, Roberts, Mimitz, Bakken, Bigalke, Curry, Huggett, Riley, Selman, Suhonen, Virtue)
- **NETL** (Boswell, Seol, Gulliver, Choi, Jarvis, Myshakin, Ajayi, Lei)
- **U. S. Geological Survey** (Collett, Waite, Jang, Pohlman)
- **Pettigrew Engineering** (Pettigrew)
- **Ohio State** (Cook, Portnov, Darrah, Sawyer)
- **Georgia Tech** (Dai, Glass, Kostka)
- **Columbia U.** (Guerin, Malinverno, Goldberg)
- **BOEM** (Frye, Shedd, Palmes)
- **U. Washington** (Solomon)
- **U. New Hampshire** (Divins, Johnson)
- **ExxonMobil** (Summers, Walters, Higgins+)
- **Cal Tech** (Eiler)
- **Oregon State** (Colwell)
- **Arizona State** (Jang)
- **Tufts U.** (Germaine)
- **U Pittsburgh:** (Lin)
- **Rensellear Polytech:** (Uchida)
- **U. Salamanca (Spain):** (Abel-Flores)

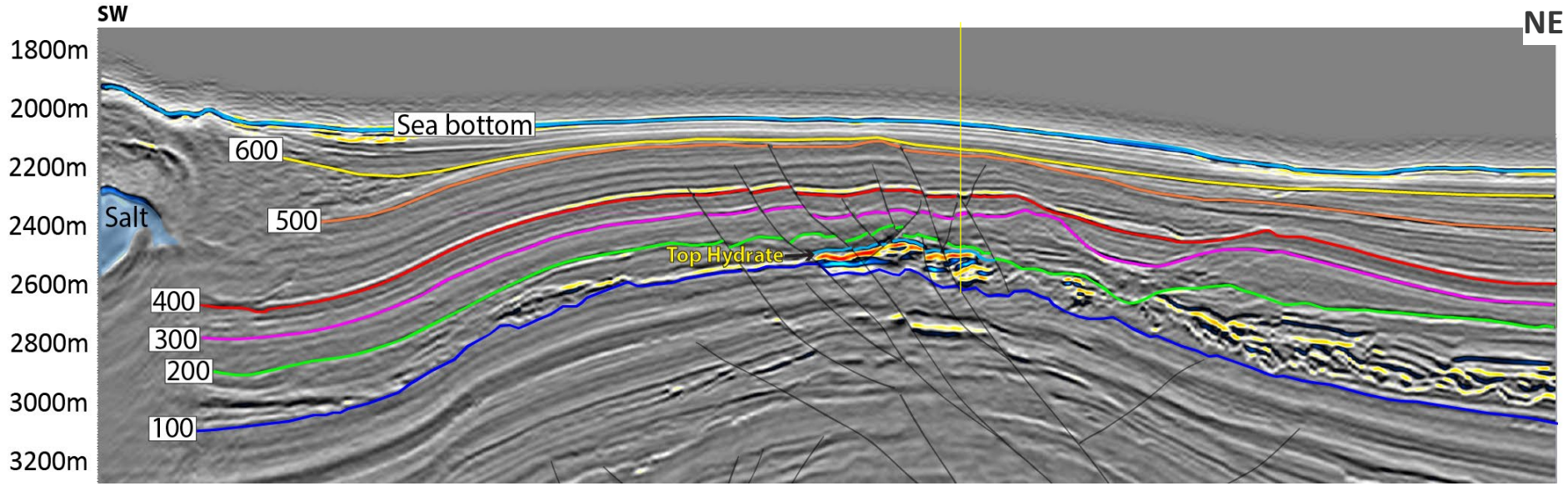
Pressure-Core Technology



Initial Results: Geologic Framework

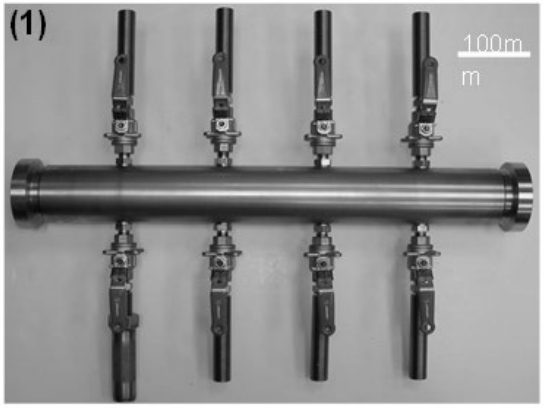
Santra et al., in review

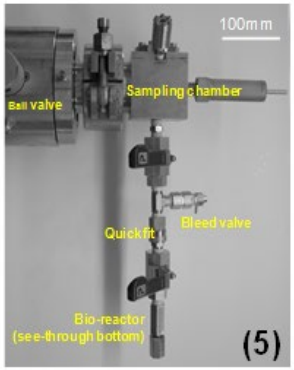


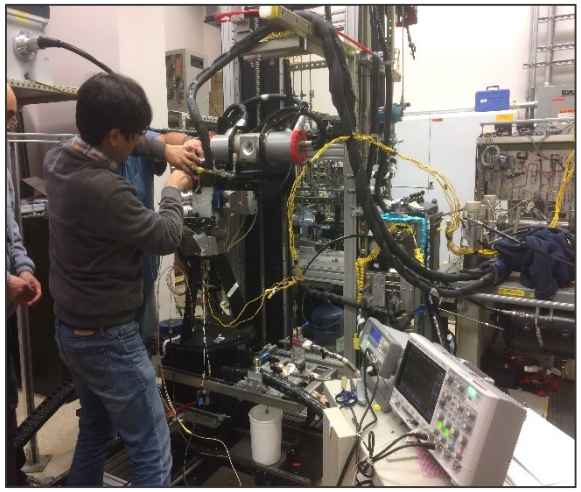


Post Expedition - 1 Core Characterization

Pressure **C**ore **C**haracterization **T**ool**s**; UT-Austin: USGS: NETL Laboratories



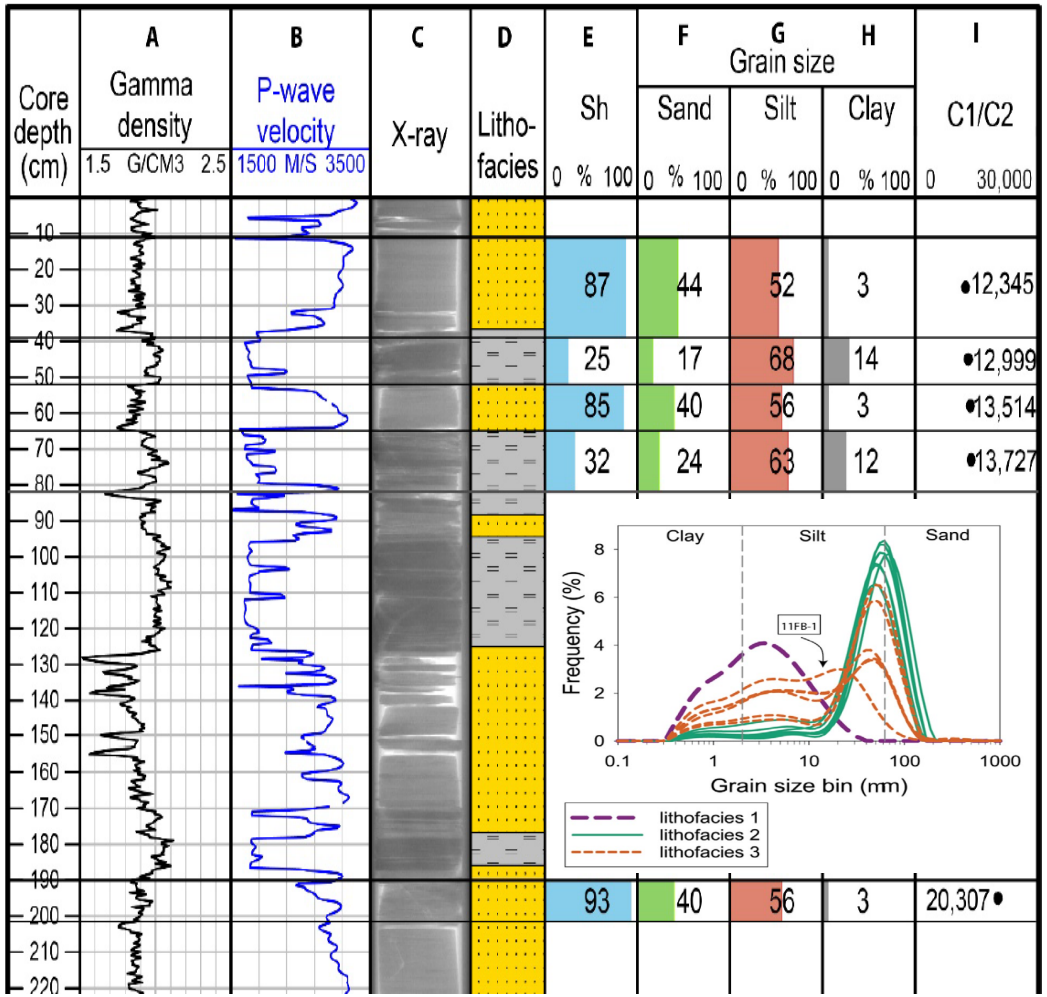


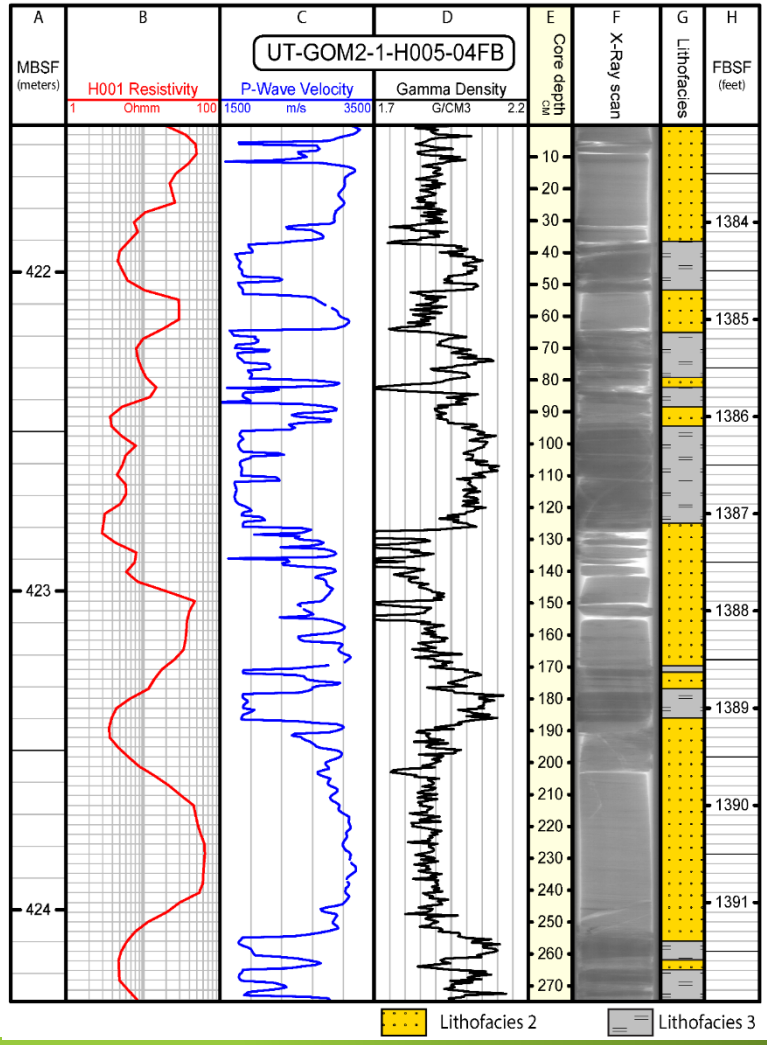


Dai et al., ICGH 2017

Initial Results: Gas Hydrate Systems

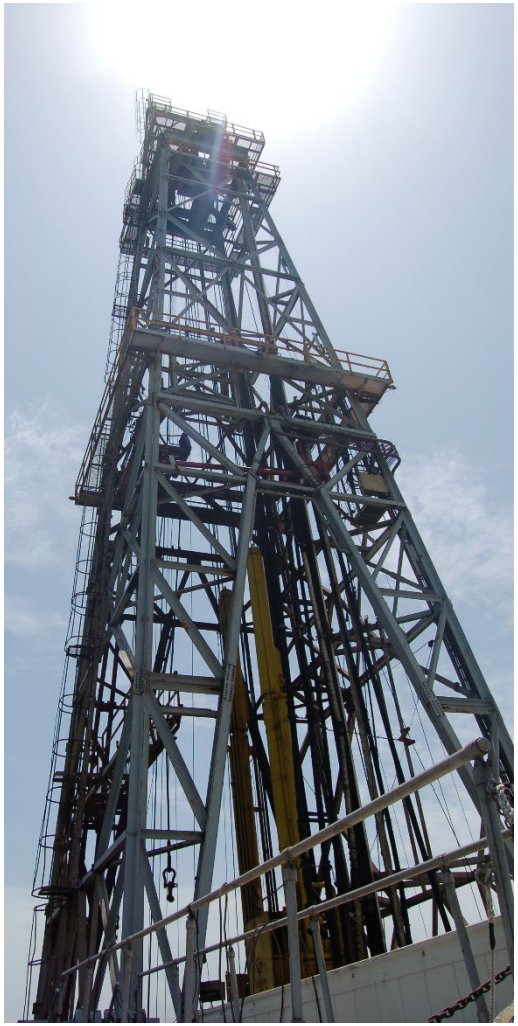
Portnov et al., (2019); Flemings et al., Phillips et al., Meazell, et al., Thomas et al. (in review)





Project Status

Continuing Planning for Expedition GOM2-2 from a UT-A contracted vessel

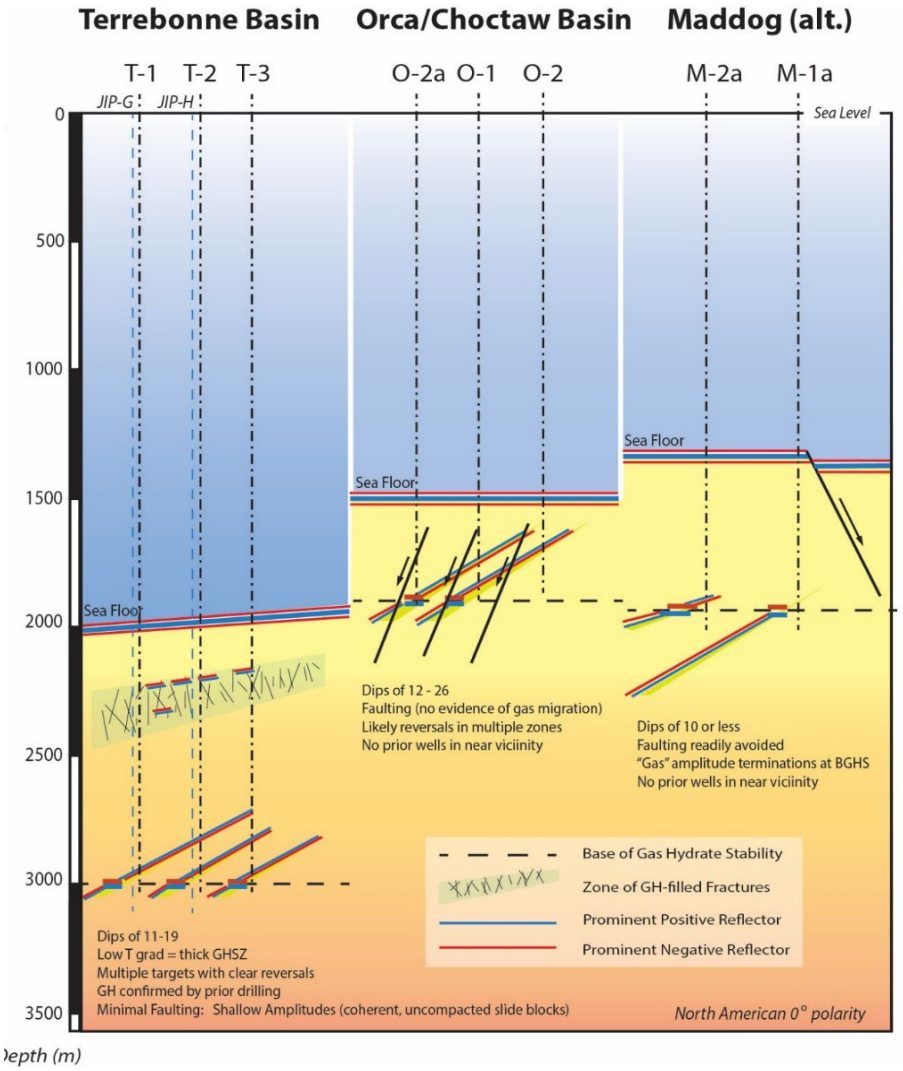


- IODP drillship *Joides Resolution* is unable to operate in the Gulf of Mexico as currently designed
- Necessary alterations to the JR deemed not feasible.
- An effort to approach IODP's "mission specific platform" organization (ECORD) was not successful.
- Substantial loss of cost savings on vessels and (potentially) on basic supporting science.
- Another round of science discussions within the GOM2-2 team and advisors to arrive at revised plan to optimize science

Impact on GOM2-2 Plans

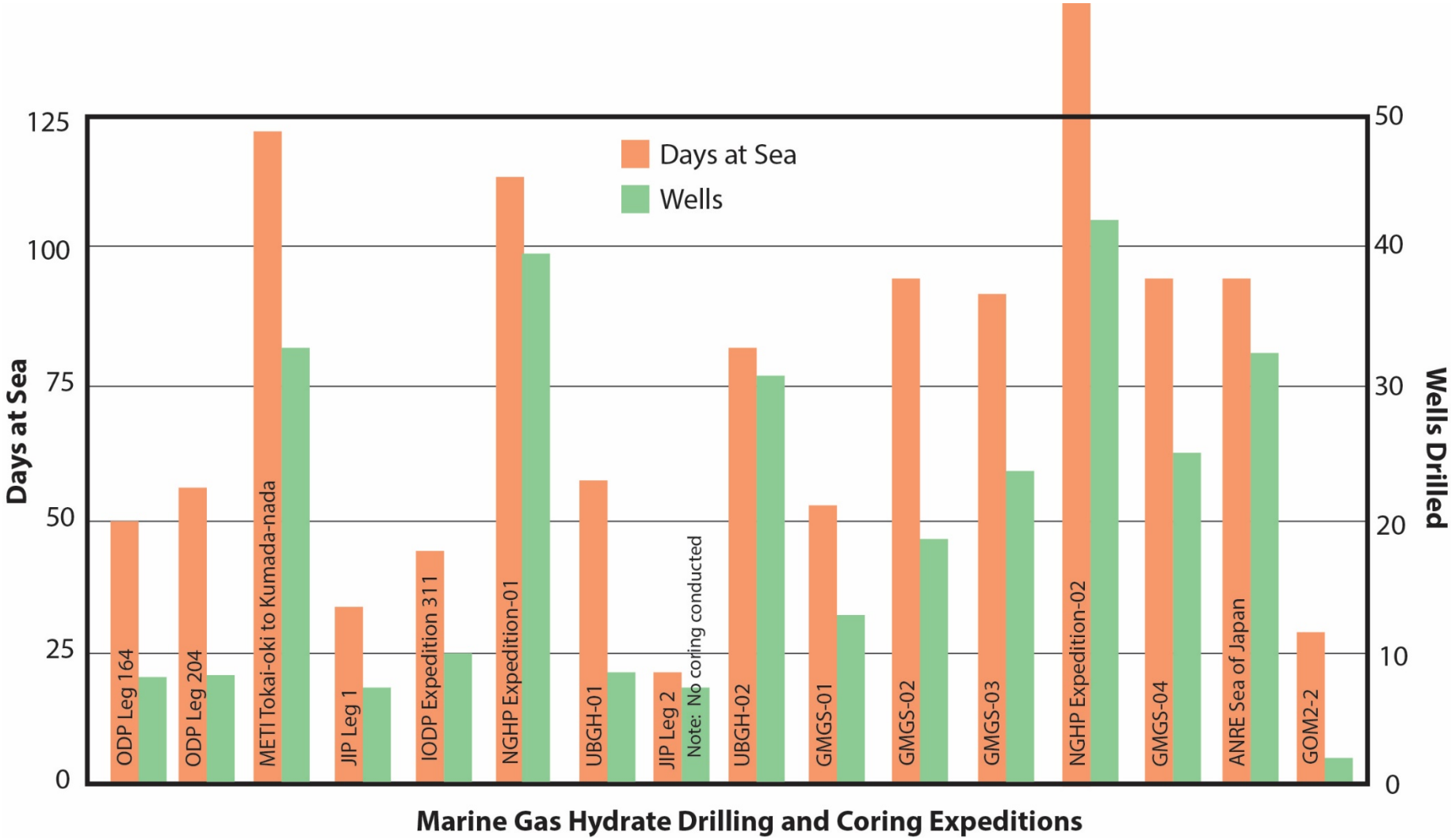
Continued refinement as costs and budgets evolve

- Emergent GOM regulatory issues = time sacrifices
- Cost issues = time sacrifices
- Time is a major operational risk mitigator
- In order to manage risk, science must be further constrained
- Continued focus on distributed pressure coring (w/ sp. focus on reservoirs)
- Desire to support reservoir-focus (petrophysical) evaluation and systems-focus (geochemical, microbiological, etc.)
- Desire to include exploratory drilling (Orca mini-basin or perhaps step-outs within the Terrebonne basin).



Marine Gas Hydrate Science Expeditions

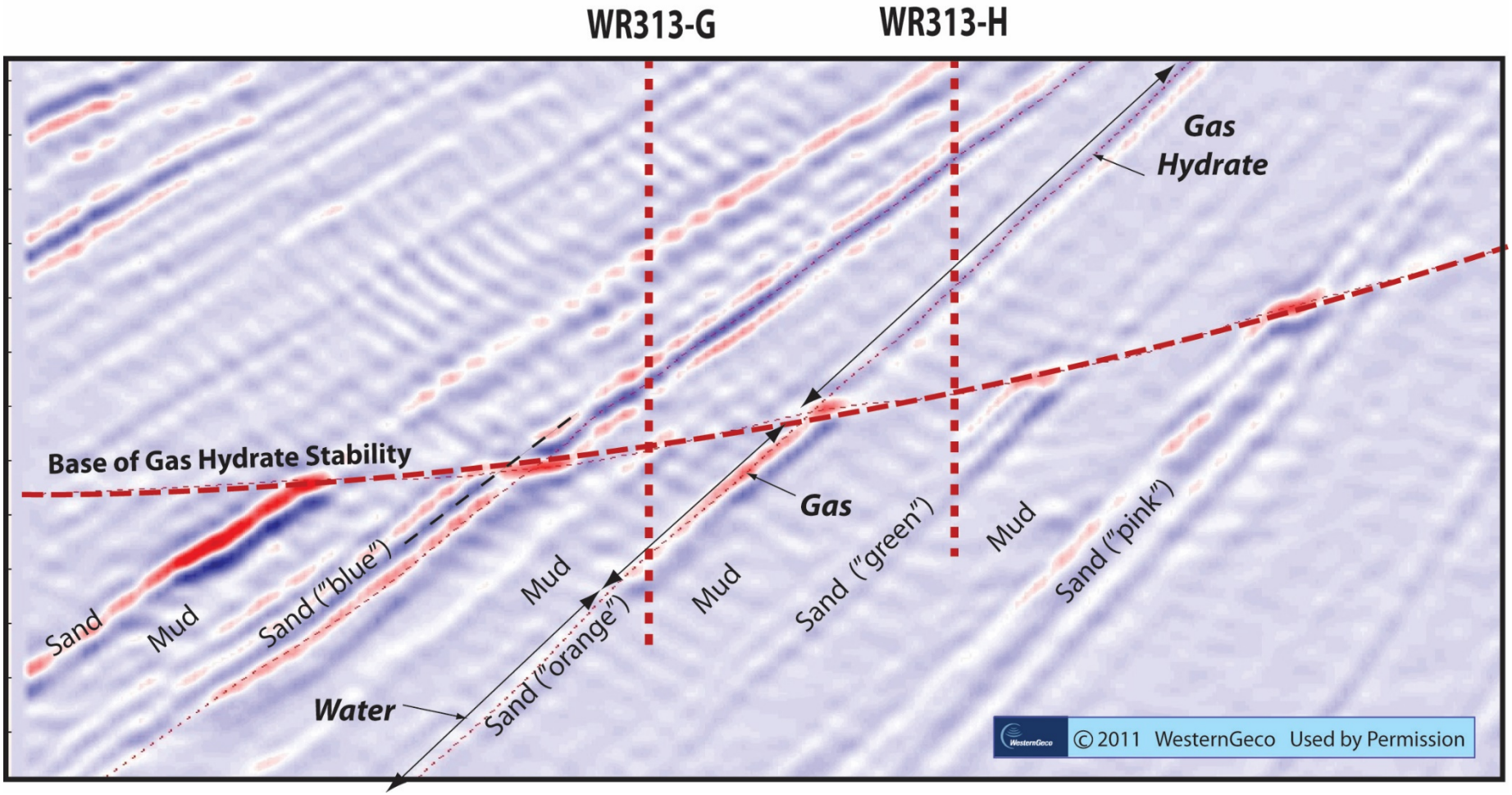
Typical Scale



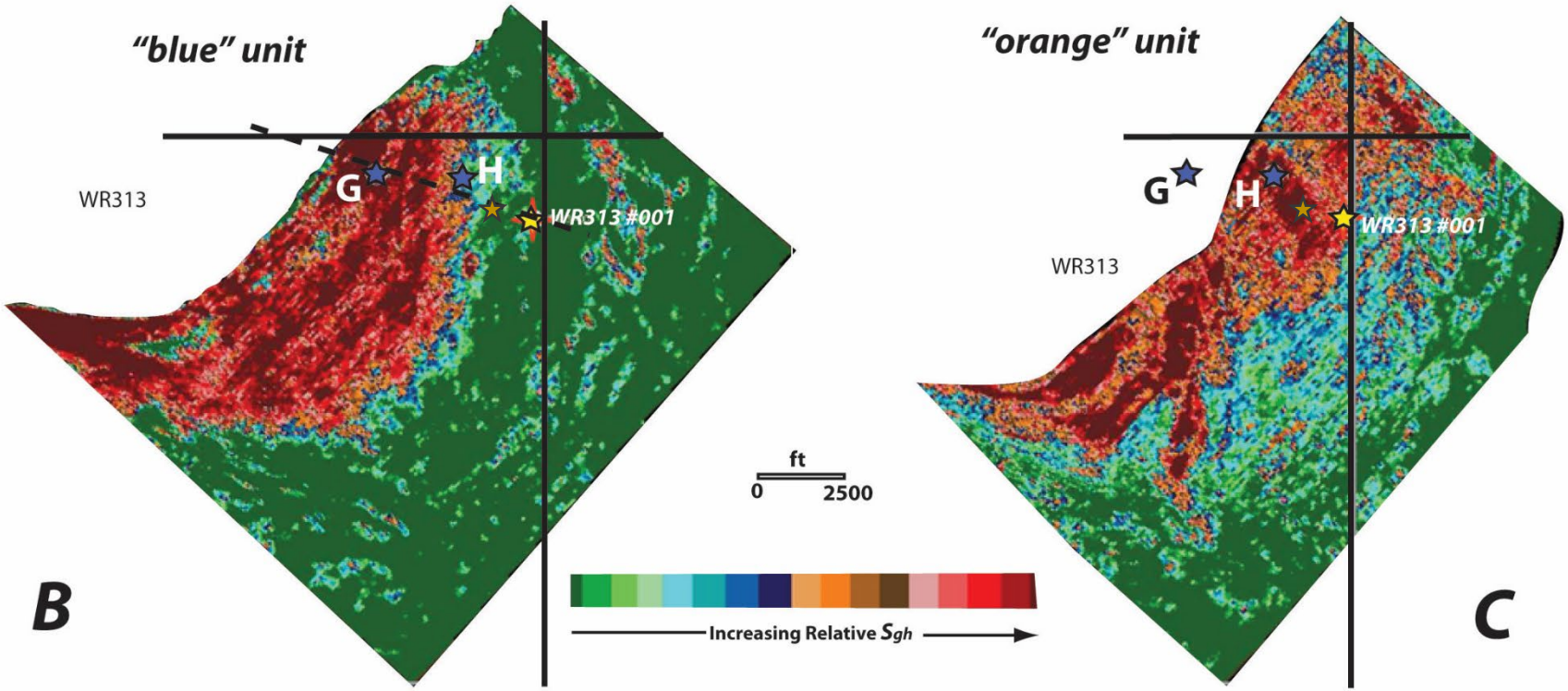
Note 2018 GMGS-05: 10 wells; ?? days

Walker Ridge 313

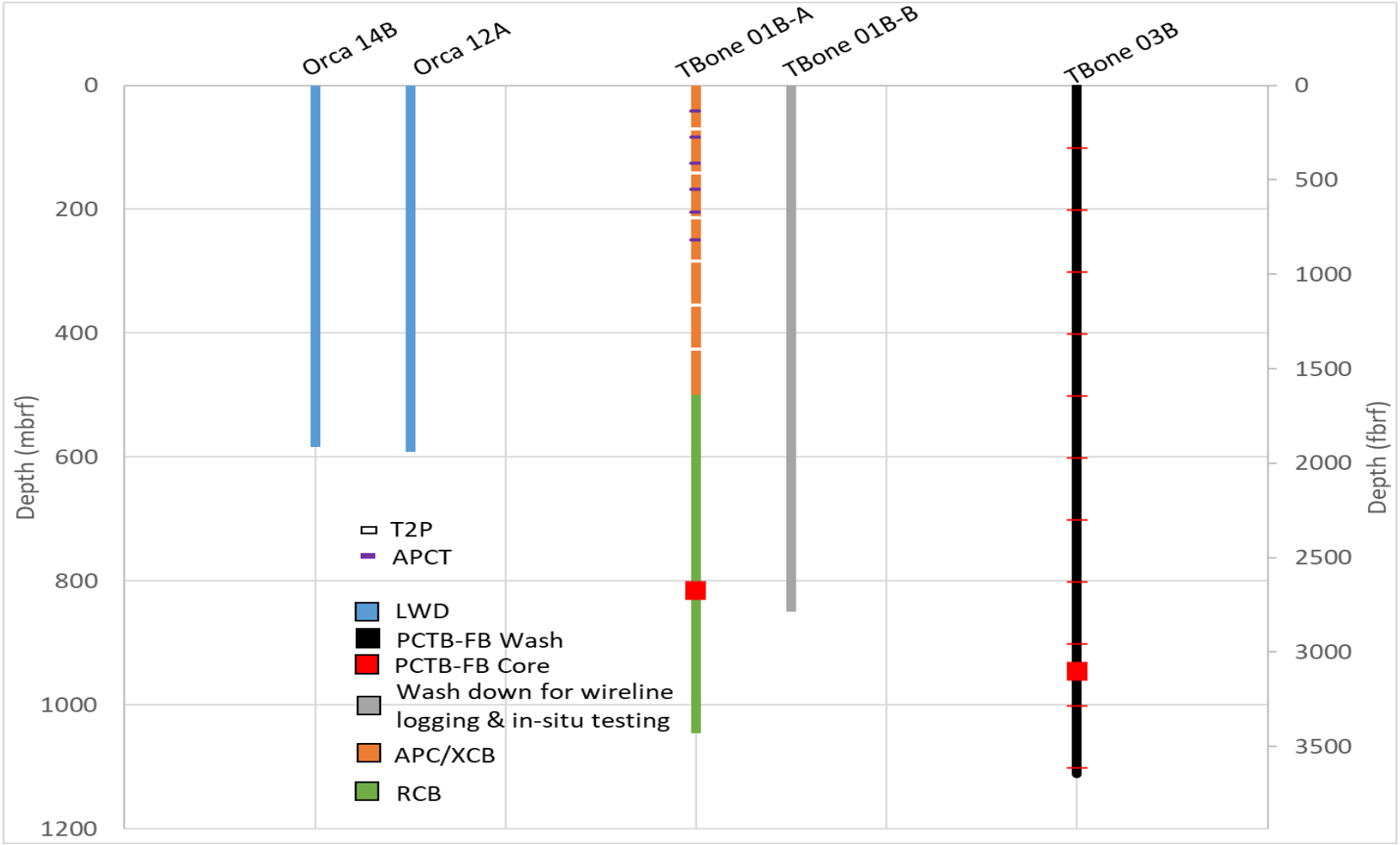
Two wells drilled in 2009: WR313-H & WR313-G



WR313 Blue and Orange Sands

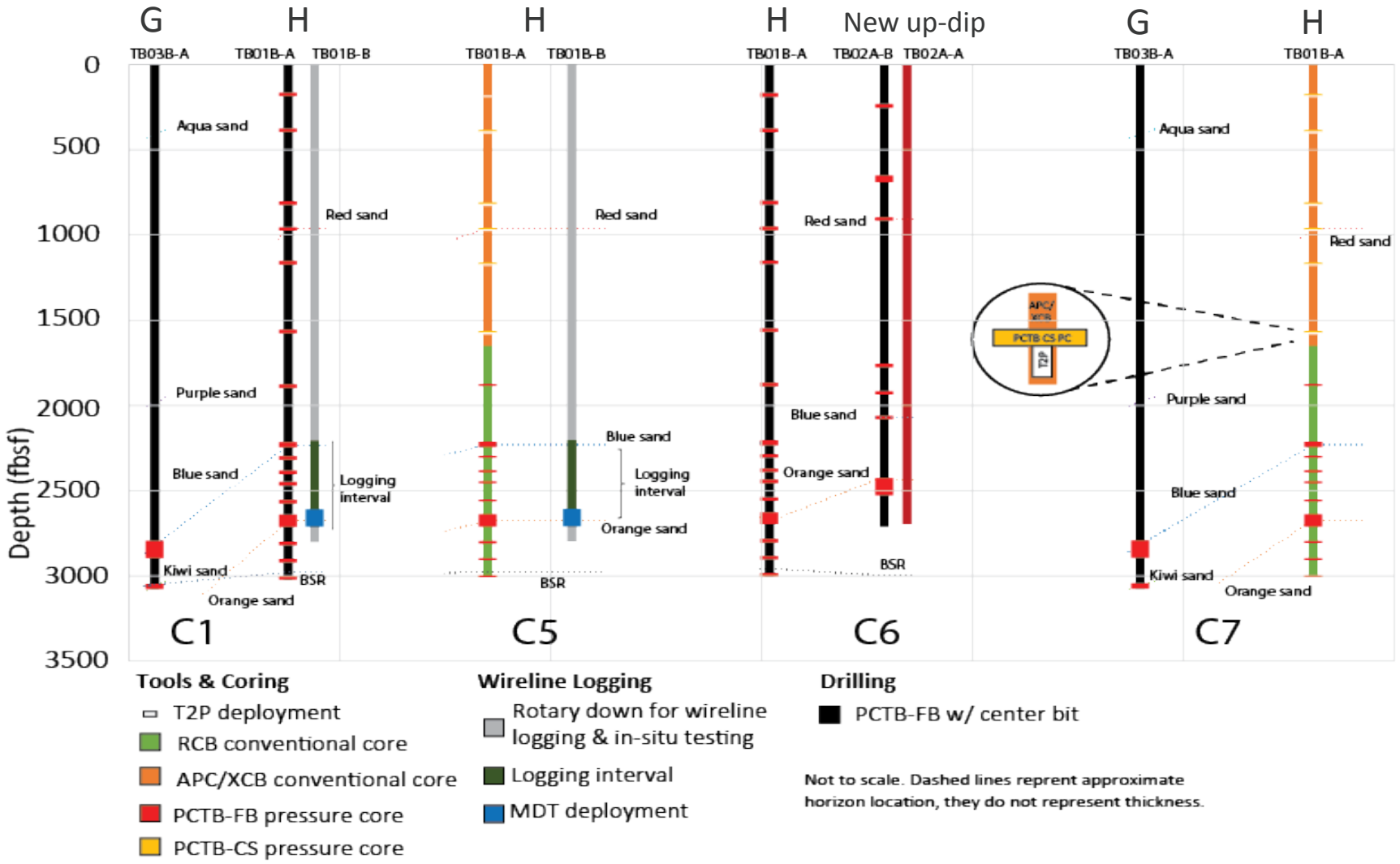


Plan B-3 (presented last meeting)



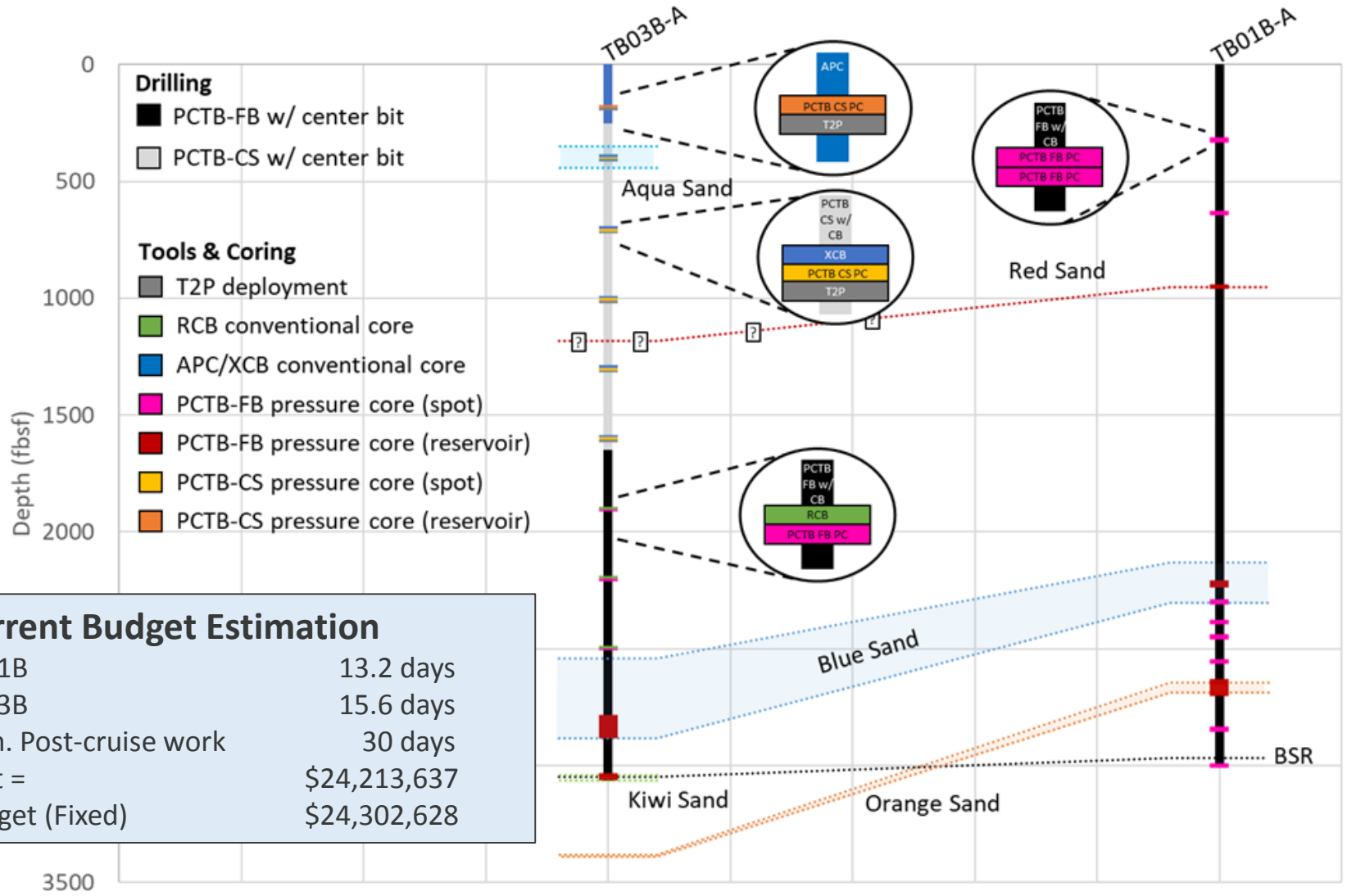
Example Current Options

Under evaluation



Recommended Option

AKA "Plan C-8"



Current Budget Estimation

TB01B	13.2 days
TB03B	15.6 days
Imm. Post-cruise work	30 days
Cost =	$24,213,637
Budget (Fixed)	$24,302,628

Science Implications

To prudently balance science objectives and operational risk

Science Enabled

- 7 pressure-cores through "Orange sand" and transitions
- Pressure coring in "blue sand" in both wells, providing insight on lateral variations in GH systems.
- Distributed spot-coring (pressure and conventional) in both wells through full section to maximize characterization of geochemical and microbial systems.
- Deployment of penetrometer to measure temperature profiles

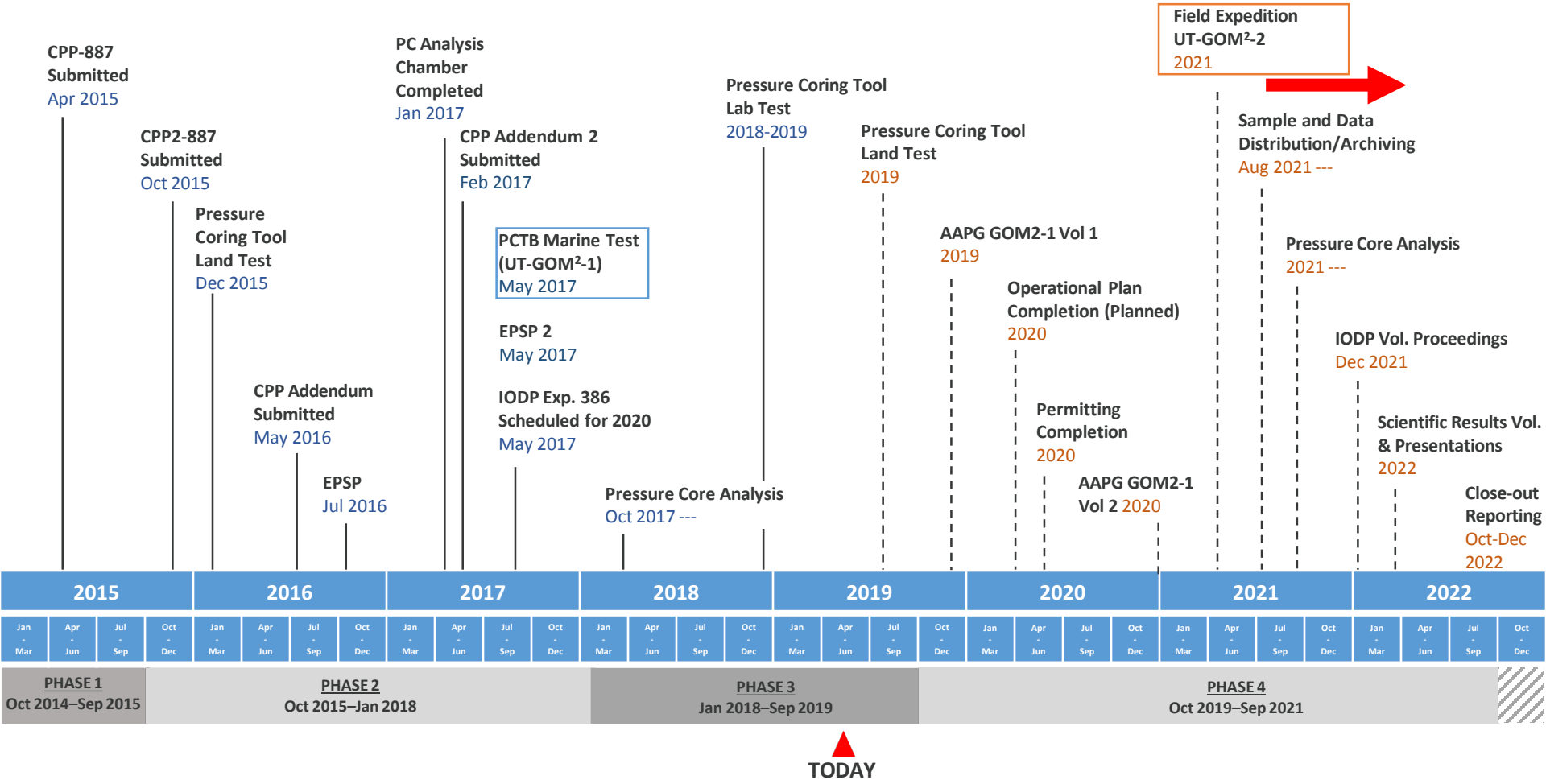
Risk Mitigation

- Hole #1 will focus on pressure coring with Face-bit tool, maximizing opportunity to address operational issues.
- Prior land-test of modified RCB tool and penetrometer (Hole #2).

Science Deferred

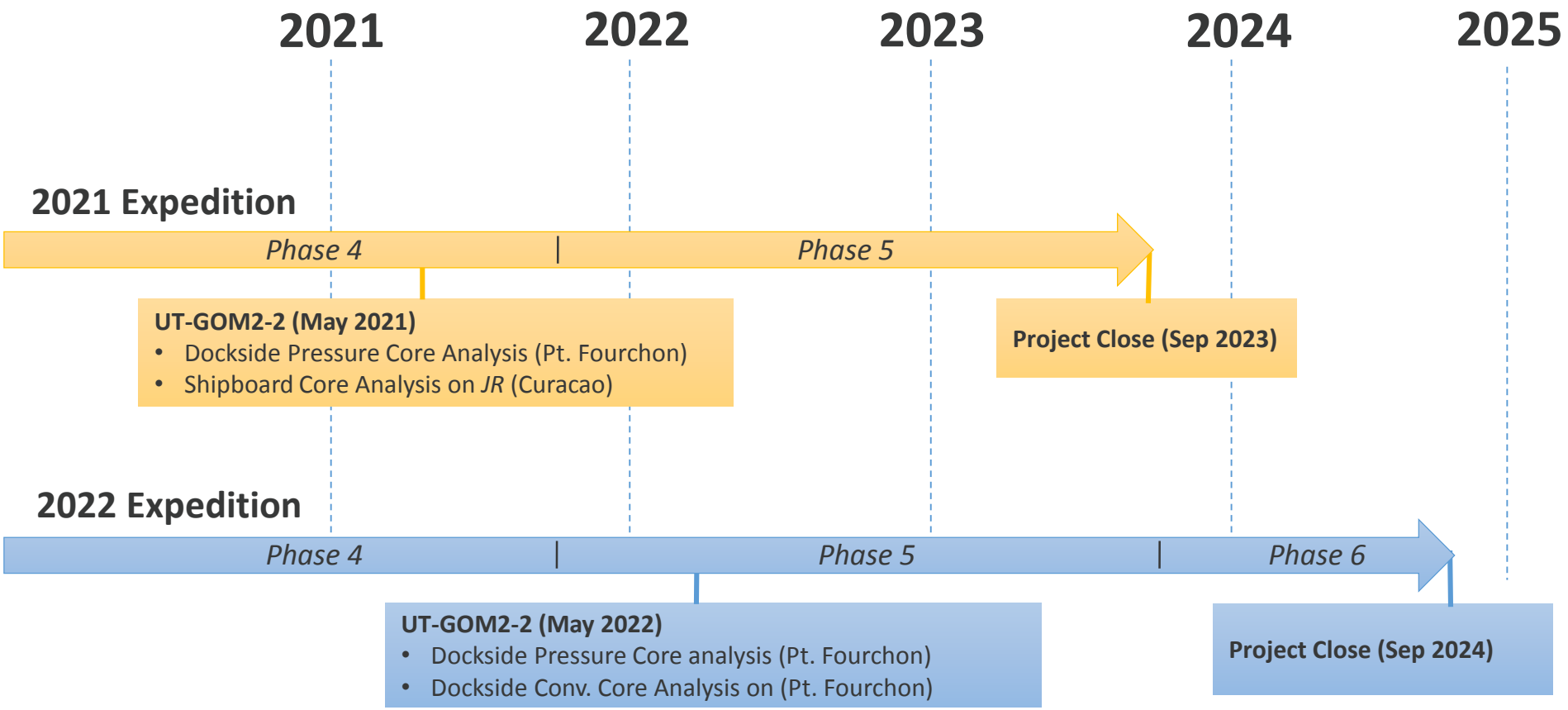
- There will be no exploratory drilling (time) – estimated cost @ $4.2 MM.
- There will be no wireline logging or wireline pressure testing (time and risk) – estimated cost @ $4.0 MM
- There will be no continuous conventional coring (time) – estimated cost @ $3.2 MM
- The comparison of GH reservoir properties in a single unit at different positions relative to the BGHS will be accomplished, original conceived for the "orange sand", will focus on the lower quality, more thinly-bedded "blue sand". – estimated cost @ $8.6 MM.

UT GOM2 project timeline



Alternative Timelines

2021 Expedition can access JR for core analysis



THANK YOU