

UT-GOM2-2 OPERATIONS PLAN

Version 2.3 update based on final budget

Deepwater Methane Hydrate Characterization and Scientific Assessment

DOE Award No. DE-FE0023919

The University of Texas at Austin

U.S. Department of Energy

National Energy Technology Laboratory

Updated June 5, 2023

PREFACE

This document has been prepared by The University of Texas at Austin and the DE-FE0023919 project team. The purpose of this document is to define the technical and operational activities required to achieve the science goals of the UT-GOM2-2 Scientific Drilling Program. This document will be revised on an as-needed basis to update information, incorporate changes, and provide clarification on the UT-GOM2-2 Scientific Drilling Program prior to its execution.

Major revisions to the document will be tracked in the ‘Record of Revisions’ table provided below.

Record of Revisions

REV.	DATE	AUTHORS	DESCRIPTION
0.0	04/12/18	Flemings, Houghton, Thomas	Initial issuance following approval of CPP & scheduling of IODP Expedition 386.
1.0	10/01/19	Cook, Flemings, Houghton, Morrison, Phillips, Pettigrew, Polito, Portnov, Santra, Thomas	Major revisions throughout, including presumed use of drilling vessel other than <i>JR</i> and significantly revised field program focused on coring two existing LWD locations in Terrebonne Basin.
1.1	12/13/19	Cook, Flemings, Houghton, Morrison, Polito, Santra, Thomas	Minor edits throughout document based on technical input from Geotek and quality control review.
1.2	12/16/19	Santra, Houghton	Updated Mud Weight Plots on pages 31, 32.
1.3	12/20/19	Houghton	Minor edits and corrections throughout. Updated List of Acronyms.
1.4	7/3/20	Portnov, Santra, Cook, Thomas, Morrison	Hole locations edited to ~50 ft from original JIP location, tops tables and resulting text changes. Updated Coring Plan and container logistics.
2.0	12/11/20	Flemings, Morrison, Portnov, Santra, Pettigrew, Thomas, Cook, Houghton	Moderate revisions throughout to incorporate updates from Exploration Plan, Science and Sample Distribution Plan, and logistics planning. Figures and tables updated throughout with minor edits. Added discussion of H2S hazards.
2.1	10/11/21	Thomas, Houghton	Moderate revisions throughout to incorporate updates from the Science and Sample Distribution Plan Rev V2. to the schedule, coring program, and container logistics. Added Tufts under Project Organization
2.2	11/01/2022	Thomas, Portnov, Houghton	Moderate revisions throughout to incorporate updates moving the second well from G002 to H003.
2.3	6/5/2023	Thomas, Portnov, Houghton, Pettigrew	Minor revisions throughout to shorten TDs, core estimates, etc. based on the now know expedition budget. First hole was modified to H003. Cementing plan modified.

Contents

1	Executive Summary.....	8
2	Science Objectives	9
2.1	Characterize the Orange sand and Upper Blue sand hydrate reservoirs and their bounding units. 9	
2.2	High resolution geochemical and sedimentary profiles: understanding the hydrate system....	10
2.3	Measure the in-situ temperature and pressure profile.....	10
2.4	Characterize dissolved methane concentration and gas molecular composition with depth ...	10
2.5	Reservoir characterization—other targets of interest.....	11
3	Geologic Program.....	11
3.1	Introduction	11
3.2	Proposed Well Locations.....	13
3.3	Top Hole Stratigraphy	14
3.4	Top Hole Prognosis	22
3.4.1	Identification and projection of tops from existing well data	22
3.4.2	WR313 H002 and WR313 H003	23
3.5	Borehole Temperature and Hydrate Stability Field	28
3.6	Pore Pressure Plots	29
3.6.1	Methodology.....	29
3.6.2	Previous drilling.....	33
4	Drilling Program	34
4.1	Coring Bits	34
4.2	Center Bit	35
4.3	Drill String.....	35
4.4	Bottom Hole Assembly.....	35
4.5	Coring Tools	36
4.6	Slickline	40
4.7	Borehole Inclination/Azimuth Surveys	40
4.8	Rig Position Survey.....	40
4.9	Site Surveys	40
5	Mud Program	40
5.1	Working Mud	40
5.2	Kill Mud	40

5.3	Drilling and Coring Mud	40
5.4	Sweep Mud	41
5.5	Pad Mud.....	41
5.6	Abandonment Mud.....	41
6	Coring Program	41
6.1	Coring Plan Overview.....	41
6.1.1	WR313 H003	41
6.1.2	WR313 H002	41
6.2	On-board Core Analysis	43
6.2.1	Pressure Core Processing Flow	44
6.2.2	Conventional Core Processing Flow.....	45
6.3	Dockside Core Analysis	45
6.3.1	Dockside Pressure Core Processing Flow.....	46
6.3.2	Conventional Core Processing Flow.....	47
7	Plugging and Abandonment.....	47
8	Schedule.....	49
8.1	UT-GOM2-2 Hydrate Expedition Schedule	49
8.2	Core Processing Schedule	49
8.2.1	PCATS pressure core acquisition time	49
8.2.2	Pressure Core Processing Time	50
9	Risk Management	50
9.1	Environmental.....	50
9.2	Personnel and Equipment.....	51
9.3	Meeting Science Objectives.....	52
9.4	Adverse Weather Conditions	52
10	Drilling Vessel.....	53
11	Personnel	53
11.1	Project Organization	53
11.2	UT-GOM2-2 Scientific Drilling Program Personnel – Onboard	54
11.3	UT-GOM2-2 Scientific Drilling Program Personnel – Dockside Core Processing	54
12	Permitting	55
13	Logistics.....	55
13.1	Designated Port and Heliport / Boat and Helicopter Services.....	55

13.2	Mobilization / Demobilization Plans.....	55
13.3	Customs.....	56
13.4	Trucking/Transport/Shipping.....	56
13.5	Port Support.....	56
13.6	Supply Vessels and Crew Boats.....	56
13.7	Supplies and Equipment	56
13.7.1	Equipment.....	56
13.7.2	Baskets & Containers	57
13.7.3	Personnel	59
13.8	Demobilization from Rig	60
13.8.1	Materials and Equipment.....	60
13.8.2	Personnel	60
13.9	Remobilization Dockside (Salt Lake City, UT).....	60
13.9.1	Geotek Site Plan	60
13.9.2	Dockside Containers.....	61
13.10	Dockside Core Processing	62
13.10.1	Samples and Cores	62
13.10.2	Reporting.....	62
13.10.3	Personnel	62
13.11	Demobilization from Dockside.....	62
14	List of Acronyms.....	63
15	References	66

Figures

Figure 3-1. Shaded relief map of sea floor in the northwestern part of Walker Ridge Protraction Area ..	12
Figure 3-2. Bathymetry map of the study area based on 3D seismic data in southern Terrebonne Basin.	14
Figure 3-3. Identification of coarse-grained intervals (hydrate bearing or water bearing) and interpreted hydrate bearing marine mud from LWD data.	17
Figure 3-4. Seismic section AA' through existing wells in block WR313.....	18
Figure 3-5. SW-NE oriented seismic section BB'	18
Figure 3-6. Instantaneous amplitude map extracted at Horizon 0400 (Blue Horizon) showing geological interpretation for the Blue sand	21
Figure 3-7. Instantaneous amplitude map extracted at Horizon 0300 (Orange Horizon) showing geological interpretation for the Orange sand	22
Figure 3-8. Seismic cross section CC' through Location WR313 H002 with interpreted lithology	24
Figure 3-9. Seismic cross section CC' through Location WR313 H003 with interpreted lithology	26
Figure 3-10. Estimated thermal gradient.....	29
Figure 3-11. Seismic section EE' through proposed wells, showing hydrate-bearing sands, hydrate-gas contacts, and gas-water contacts.	31
Figure 3-12. Equivalent mud weight plot for the planned WR313 H002.	32
Figure 3-13. Equivalent mud weight plot for planned WR313 H003.....	33
Figure 4-1. PCTB Coring Bit Configurations.....	35
Figure 4-2. Drilling/Coring Bottom Hole Assemblies Configurations.....	36
Figure 4-3. Geotek Advanced Piston Corer.....	38
Figure 4-4. Geotek eXtended Core Barrel.....	38
Figure 4-5. Pressure Coring Tool (PCTB) schematic	39
Figure 6-1. UT-GOM2-2 drilling and coring plan for WR313 H002 and WR313 H003	42
Figure 7-1. Plug and abandon cement plug emplacement hole schematic for H003.....	48
Figure 11-1. Personnel organization chart.....	53

Tables

Table 1-1. UT-GOM2-2 Scientific Drilling Program Schedule.....	9
Table 3-1. Existing wells - Locations in Walker Ridge Block 313.....	13
Table 3-2. Existing wells – Well information.....	13
Table 3-3. Planned well locations and depths.	13
Table 3-4. Interpretation of sediment type	15
Table 3-5. Projected tops for the proposed location WR313 H002 (Table 3-3).	25
Table 3-6. Projected tops for the proposed location WR313 H003 (Table 3-3).	27
Table 4-1. BHA to tool compatibility chart.	37
Table 6-1. Estimated total amount of pressure and conventional core	43
Table 6-2. Summary of sample type, analysis type, with required laboratory space, equipment.....	44
Table 6-3. Planned Analyses including sample type, analysis, location, and required equipment.	46
Table 8-1. UT-GOM2-2 Scientific Drilling Program Overview	49
Table 8-2. UT-GOM2-2 Scientific Drilling Program Offshore Operations Schedule.....	49
Table 9-1 Identified highest risks for meeting the Science objectives	52
Table 11-1. UT-GOM2-2 onboard personnel	54
Table 11-2. Dockside core analysis program personnel.	54

Table 13-1. Name, type and size, container description, comparison to the previous expedition, container activities, mobilization location, and required hook-up, and required hook-up. Zoom in to read table 58

Table 13-2. Dockside Container - name, type and size, container description, comparison to the previous expedition, container activities, mobilization location, and required hook-up 61

Table 14-1. List of Acronyms..... 63

1 Executive Summary

The UT-GOM2-2 Scientific Drilling Program is part of the *Deepwater Methane Hydrate Characterization & Scientific Assessment Project* (DE-FE0023919), funded by the Department of Energy and advised by the United States Geological Survey (USGS) and the Bureau of Ocean Energy Management (BOEM). The objective of the project is to gain insight into the nature, formation, occurrence and physical properties of methane hydrate bearing sediments for the purpose of methane hydrate resource appraisal through the planning and execution of drilling, coring, logging, testing and analytical activities that assess marine methane hydrate deposits in the northern Gulf of Mexico.

This is the operational plan for the UT-GOM2-2 Scientific Drilling Program. The UT-GOM-2 expedition will be accomplished with a deepwater drilling/intervention vessel that is commercially contracted.

Full function tests of the wireline tools will be conducted before spudding the first well.

Two wells will be drilled in Walker Ridge Block 313 (WR313) in the northern Gulf of Mexico. The surface location of each well will be approximately 60 feet of a well previously drilled with logging while drilling (LWD) tools as part of the 2009 JIP II Methane Hydrates LWD program (Collett et al., 2009). Water depth at the well locations is 6,460 feet below sea level.

In the first well (H003), conventional cores, pressure cores, and temperature/ pressure measurements will be obtained in the shallow interval. Pressure-cores will be obtained from hydrate-bearing targets (Red, Upper Blue, and/or Orange sands), bounding mud, and background mud to total depth. The depth of the target sands range from ~950 to 2,700 fbsf. Coring tools will be deployed through the drill string via slickline.

In the second well (H002), intermittent spot pressure-cores will be acquired throughout the borehole. Coring tools will be deployed through the drill string via slickline.

The wells will be permanently abandoned at the conclusion of the program. There will be no pipelines or other facilities installed that would require decommissioning.

The Geotek pressure Core Analysis and Transfer System (PCATS) will be used onboard to perform characterization, cutting, and transfer of pressure cores. Sections of pressure cores will be selected for quantitative degassing and future analysis at UT and other institutions. Pressure cores will be demobilized via supply vessel. PCATS and quantitative degassing manifolds will be remobilized at our new 'dockside' facility, Geotek Coring Inc, Salt lake City, to complete the processing of any remaining pressure core not addressed onboard. All intact quantitatively degassed sections of core will be processed as conventional core as possible.

The Geotek MSCL-IR scanner will be used to scan conventional core as it reaches the rig floor. Pore water squeezing will be conducted on sections of conventional and depressurized core onboard to assess ephemeral properties. Pore water samples will also be preserved for additional analysis on shore. Conventional and depressurized whole round core and other samples will also be collected and preserved for headspace gas analysis and microbiology. Void gas samples will be collected and strength measurements made. Dockside, whole round conventional and depressurized core will be scanned using the Geotek MSCL and CT imaging. After imaging, whole round samples will be cut for moisture and density, geomechanical testing, other physical properties. The remaining core will then be split,

photographed, and scanned using the Geotek Geoscan camera, color spectrophotometry, magnetic susceptibility, and x-ray fluorescence scanners. A team of scientists will conduct conventional core analysis including smear slide preparation and microscopy, initial biostratigraphy, sediment weight and dry weights. Plugs of material will also be preserved for future analysis at various institutions.

The maximum scientific program will require just over 9 weeks to complete (Table 1-1). Mobilization, requiring 3.8 days, involves transporting equipment and personnel to the drilling vessel and preparing for field science operations. Full function tests will require 0.4 days. The onboard drilling and science program will require a total of 20.1 days, followed by demobilization of personnel and equipment, requiring 3.2 days. A dockside core analysis program will then be initiated. Transit and remobilization require ~5 days. Core logging and imaging require ~14 days. The dockside science party will require ~16 days. This is followed by additional time for Geotek to complete split core logging.

Table 1-1. UT-GOM2-2 Scientific Drilling Program Schedule.

No.	TASK	LOCATION	ESTIMATED DURATION (Days)	CUMULATIVE DURATION (Days)
1	Mobilization	Port of Embarkation	3.8	3.8
2	Full Function Tests	Walker Ridge 313	0.4	4.2
2	WR313 H003 Coring Program*	Walker Ridge 313	16.9	21.1
3	WR313 H002 Coring Program*	Walker Ridge 313	3.2	24.3
4	Demobilization	Walker Ridge 313	3.2	27.5
5	Transit and Remobilization	Port of Disembarkation to Salt Lake City, UT	5.0	32.5
6	Dockside Core Logging	Salt Lake City, UT	14.0	46.5
7	Dockside Science Party	Salt Lake City, UT	16.0	62.5
* From _WR313-H002 MAXIMUM; includes pre-tour safety meeting and 20% non-productive time				

2 Science Objectives

The prioritized science objectives for the UT-GOM2-2 Scientific Drilling Program and the plans to meet them are detailed in the science prospectus. A high-level summary is as follows.

2.1 Characterize the Orange sand and Upper Blue sand hydrate reservoirs and their bounding units.

We will meet Objective 1 by pressure coring through the Orange sand and bounding mud. Pressure core analysis will be done on-board and dockside. Conventional core analysis will be done on depressurized pressure cores. We will characterize the 1) hydrate concentration, dissolved methane concentration, and produced gas composition, 2) pore water dissolved solute concentration and composition, 3) lithofacies identification, grain size, and sorting, 3) permeability, 4) compressibility, 5) strength behavior, 6) sediment composition and age, 7) microbial communities and activity. We will illuminate the diffusion rate and direction of methane and other solutes diffusion by taking background cores 16.4, 49.2, and 148 ft (5, 15 and 45 m) above and 49.2 ft (15 m) below the orange sand.

2.2 High resolution geochemical and sedimentary profiles: understanding the hydrate system

A sedimentary profile with high resolution pore water, sedimentology, physical properties, microbiological, and mechanical properties sampling will be acquired. We will continuously core to ~660 fbsf, spot conventional and pressure core, and pressure core to total depth. We will derive the following:

1. Measure organic matter content and source indicators (total organic carbon, bulk organic $\delta^{13}\text{C}$, C/N ratios) with depth to constrain the amount of organic carbon available for microbial fermentation and methanogenesis, and determine if this organic carbon can drive sufficient in situ microbial methane production to form high saturation hydrate in the Orange sand and Upper Blue sand.
2. Observe abrupt transitions and general behavior of the pore water composition to infer fluid flow, hydrate formation/dissociation, and diagenesis.
3. Determine the age of the strata through nannofossil biostratigraphy in both holes.
4. Characterize the continuous record of lithologic properties including the reservoir seals.
5. Determine presence, numbers, and activities of key microbial communities responsible for methane generation and link these observations to pore-water, lithologic, and formation properties.

2.3 Measure the in-situ temperature and pressure profile

Formation temperature will be measured in two ways. We will measure pressure and temperature with a penetrometer. We will use the 'Temperature 2 Pressure' (T2P) probe. The tool is only compatible with PCTB-CS BHA.

In addition, we will measure temperature while piston-coring using the IODP APC temperature sensor ([APCT Tool Sheet \(tamu.edu\)](https://www.tamu.edu/APCT/Tool_Sheet) during APC coring. In this approach, two sensors embedded in the cutting shoe of the piston corer record the cutting shoe temperature while the piston-core is advanced, held in the formation for 10 minutes, and the inner core barrel is extracted. The in-situ temperature is then inferred from the acquired temperature history.

2.4 Characterize dissolved methane concentration and gas molecular composition with depth

We will meet Objective 3 by pressure coring over a range of depths in the muds surrounding the coarse-grained hydrate intervals to obtain a profile of dissolved methane and gas composition. The location of these pressure cores will be coordinated between the two holes. Initial dissolved methane concentrations from H003 will be used to predict concentrations in H002 and adjust coring points. Deeper pressure cores will focus on the interval between the Orange and Blue Sand to test the long-range transport model. The dissolved methane concentrations, together with analyses from conventional coring, will focus on characterizing the microbial methane 'factory' and target an expected increase in dissolved methane from below the sulfate-methane transition (SMT) to the depth at which methane reaches maximum solubility. The depth of the SMT is commonly within the upper 20 m in methane-bearing continental margin sediments. The SMT at WR313 H003 is unknown.

We will acquire a depth profile of dissolved gas concentration and the gas molecular/isotopic composition to characterize the gas source and the microbial methane production. Degassing experiments will be performed on longer intervals of high-quality core to be able to resolve changes in dissolved methane. Quantitative degassing of pressurized core sections will directly measure the volume of gas and methane produced, and will use this methane volume with core volume and porosity to calculate the dissolved methane concentration. The molecular (C1-C5) hydrocarbon composition of the hydrocarbons (C1-C5) of the produced gas will be measured. The isotopic composition of methane ($\delta^{13}\text{C}$ and $\delta^2\text{H}$) and CO_2 ($\delta^{13}\text{C}$) will also be measured. We will also measure any atmospheric N_2 or O_2 contamination.

2.5 Reservoir characterization—other targets of interest

We will meet Objective 6 by pressure coring the Red sand. Pressure core analysis will be done on-board and dockside. Conventional core analysis will be done on depressurized pressure cores. We will characterize the 1) hydrate concentration, dissolved methane concentration, and produced gas composition, 2) pore water dissolved solute concentration and composition, 3) lithofacies identification, grain size, and sorting, 3) permeability, 4) compressibility, 5) strength behavior, 6) sediment composition and age, 7) microbial communities and activity.

3 Geologic Program

3.1 Introduction

The study area in Walker Ridge Block 313 (WR313) is located near the southern boundary of Terrebonne Basin (Figure 3-1). The Terrebonne Basin is an intraslope salt withdrawal minibasin in the Walker Ridge protraction area (Figure 3-1, Figure 3-2). The Terrebonne Basin is a salt-floored, salt-bounded, minibasin (Frye et al., 2012), with water depths ranging between 6000 ft and 6800 ft. The local seafloor topographic gradient at the proposed well sites vary between 2° and 3°.

One exploration well, WR313 001, was drilled in the 'Orion south' prospect in 2001 by Devon Energy (Figure 3-1). The WR313 G001, and WR313 H001 wells (Figure 3-1, Table 3-1, Table 3-2) were drilled during the 2009 Gas Hydrates Joint Industry Project Leg II (JIP II) LWD program (Boswell et al., 2012a; Boswell et al., 2012b; Shedd et al., 2010). Two major gas hydrate-bearing units, the Blue and Orange sands (Figure 3-4), were encountered during the 2009 JIP II drilling.

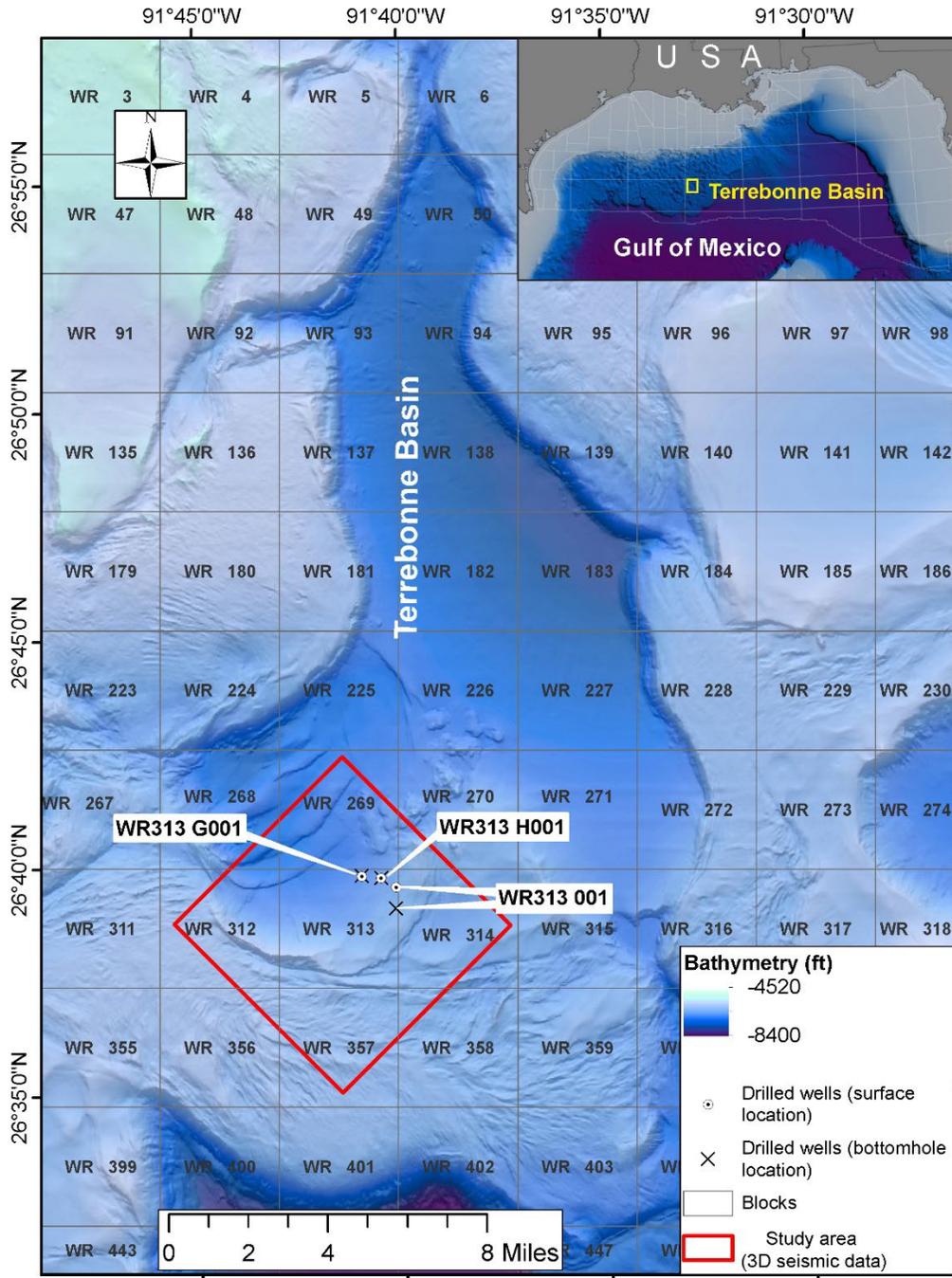


Figure 3-1. Shaded relief map of sea floor in the northwestern part of Walker Ridge Protraction Area showing Terrebonne Basin and existing wells in Walker Ridge Block 313 (WR313). Inset map shows the position of Terrebonne Basin in northern Gulf of Mexico. Bathymetry data are from BOEM Northern Gulf of Mexico Deepwater Bathymetry Grid from 3D Seismic (Kramer and Shedd, 2017).

Table 3-1. Existing wells - Locations in Walker Ridge Block 313.

Well Name	API Well Number	Surface Lat. (NAD27)	Surface Long. (NAD27)	X (NAD 27 UTM 15N US ft)	Y (NAD 27 UTM 15N US ft)	Bottom Lat. (NAD27)	Bottom Long. (NAD27)	X (NAD 27 UTM 15N US ft)	Y (NAD 27 UTM 15N US ft)
WR313 001	608124000700	26.659120	-91.669906	2074707	9675848	26.651294	-91.670086	2074674	9673003
WR313 G001	608124003900	26.663190	-91.683872	2070127	9677280	26.663308	-91.683837	2070138	9677323
WR313 H001	608124004000	26.662458	-91.676041	2072687	9677040	26.662498	-91.675882	2072739	9677055

Table 3-2. Existing wells – Well information.

Well Name	API Well Number	Total MD, RKB (ft)	Total TVD, RKB (ft)	Air Gap (ft)	Water Depth (ft)
WR313 001	608124000700	16,720	16,072	72	6,216
WR313 G001	608124003900	10,200	10,199	52	6,562
WR313 H001	608124004000	9,888	9,887	51	6,462

3.2 Proposed Well Locations

We will drill one to two locations in Walker Ridge Block 313: WR313 H002 and WR313 H003. WR313 H002 and WR313 H003 will be located approximately 62 ft from the existing well WR313 H001 and approximately 124 ft from each other.

Table 3-3. Planned well locations and depths. Geographic coordinates, projected coordinates, water depth, and planned total depth below seafloor are listed.

Proposed Locations	Latitude NAD27	Longitude NAD27	X NAD27 UTM15N	Y NAD27 UTM15N	X WGS84 UTM15N	Y WGS84 UTM15N	Water depth	Total depth below seafloor
	degree (N)	degree (W)	(ft)	(ft)	(m)	(m)	(ft)	(ft)
WR313 H002	26.662282	91.676081	2072674.5	9676976.2	631744.0	2949746.0	6460	975
WR313 H003	26.662625	91.675996	2072700.7	9677100.9	631752.0	2949784.0	6460	3010

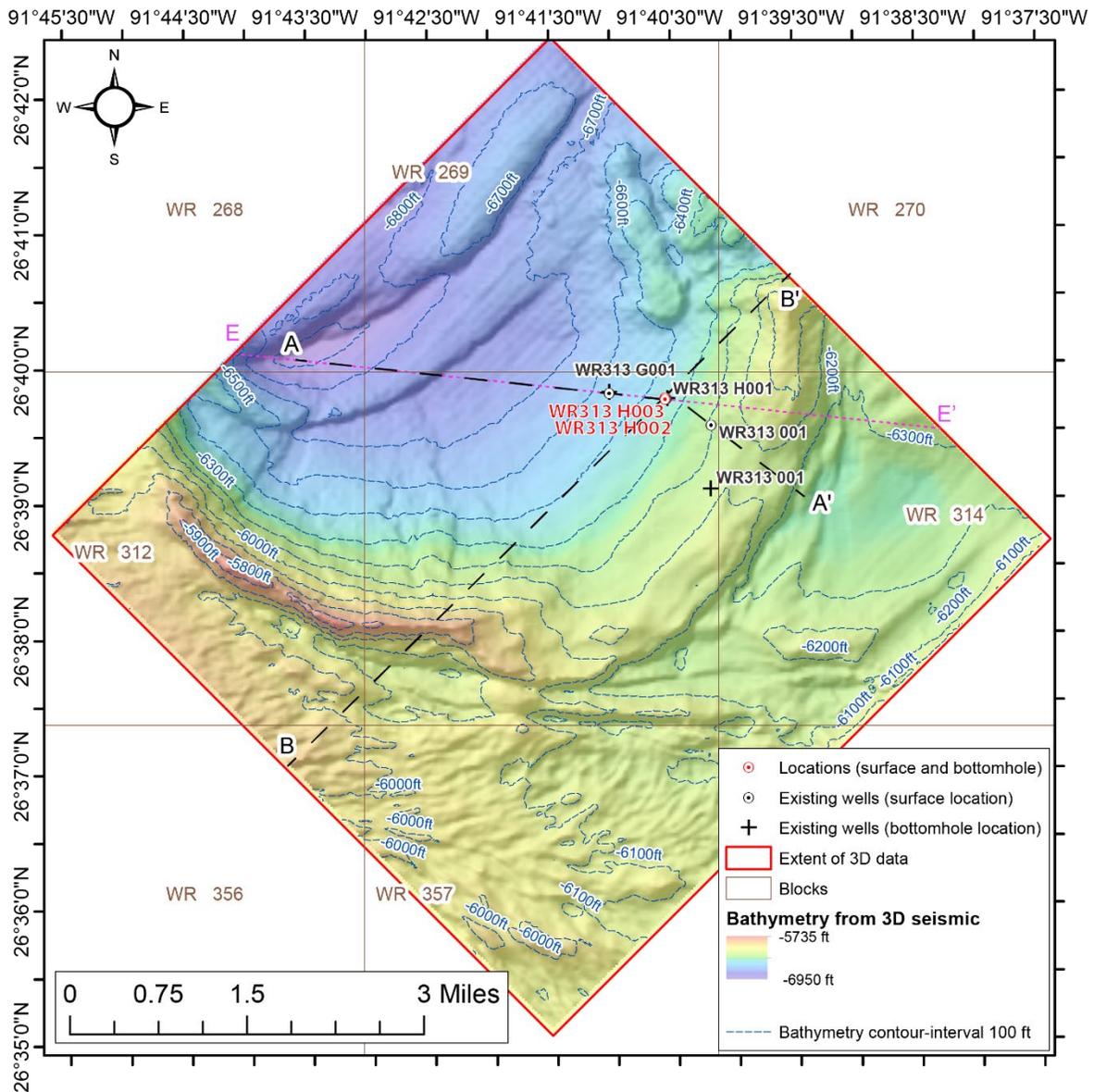


Figure 3-2. Bathymetry map of the study area based on 3D seismic data in southern Terrebonne Basin. The map shows existing wells and proposed locations in Walker Ridge Block 313 (WR313). 3D seismic data were used with permission of WesternGeco.

3.3 Top Hole Stratigraphy

The shallow sedimentary succession at WR313 consists of hemipelagic sediments, turbidites from channel-levee systems, and mass transport deposits. A discontinuous BSR is imaged in seismic data (Figure 3-4). This is interpreted as the base of gas hydrate stability zone.

Intervals with low gamma ray values that are interpreted as coarse-grained were found in both wells WR313 H001 and WR313 G001 at multiple levels, often with high gas hydrate saturations ($S_h > 70\%$) (Boswell et al., 2012a; Boswell et al., 2012b; Collett et al., 2009; Collett et al., 2010; Frye et al., 2012). In our interpretation (Figure 3-3, Table 3-4), we assume coarse-grained sediments are defined by low gamma-ray ($API < 65$), which distinguish them from higher gamma ray mud-rich sediments. Hydrate-

bearing coarse-grained sediments have high resistivity and velocity coupled with low gamma ray (API < 65); because both the resistivity and velocity have corresponding increases (without increase in density) these intervals are most likely pore-filling hydrate (Table 3-4). Similarly, some thin mud intervals also have corresponding moderate increases in resistivity and velocity which we also interpret as pore-filling (Table 3-4). Water bearing sands have low resistivity (often lower than background), enlarged borehole size and low gamma ray (API < 65) (Table 3-4). Fracture-filling gas hydrates have also been observed at Terrebonne (Cook et al., 2014). These intervals are primarily marine mud and have increases in resistivity, fractures visible on resistivity image logs, and propagation resistivity curve separation (Cook et al., 2010). One notable hydrate-filled fracture interval is called the JIP unit, a several hundred meter thick mud unit that appears in both holes (Cook et al., 2014) (Figure 3-8 & Figure 3-9).

Table 3-4. Interpretation of sediment type, pore constituents, and fractures based on well log response.

Sediment Type	Approximate Gamma Ray (API)	Interpretation	Well Log Response
coarse-grained sediment (sand and coarse silt sized grains)	<65	pore-filling hydrate	corresponding moderate to high increase in resistivity and velocity above background, possible slight drop in density, caliper near bit size
		gas-bearing	increase in resistivity or background resistivity with a drop-in velocity, caliper measuring borehole enlargement
		water-bearing	resistivity and velocity at or slightly below background, drop in density, caliper measuring borehole enlargement
marine mud sediment (silt and clay sized grains)	>65	pore-filling hydrate	corresponding moderate increase in resistivity and velocity above background, possible slight drop in density, caliper near bit size
		fracture-filling hydrate	increase in resistivity, fractures visible on borehole images, propagation resistivity curve separation, little to no increase in velocity above background, caliper near bit size
		water-bearing	resistivity and velocity at background, caliper near bit size

The two major coarse-grained intervals encountered in WR313 H001 well, the Upper Blue sand and the Orange sand, are associated with two prominent seismic reflectors called the Blue Horizon and the Orange Horizon (Boswell et al., 2012a; Boswell et al., 2012b; Frye et al., 2012) (Figure 3-4, Figure 3-5). The hydrate-bearing Upper Blue sand in WR313 H001 is just above the interpreted Blue Horizon. The WR313 G001 well encountered hydrate-bearing coarse-grained sediments both above and below the Blue Horizon, the Upper Blue sand and Lower Blue sand, respectively. The Orange sand was intersected

in both WR313 G001 and WR313 H001 wells. The WR313 H001 intersected a relatively thick coarse-grained package with high gas hydrate saturation at this level. However, the WR313 G001 encountered a thin, water-bearing, muddy/coarse package below the BSR at the Orange Horizon. An additional thin coarse-grained interval, the Kiwi sand (Hillman et al., 2017), was encountered in well WR313 G001 at the base of gas hydrate stability zone and contains both gas hydrate and a low saturation of gas (Figure 3-4).

The stratigraphic nomenclature used in this document is different from published studies in this area such as Boswell et al. (2012a), Boswell et al. (2012a), or Hillman et al. (2017). Each mapped stratigraphic surface was assigned a numerical designation; for example, the Orange Horizon is Horizon 0300 (Hrz 0300; see Figure 3-4 for the names and positions of stratigraphic surfaces). In addition to the stratigraphic surfaces, a surface was also generated connecting the discontinuous but locally strong BSR, which is interpreted to record the base of the gas hydrate stability zone (BHSZ) (Figure 3-4). The Orange Horizon/Hrz 0300, and Blue Horizon/Hrz 0400 are prominent reflectors in 3D seismic data and display a distinct phase reversal when they intersect the BSR. This phenomenon, which is a result of transition between gas hydrate (above) and free gas (below) within the pore spaces, guided our mapping strategy. Each of these three stratigraphic surfaces was traced as a seismic peak above the BSR, and following the phase reversal, traced as a seismic trough below the BSR (see Boswell et al. (2012b) for an explanation of mapping strategy).

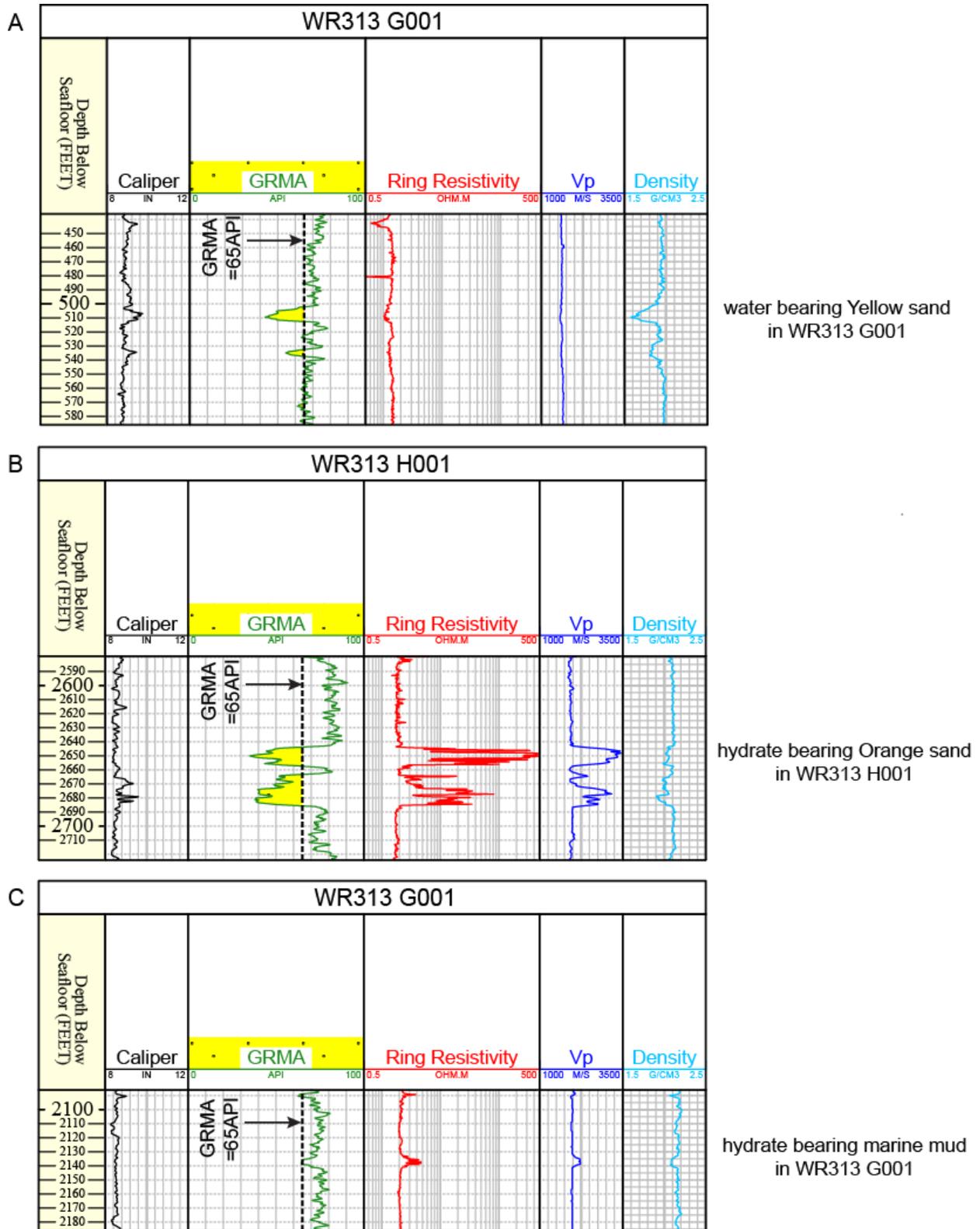


Figure 3-3. Identification of coarse-grained intervals (hydrate bearing or water bearing) and interpreted hydrate bearing marine mud from LWD data. A) Example of interpreted coarse-grained intervals with water showing low gamma ray (GRMA <65) values and low resistivity (lower than background); B) example of a hydrate bearing coarse-grained interval with low gamma ray

(GRMA<65), high resistivity, high p-wave velocity, and low density; C) example of an interpreted hydrate bearing marine mud interval with moderately low gamma ray values, moderately high resistivity, and moderately high p-wave velocity.

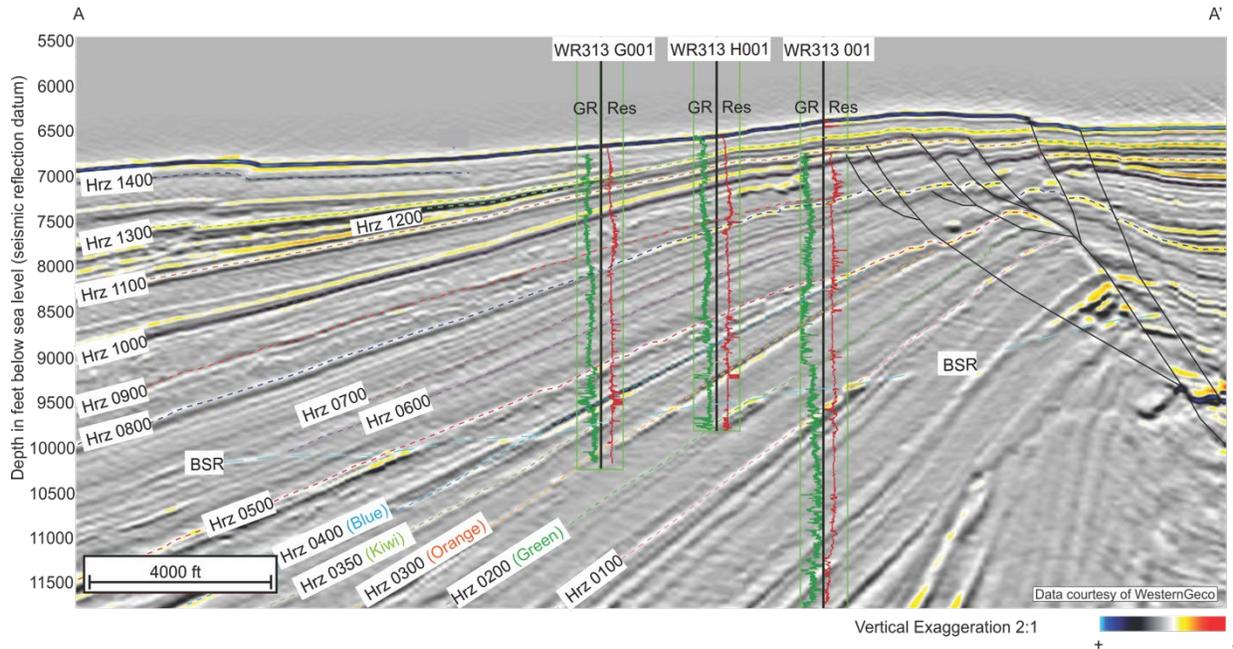


Figure 3-4. Seismic section AA' through existing wells in block WR313 (location in Figure 3-2), showing all interpreted stratigraphic horizons, BSR, and gamma ray (GR) and resistivity (Res) logs at existing wells. Stratigraphic nomenclature used for some previous studies in the area for relevant reservoir intervals (Boswell et al., 2012b; Frye et al., 2012; Hillman et al., 2017) are presented for comparison with nomenclature used in this study. Seismic data courtesy of WesternGeco.

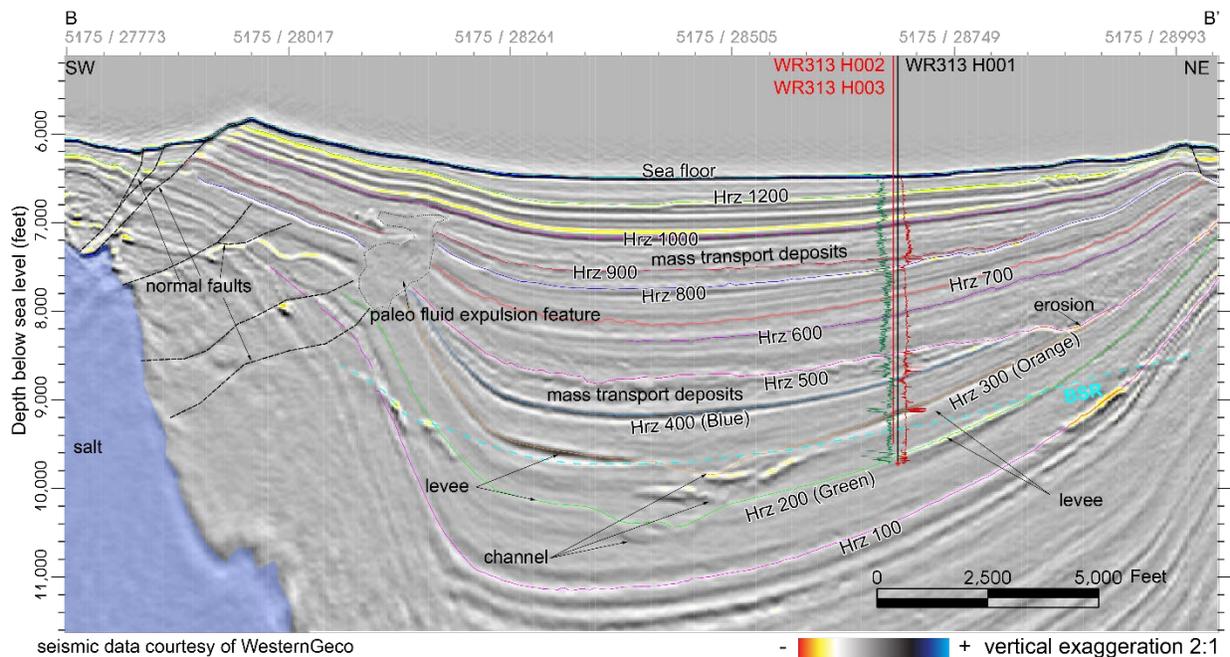


Figure 3-5. SW-NE oriented seismic section BB' (location in Figure 3-2) through well WR313 H001 showing major stratigraphic features in the study area. Resistivity (RES) and gamma ray (GR) logs are shown at WR313 H001 well. High resistivity indicates presence of gas hydrate. Seismic data courtesy of WesternGeco.

Five major lithostratigraphic units are identified based on seismic reflection character and log response from existing wells WR313 H001 and WR313 G001.

Unit 1 extends from seafloor to the depth of 773 fbsf in WR313 G001 and to 520 fbsf in WR313 H001. In the seismic data Unit 1 is imaged as sub-parallel reflections (Figure 3-4). In log character, it has a high gamma ray response indicating marine mud, with few relatively thin low-gamma-ray intervals. The base of Unit 1 is defined by Horizon 1000. Unit 1 is interpreted as fine-grained hemipelagic interval, with thin, coarse-grained layers, identified as the Aqua and Yellow sands (Table 3-5 & Table 3-6). In WR313 G001, part of this unit contains very low-concentration gas hydrate in near-vertical fractures, called the Mendenhall unit.

Unit 2 extends from the base of Unit 1 (marked by Horizon 1000) to 1316 fbsf at WR313 G001 and 1038 fbsf at WR313 H001; on the well logs, gas hydrate was identified in this interval in near-vertical fractures. The gamma ray in Unit 2 are slightly lower than overlying section. Based on discontinuous and chaotic seismic reflections of variable amplitude (Figure 3-4 & Figure 3-5), we interpret this section as mass transport deposits (MTD) possibly with a higher amount of silty material compared to hemipelagic deposits described in Unit 1.

Unit 3 underlies Unit 2 (base marked by Horizon 0800) and extends down to 2,412 fbsf at WR313 G001 and 2,000 fbsf at WR313 H001. In seismic data, Unit 3 is characterized by continuous parallel reflections of moderate amplitude (Figure 3-4 & Figure 3-5), while in the wells WR313 G001 and WR313 H001, the corresponding section shows high gamma ray that changes to slightly lower gamma ray in the lower part of Unit 3. The lower boundary of this unit is a prominent seismic reflector identified as Horizon 500. Unit 3 is interpreted as a hemipelagic mud-dominated section.

Unit 4 underlies Unit 3 and extends from Hrз 500 down beneath the Upper Blue sand interval to 2,796 fbsf at WR313 G001 and 2,285 fbsf at WR313 H001. Horizon 500 is a strong seismic reflector, which has the characteristics of an erosion surface (Figure 3-4 & Figure 3-5) and is associated with abrupt increase in gamma ray in both wells. The seismic reflection data within the lower-most section of Unit 4 (below Horizon 500) is characterized by discontinuous reflections with variable amplitude. This section has been interpreted as mass transport deposits (MTD), which may be silt-rich mud as indicated by moderately low gamma ray. Very thin low gamma-ray and low resistivity streaks within this zone indicate presence of thin water-bearing coarse-grained intervals. The hydrate-bearing Upper Blue sand interval (2180-2256 fbsf in WR313 H001, 2706-2779 fbsf in WR313 G001) is near the base of this interval. The Upper Blue sand is a prominent hydrate bearing interval in both WR313 H001 and WR313 G001.

Unit 5, which underlies Unit 4, includes three major coarse-grained intervals associated with Hrз 0400 (Lower Blue sand), Hrз 0300 (Orange sand), and Hrз 0200 (Green sand); as indicated by low gamma ray values recorded in wells WR313 G001 and WR313 H001. These three coarse-grained intervals are separated by intervals of marine mud with higher gamma ray values. High resistivity, high P-wave velocity (V_p) and low density in the Blue and Orange sand indicate the presence of pore-filling, high saturation gas hydrate (Table 3-4).

In both WR313 G001 and WR313 H001, the top of Unit 5 is at the prominent reflector marked as Horizon 0400 (2,796 fbsf in WR313 G001; 2,285 fbsf in WR313 H001). The Lower Blue sand interval (just below Horizon 0400) is present in WR313 G001 well but absent or of poor quality in WR313 H001 well. Frye et al. (2012) interpreted that the Blue sand represented mud-rich intra-slope ponded submarine

fan complex, with both sand sheets and leveed channels. Seismic amplitude distribution at Horizon 0400 (Blue Horizon) suggests channel and sheet-like coarse-grained deposits (Figure 3-6). The Blue sand is followed by a predominantly high gamma-ray (interpreted as mud) interval in both wells, which extends down to the top of the next major coarse-grained interval that starts just above Horizon 0300 (3370 and 2642 fbsf in WR313 G001 and WR313 H001 respectively).

In WR313 G001 a thin low gamma-ray interval can be identified at 3042-3063 fbsf, which contains both gas hydrate and low saturation gas (Hillman et al., 2017). This thin sand interval coincides with a discontinuous but locally prominent reflector, mapped as Horizon 0350 in this study and previously described as the Kiwi sand (Hillman et al., 2017).

The low gamma ray interval associated with Horizon 0300 (Orange sand) is gas hydrate bearing with high gas hydrate saturation in WR313 H001 but water-bearing and mud rich in WR313 G001 (alternatively, the Orange sand is completely missing in WR313 G001). The Orange sand as encountered in wells WR313 H001, was interpreted as coarse-grained levee deposits associated with a submarine channel (Frye et al., 2012). A NNE-SSW oriented channel, and coarse-grained levee deposits on its both flanks can be identified on an amplitude map at Horizon 0300 (Figure 3-7).

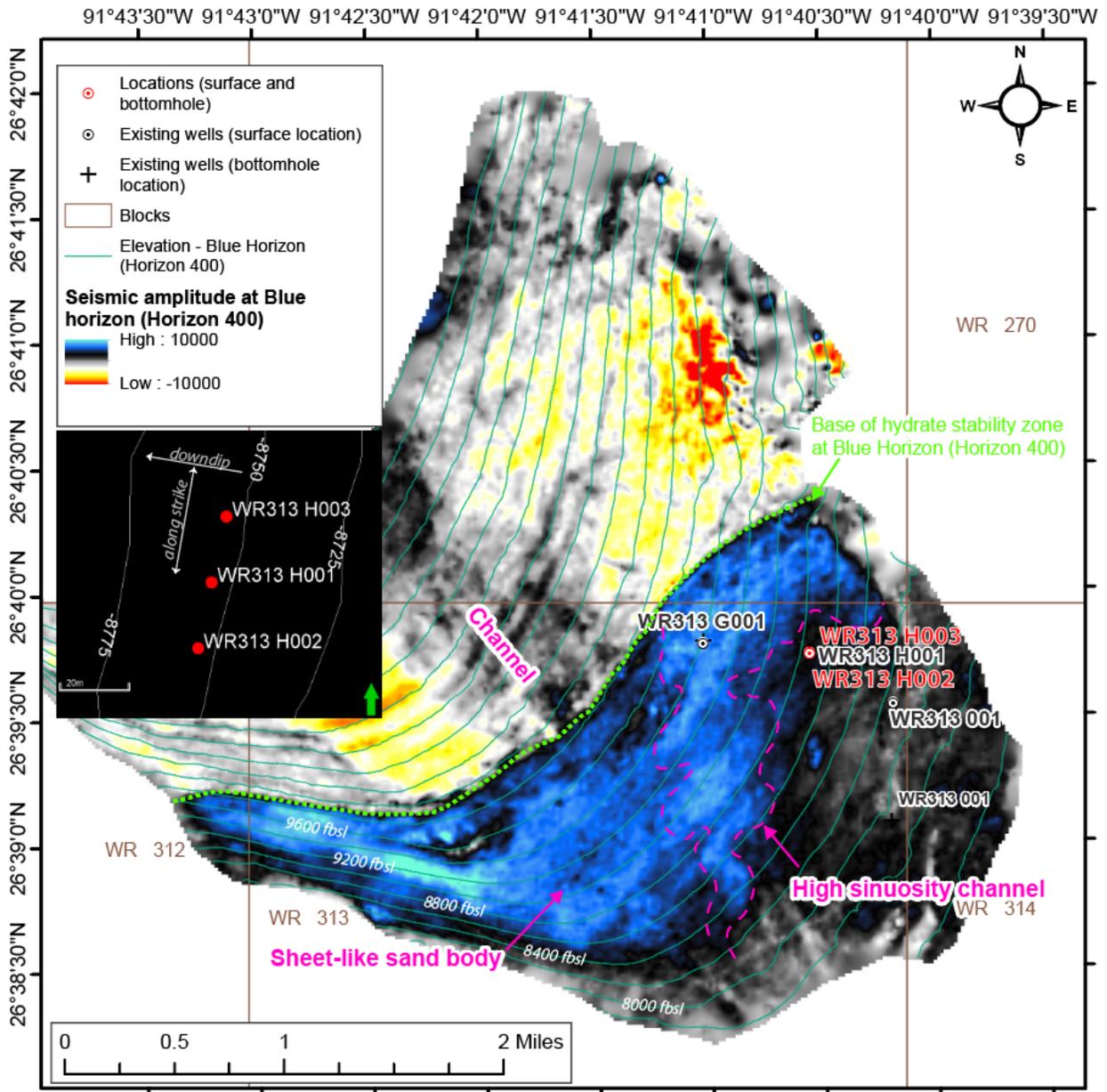


Figure 3-6. Instantaneous amplitude map extracted at Horizon 0400 (Blue Horizon) showing geological interpretation for the Blue sand – the upper of the two hydrate bearing target intervals. Maps generated from 3D seismic data used with permission of WesternGeco.

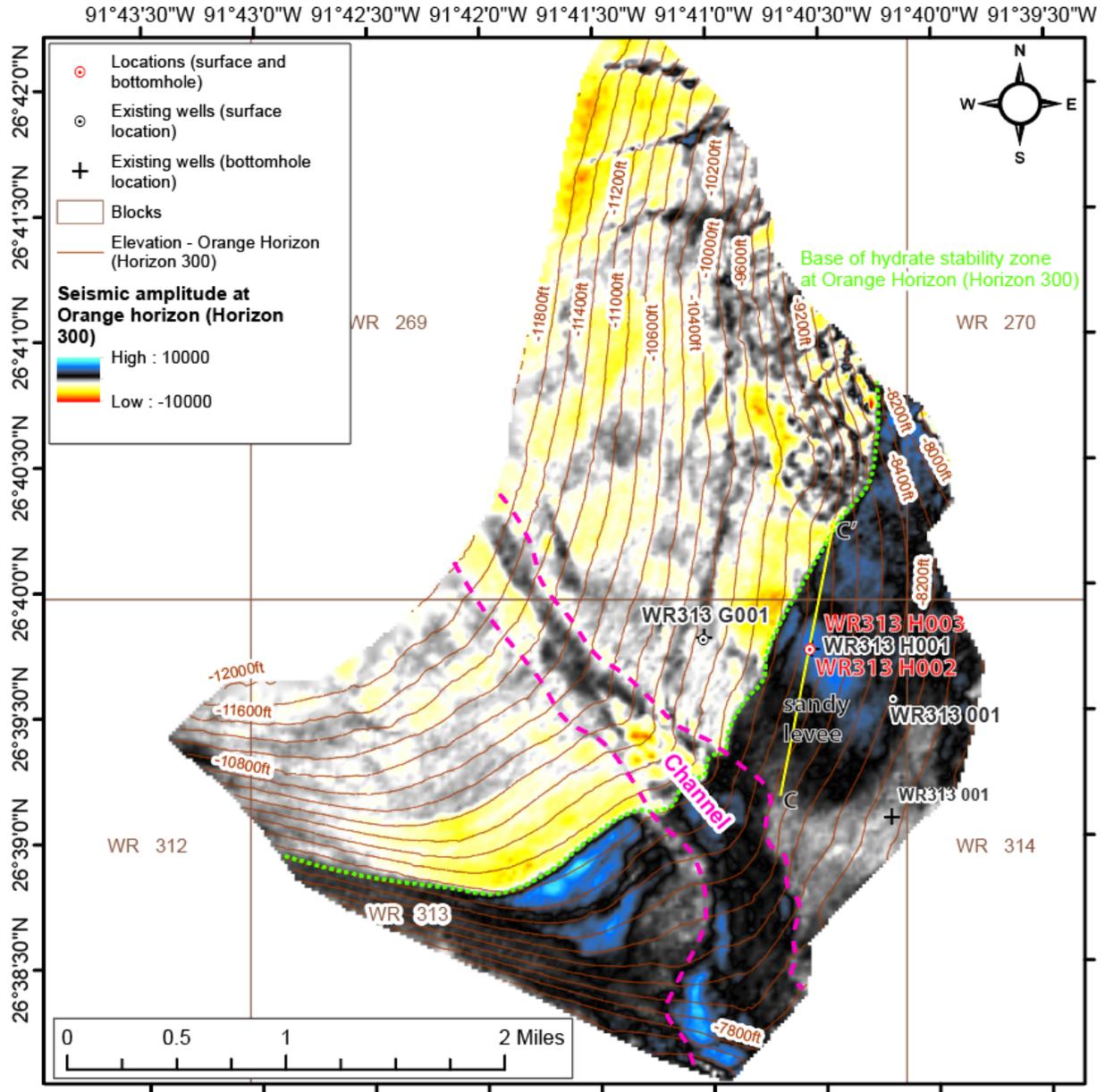


Figure 3-7. Instantaneous amplitude map extracted at Horizon 0300 (Orange Horizon) showing geological interpretation for the Orange sand – the lower of the two hydrate bearing target intervals. The well WR313 H001 and the proposed locations WR313 H002 and WR313 H003 target gas hydrate-bearing sandy levee deposits showing strong positive amplitude response (blue color). Maps generated from 3D seismic data used with permission of WesternGeco.

3.4 Top Hole Prognosis

3.4.1 Identification and projection of tops from existing well data

Major boundaries were identified in WR313 H001, including tops and bases of coarse-grained units and hydrate-bearing marine mud units. These were tied to the seismic data to identify corresponding seismic reflections. The seismic reflections were then projected to the proposed locations. The WR313 H002 and WR313 H003 wells are located ~62 feet from the original location WR313 H001. Both proposed wells are

planned along strike from WR313 H001 (see Figure 3-6 inset), which means the tops depths in the proposed wells are identical to the tops interpreted in WR313 H001 (Table 3-5 and Table 3-6).

3.4.2 WR313 H002 and WR313 H003

WR313 H002 is located ~62 ft to the SW from the well WR313 H001, and WR313 H003 is located ~62 ft to the NW from the well WR313 H001 (Table 3-3 and Figure 3-2, Figure 3-6 inset). WR313 H001 was drilled previously without incident (Collett et al., 2009). Top-hole prognoses for WR313 H002 and WR313 H003 are identical and are shown in Figure 3-8, Figure 3-9 and Table 3-5, Table 3-6. The seafloor at WR313 H002 and WR313 H002 is projected to be at 6460 feet below sea level (fbsl). We infer we will encounter similar lithology and horizon depths as at the WR313 H001 well.

Unit 1 (0-520 fbsf) is composed of mud interlayered with thin coarse-grained layers. Within this mud interval, there are two intervals containing coarse-grained sediments, identified as the Aqua sand (202.0-264.0 fbsf, with a total of 12 ft of sand) and the Yellow sand (333.0-344.0 fbsf, with a total of 9.5 ft of sand) (Table 3-5). Both coarse-grained layers likely water-saturated however, the Aqua sand might contain a low concentration of gas hydrate in a ~1.5 ft thick interval. These intervals correlate with seismic reflections that are continuous between wells; the Aqua Sand has positive polarity and the Yellow sand has negative polarity. In the WR313 H001 well, Unit 1 was drilled with only water and occasional gel sweeps (Collett et al., 2009). No flows into the well bore were reported.

Unit 2 (520.0-1038.0 fbsf) is composed of mud with hydrate in near-vertical fractures and is called the JIP mud unit. The interval is interpreted as a mass transport deposit and is more compacted or de-watered than the overlying mud. The Red sand, an 8 ft thick coarse-grained layer is present in this interval at 958.0-966.0 fbsf (Table 3-5) and has hydrate at high saturation. The Red sand does not connect between the drilled wells WR313 H001 and WR313 G001. The Red sand is associated with a mappable seismic reflection (Horizon 0800), however, reflection characteristics are laterally variable. In the WR313 H001 well, this unit was drilled with only water and occasional gel sweeps (Collett et al., 2009). No flows into the well bore were reported.

Unit 3 (1038.0-2000.0 fbsf) is predominantly mud with one interval containing water-bearing thin coarse-grained layers (1096.0-1100.0 fbsf) and two thin marine muds containing pore-filling hydrate (1716.0-1722.0 fbsf and 1832.0-1846.0 fbsf) (Table 3-5).

Unit 4 (2000-2285.0 fbsf) is a muddy mass transport deposit, with two coarser intervals. The upper interval is a thinly-bedded hydrate-bearing coarse-grained interval (2017.0-2042.0 fbsf, total thickness of coarse-grained sediments is 12 ft). The lower interval is part of our key reservoirs for coring: the hydrate-bearing, thinly bedded Upper Blue sand interval (2180.0-2256.0 fbsf, total thickness of coarse-grained layers is 13 feet).

Unit 5 (beginning at 2285.0) is predominantly mud but contains one hydrate bearing thin pore-filling mud interval (2578.0-2580.0 fbsf) and the Orange sand (2642.0-2686.0, total thickness of coarse-grained sediments is 39 ft), which is a thick hydrate-bearing reservoir and the primary coring target in WR313 H002. The BHSZ is likely to be encountered at WR313 H002 and WR313 H003 at approximately 2900 fbsf, however, there is no indication of this event on the well logs or seismic at the proposed locations. The total depth of WR313 H002 and WR313 H003 wells will be 3010 fbsf and it will lie within Unit 5. Based on interpolation of the BSR from nearby locations, the base of the hydrate stability zone is interpreted to be at 2935 fbsf. Thus, the well will cross the base of the hydrate stability zone. However,

Unit 5 is composed of marine muds and no hydrate or free gas is expected in this interval as was demonstrated by the adjacent WR313 H001 well.

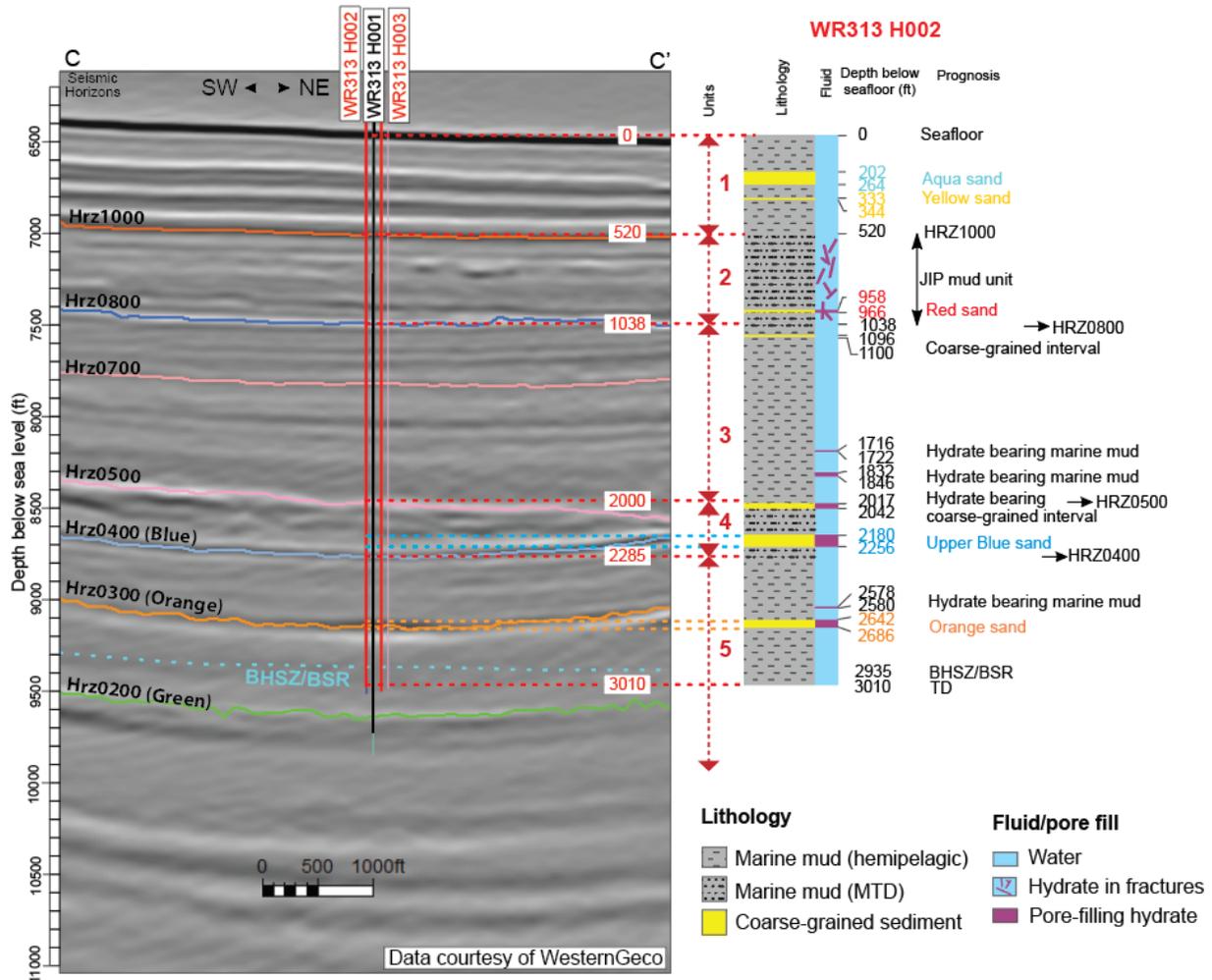


Figure 3-8. Seismic cross section CC' through Location WR313 H002 with interpreted lithology, hydrocarbon presence and major stratigraphic tops. Lithologic units (Units 1, 2, 3, 4, and 5) are marked next to lithology column in red; The line of section is located in Figure 3-7. Note that the displayed total depth of H002 is to the permitted depth of 3010 fbsf; not the expected as-drilled total depth of 965 fbsf.

Table 3-5. Projected tops for the proposed location WR313 H002 (Table 3-3). Note that tops are shown below the projected total depth of WR313 H002.

			Water depth (ft)	Drilled Footage (fbsf)	Total depth (fbsl)	
WR313 H002			6,460.0	3,010.0	9,470.0	
Events, Sands & Units			WR313 H001	WR313 H002		
			Depth (fbsf)	Projected Depth (fbsf)	Projected Depth (fbsl)	
Seafloor			-	-	6,460.0	
water bearing Aqua sand	Top	Unit 1	201.5	201.5	6,661.5	
	Base		264.0	264.0	6,724.0	
water bearing Yellow sand	Top		333.0	333.0	6,793.0	
	Base		344.0	344.0	6,804.0	
Horizon 1000			520.0	520.0	6,980.0	
JIP mud unit with low concentration hydrate	Top		Unit 2	520.0	520.0	6,980.0
hydrate bearing Red sand	Top	958.0		958.0	7,418.0	
	Base	966.0		966.0	7,426.0	
JIP mud unit with low concentration hydrate	Base	1,038.0		1,038.0	7,498.0	
Horizon 0800			1,038.0	1,038.0	7,498.0	
water bearing coarse-grained interval	Top	Unit 3	1,096.0	1,096.0	7,556.0	
	Base		1,100.0	1,100.0	7,560.0	
hydrate bearing marine mud	Top		1,716.0	1,716.0	8,176.0	
	Base		1,722.0	1,722.0	8,182.0	
hydrate bearing marine mud	Top		1,832.0	1,832.0	8,292.0	
	Base		1,846.0	1,846.0	8,306.0	
Horizon 0500			2,000.0	2,000.0	8,460.0	
hydrate bearing coarse-grained interval	Top	Unit 4	2,017.0	2,017.0	8,477.0	
	Base		2,042.0	2,042.0	8,502.0	
hydrate bearing Upper Blue sand	Top		2,180.0	2,180.0	8,640.0	
	Base		2,256.0	2,256.0	8,716.0	
Horizon 400			2,285.0	2,285.0	8,745.0	
hydrate bearing marine mud	Top	Unit 5	2,578.0	2,578.0	9,038.0	
	Base		2,580.0	2,580.0	9,040.0	
hydrate bearing Orange sand	Top		2,642.0	2,642.0	9,102.0	
	Base		2,686.0	2,686.0	9,146.0	
Interpreted base of hydrate stability			2,935.0	2,935.0	9,395.0	

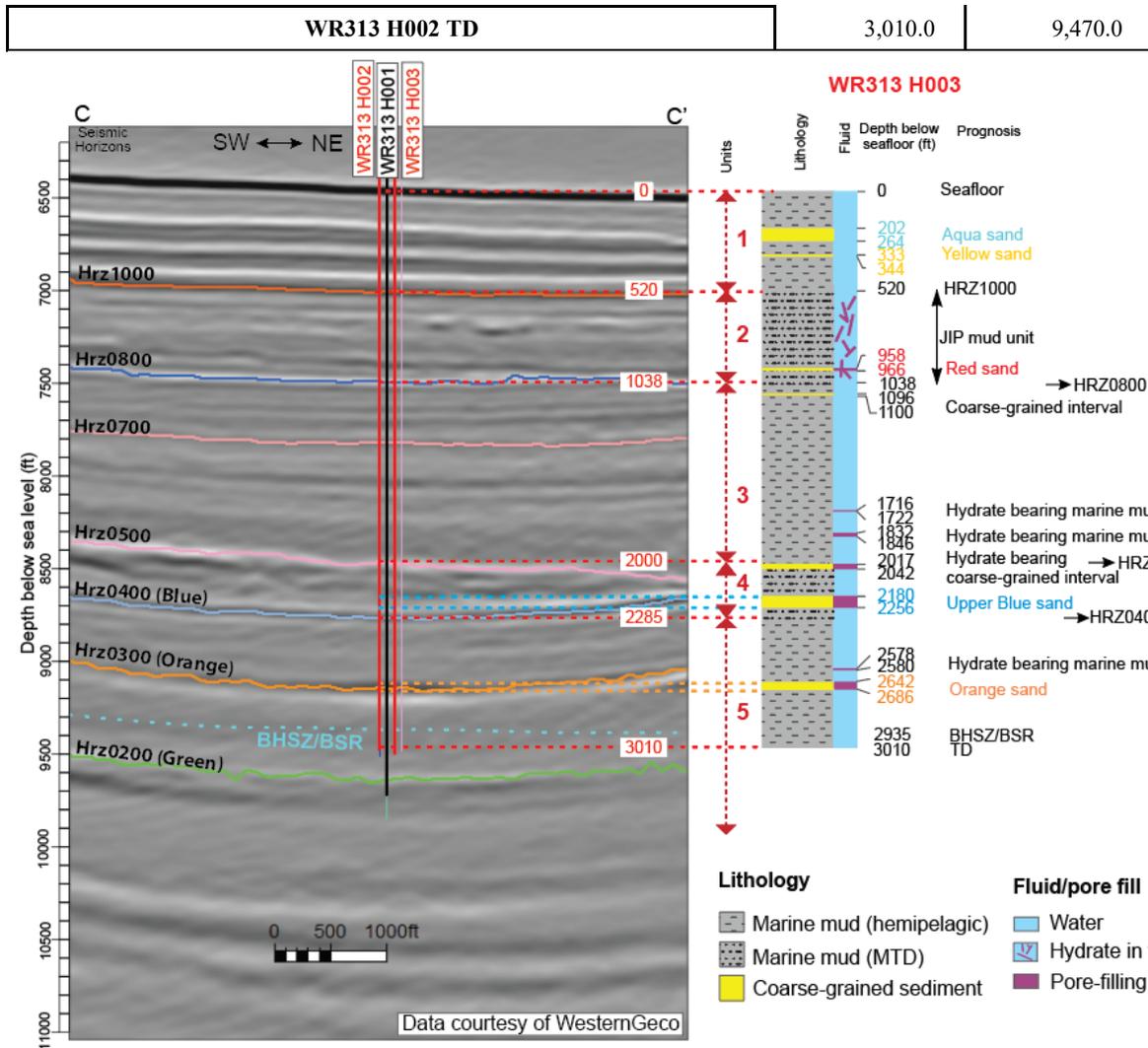


Figure 3-9. Seismic cross section CC' through Location WR313 H003 with interpreted lithology, hydrocarbon presence and major stratigraphic tops. Lithologic units (Units 1, 2, 3, 4, and 5) are marked on lithology column in red; the line of section is located in Figure 3-7. Note that the displayed total depth of H002 is to the permitted depth of 3010 fbsf; not the expected as-drilled total depth of 965 fbsf.

Table 3-6. Projected tops for the proposed location WR313 H003 (Table 3-3).

			Water depth (ft)	Drilled Footage (fbsf)	Total depth (fbsl)
WR313 H003			6,460.0	3,010.0	9,470.0
Events, Sands & Units			WR313 H001	WR313 H003	
			Depth (fbsf)	Projected Depth (fbsf)	Projected Depth (fbsl)
Seafloor			-	-	6,460.0
water bearing Aqua sand	Top	Unit 1	201.5	201.5	6,661.5
	Base		264.0	264.0	6,724.0
water bearing Yellow sand	Top		333.0	333.0	6,793.0
	Base		344.0	344.0	6,804.0
Horizon 1000			520.0	520.0	6,980.0
JIP mud unit with low concentration hydrate	Top	Unit 2	520.0	520.0	6,980.0
hydrate bearing Red sand	Top		958.0	958.0	7,418.0
	Base		966.0	966.0	7,426.0
JIP mud unit with low concentration hydrate	Base		1,038.0	1,038.0	7,498.0
Horizon 0800			1,038.0	1,038.0	7,498.0
water bearing coarse-grained interval	Top	Unit 3	1,096.0	1,096.0	7,556.0
	Base		1,100.0	1,100.0	7,560.0
hydrate bearing marine mud	Top		1,716.0	1,716.0	8,176.0
	Base		1,722.0	1,722.0	8,182.0
hydrate bearing marine mud	Top		1,832.0	1,832.0	8,292.0
	Base		1,846.0	1,846.0	8,306.0
Horizon 0500			2,000.0	2,000.0	8,460.0
hydrate bearing coarse-grained interval	Top	Unit 4	2,017.0	2,017.0	8,477.0
	Base		2,042.0	2,042.0	8,502.0
hydrate bearing Upper Blue sand	Top		2,180.0	2,180.0	8,640.0
	Base		2,256.0	2,256.0	8,716.0
Horizon 400			2,285.0	2,285.0	8,745.0
hydrate bearing marine mud	Top	Unit 5	2,578.0	2,578.0	9,038.0
	Base		2,580.0	2,580.0	9,040.0
hydrate bearing Orange sand	Top		2,642.0	2,642.0	9,102.0
	Base		2,686.0	2,686.0	9,146.0
Interpreted base of hydrate stability			2,935.0	2,935.0	9,395.0
WR313 H003 TD				3,010.0	9,470.0

3.5 Borehole Temperature and Hydrate Stability Field

In-situ temperatures and the methane hydrate stability-boundary have been estimated for the proposed WR313 locations (Figure 3-10). The in-situ temperatures were estimated based on the following assumptions: 1) the base of the hydrate stability zone at three-phase equilibrium 2) seawater salinity of 35 ppt, 3) pore pressure gradient of 0.465 psi/ft, 4) seafloor temperature of 4.0 °C or 39.2 °F (Boyer et al., 2018), and 5) temperature increasing linearly with depth from the seafloor. The base of the hydrate stability zone at the well locations was estimated using the BSR identified and mapped in 3D seismic data, and tied-to the depth of the Kiwi sand in existing well WR313 G001 (Table 3-6).

The predicted in situ temperature at WR313 G001 and WR313 H001 wells are shown as blue dashed line and green dashed line respectively (Figure 3-10). At the WR313 G001 well, we estimate the temperature at the base of the hydrate stability zone to be 72.1°F (22.3°C) and the gradient to be 10.7° F/1000 ft (5.9°C/1000 ft). At the WR313 H001 well, we estimate the temperature at the base of the hydrate stability zone to be 71.7°F (22.0 °C) and the gradient to be 11.0°F/1000 ft (6.1°C/1000 ft). The recorded temperature at WR313 G001 and WR313 H001 wells (blue and green lines respectively in Figure 3-10) show that flushing of the cooler drilling fluid brings down the borehole temperature considerably below the in-situ temperature, making the borehole more stable for hydrates.

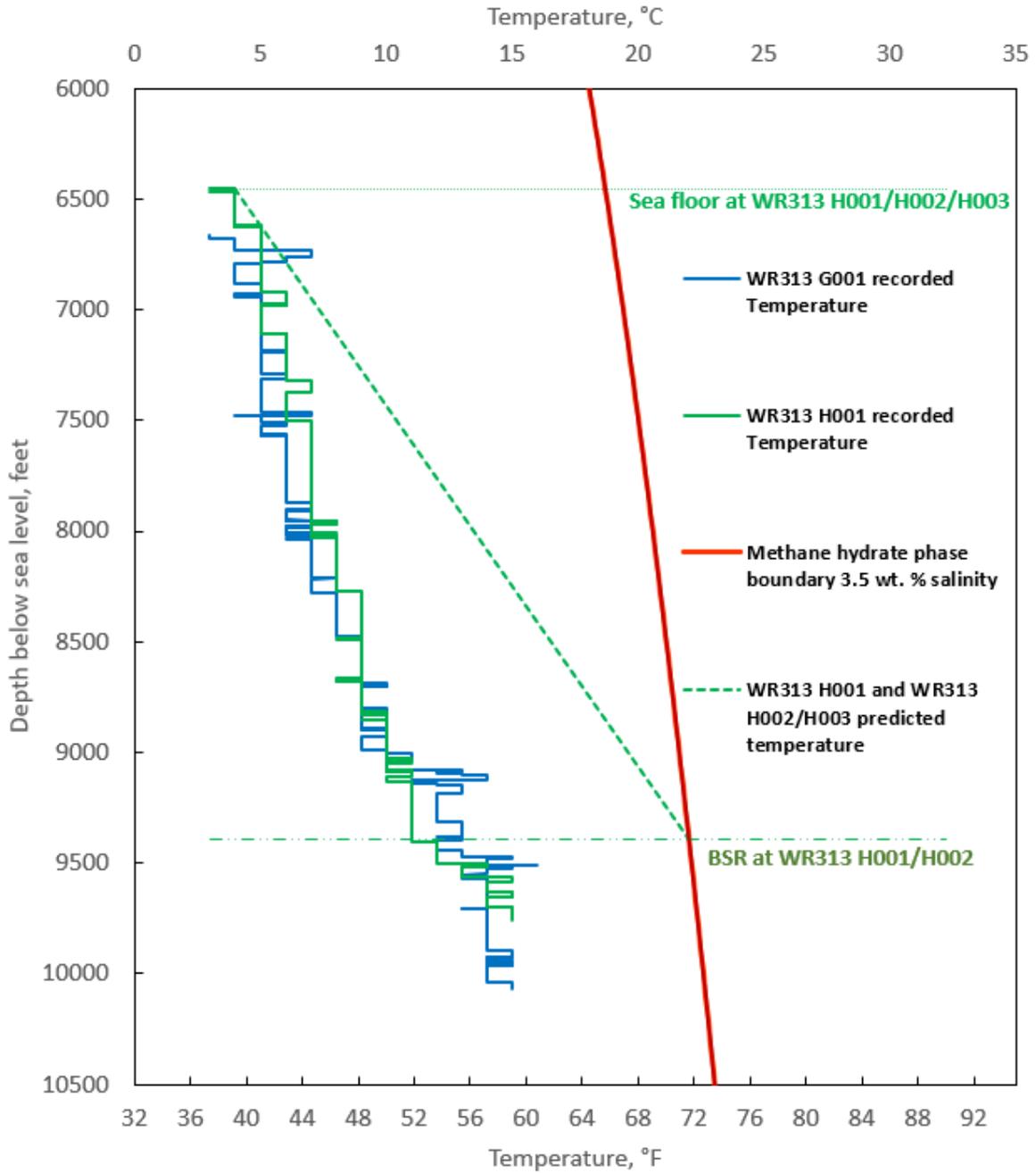


Figure 3-10. Estimated thermal gradient for WR313 G001 (blue dashed line) and WR313 H001 (green dashed line), in comparison with recorded borehole temperature (solid blue and green lines). Methane hydrate is stable on the left side of the hydrate stability phase boundary plotted in red. Horizontal lines represent interpreted base of hydrate stability zone in the wells, which intersect the corresponding predicted in situ temperature profiles at the hydrate stability phase boundary.

3.6 Pore Pressure Plots

3.6.1 Methodology

Based on seismic interpretation and offset well information from WR313 H001, the formations penetrated at the proposed locations are expected to be normally pressured. Figure 3-11 illustrates the well paths for the planned WR313 H002 and H003 wells. This diagram emphasizes the location of the

wells relative to significant hydrate reservoirs (the Blue, Orange, and Green sand). Although the Green sand is interpreted to be a significant hydrate-bearing reservoir, we will not be able to penetrate it in the hydrate-bearing section based on our decision to locate our wells at the previously drilled WR313 H001 (Figure 3-11). Within these reservoirs, we interpreted a gas leg to be present down dip from the hydrate-bearing zones (red zones, Figure 3-11). No gas leg is interpreted to be present in the Purple sand, and we have not included it in the diagram. The wells, which were all drilled in these locations previously without incident, are designed to avoid encountering free gas beneath the hydrate stability zone by penetrating the sands in the hydrate bearing intervals (green zones, Figure 3-11). Where we will penetrate the Blue and the Orange sand (Figure 3-11), we are at least 1,000 feet laterally away from the gas leg.

We generated pore pressure and fracture gradient plots for WR313 H002 (Figure 3-12) and WR313 H003 (Figure 3-13). The plots are based on the following assumptions. 1) The overburden stress (σ_v) was generated by integrating the density log from the LWD data acquired in WR313 H001. In zones where there were washouts and the density values recorded values near the density of water, density values were interpolated from the overlying and underlying zones to more effectively determine the overburden. 2) Pore water pressure was assumed to be hydrostatic (u_h) because there was no evidence of any elevated pore pressures during previous drilling of these wells. Hydrostatic pore pressure (u_h) is expressed with a pore pressure gradient of 8.95 ppg, or seawater gradient of 0.465 psi/ft. 3) The least principle stress (σ_{hmin}) was estimated using Equation 3-1.

Equation 3-1

$$\sigma_{hmin} = K * (\sigma_v - u_h) + u_h$$

Equation 3-1 is commonly used to model the fracture gradient (Eaton, 1969). K is termed the effective stress ratio and is equal to the ratio of the horizontal effective stress to the vertical effective stress. It is commonly used to model least principal stress in sedimentary basins. It is commonly observed in deepwater wells that in the shallow section (e.g. 1,000 feet below mud line), K values can approach 1.0. An upper bound of K = 0.9 and a lower bound of K = 0.7 is assumed (green dashed line and orange dashed line in Figure 3-12 and Figure 3-13).

The WR313 H002 well penetrates both the Orange and Blue sands in the hydrate-bearing interval (Figure 3-11). The WR313 H001 well at this location was drilled without incident with 10.5 PPG mud. We will drill with 10.5 PPG mud below 1600' ("mud program" in Figure 3-12). There is a gas leg in the Orange and Blue sands that is offset from the drilling location (e.g., Figure 3-11). Direct experience (two wells were drilled in this area) and observations of very low permeability in hydrate bearing intervals support that we will not observe these gas pressures at the location where the wells penetrate the hydrate-bearing interval.

The WR313 H003 well penetrates only the Blue sands in the hydrate-bearing interval. We illustrate a pore pressure plot of this well in Figure 3-13. The WR313 H001 well at this location was drilled without incident with 10.5 PPG mud. We will drill with 10.5 PPG mud below 1600' ('mud program', Figure 3-13).

There is a gas leg in the Orange and Blue sands that is offset from the drilling location (e.g., Figure 3-11). Direct experience (two wells were drilled in this area) and observations of very low permeability in hydrate bearing intervals support that we will not observe these gas pressures at the location where the wells penetrate the hydrate-bearing interval.

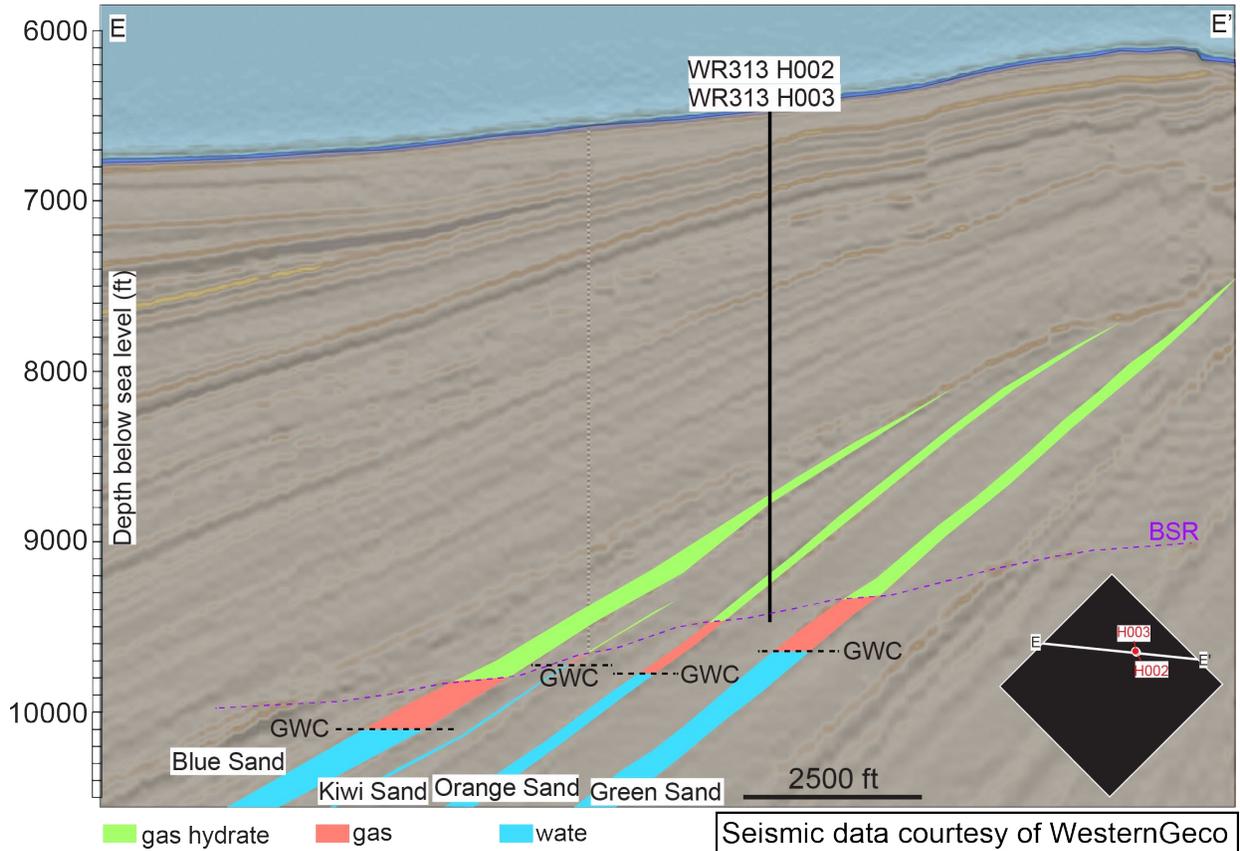


Figure 3-11. Seismic section EE' through proposed wells, showing hydrate-bearing sands, hydrate-gas contacts, and gas-water contacts.

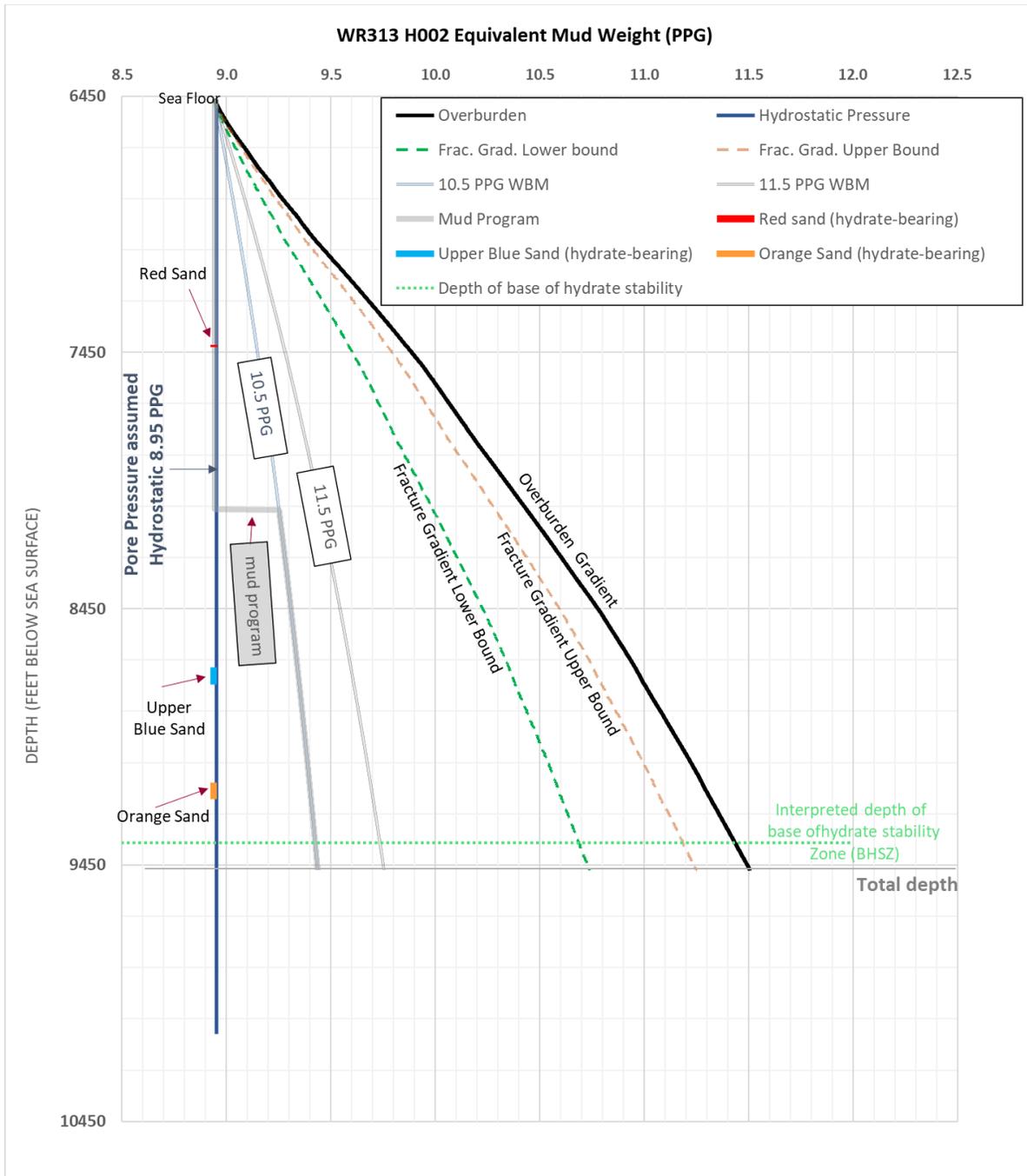


Figure 3-12. Equivalent mud weight plot for the planned WR313 H002.

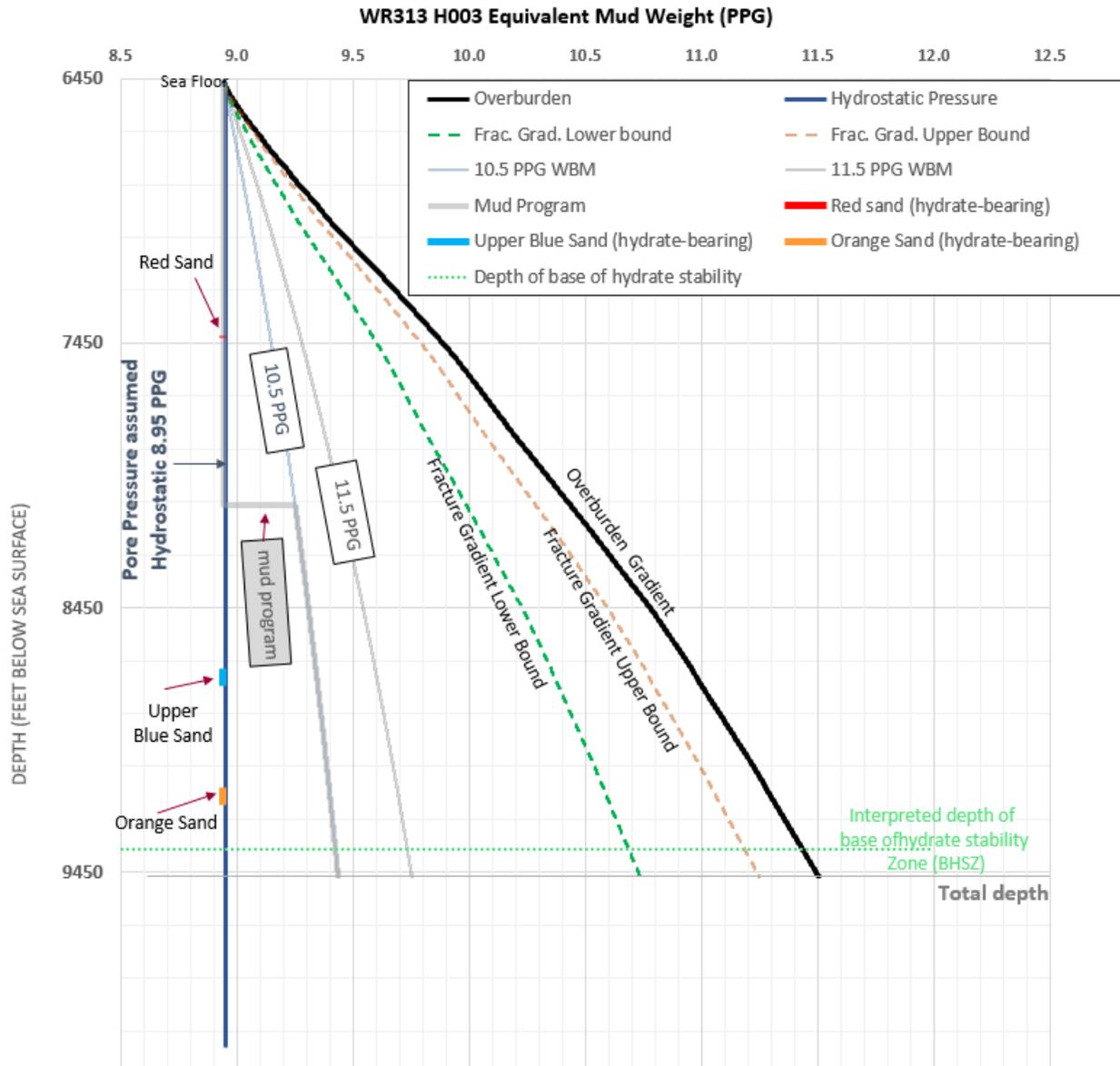


Figure 3-13. Equivalent mud weight plot for planned WR313 H003

3.6.2 Previous drilling

From the Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Logging-While-Drilling Operations and Challenges (Collett et al., 2009) and the IADC Drilling Reports for WR313 H well:

WR313 H001 was drilled during Gulf of Mexico JIP Leg II from Q4000 (April 29-May 1, 2009) using LWD technology. The seafloor was tagged at 6,501 ft md RKB (includes 52 ft air gap). A dual diameter BHA, with a 6-3/4" drill bit followed by an 8-1/2" hole opener, was used to drill from mudline to total depth at 9,886 ft md RKB (3,385 fbsf). The well spud protocol, developed to maintain good borehole conditions at the top of the hole, was followed: The first ~60 ft of the hole was drilled while circulating between 200-250 gpm of seawater and a rate of rotation of about 10-50 rpm. From 6,561 to 6,671 ft md RKB (60 - 170

fbfsf), the pump rate was slowly increased to ~250 gpm and the bit-rotation was increased to 50 rpm; after which point the drilling parameters were increased to 350 gpm and ~70 to 110 rpm. At 6,841 md RKB (340 fbsf), the pump rate was increased to 385 gpm to facilitate MWD directional surveys. From 6,501-8,501 ft md RKB (0-2,000 fbsf), the hole was drilled using seawater with WBM sweeps pumped very few stands. Fracture filling gas hydrate was encountered at 7,050-7,400 ft md RKB (549-899 fbsf). At 8,501 ft md RKB (2,000 fbsf), the instantaneous ROP was decreased to ~160 ft/hr in preparation for drilling the target zone of interest and the drilling fluid was changed to 10.5 ppg WBM. The controlled ROP of ~160 ft/hr and use of 10.5 ppg WBM continued for the remainder of the well. The primary target, consisting of two hydrate-bearing sand lobes (~15 ft and ~21 ft gross thickness), was encountered at ~9,096 ft md RKB (2,595 fbsf). After reaching the total depth of 9,886 ft md RKB (3,385 fbsf), the hole was circulated with 10.5 ppg drilling fluid, followed by displacement to 12 ppg WBM for abandonment.

Additional information on the drilling history can be found in the Gas Hydrate Joint Industry Project Leg II operational summary (Collett et al., 2009).

4 Drilling Program

The UT-GOM2-2 Scientific Drilling Program calls for penetrating several potential hydrate bearing sands throughout the boreholes. Cores, both unpressurized conventional and pressurized, will be acquired at various depths throughout. Based on drilling results from the 2009 JIP II Methane Hydrate LWD program, anticipated typical drilling/coring operations are as follows.

1. Drill/core to the top of the uppermost hydrate bearing zone with the potential to flow, or a maximum depth of 8103 fbsl (1640 fbsf), while circulating sea water and pumping 10.5 ppg high viscosity mud sweeps as required for hole cleaning.
2. Prior to penetrating the uppermost hydrate zone with the potential to flow, or a maximum depth of 8103 fbsl (1640 fbsf), begin continuous circulation of 10.5 ppg water-based mud for better hole cleaning, increased hole stability, and to counterbalance any overpressure from gas or water that may be present, and pumping 10.5 ppg high viscosity mud sweeps as required for hole cleaning.
3. At total depth (TD), displace borehole to 11.5 ppg high viscosity pad mud to support the cement plug from TD to approximately 150 feet above the upper most hydrate bearing zone with the potential to flow.
4. Emplace a cement plug beginning approximately 150 feet above the uppermost hydrate bearing zone with the potential to flow and extending upward for 300 feet.
5. Displace borehole with mud from top of cement plug to seafloor.
6. All boreholes will be visually observed via ROV continuously from spud to abandonment with an electronic video made and archived.
7. Neither well will have circulation back to surface while drilling/coring through the shallow interval above the SMT. Walker Ridge 313 has been classified as H₂S absent per email from Thomas Bjerstedt, Minerals Management Service (MMS), dated 4/3/2008.

4.1 Coring Bits

Two types of 9-7/8 in (250.8 mm) diameter Polycrystalline Diamond Compact (PDC) coring bits will be used. The first type is referred to as a face bit. The face bit has an opening through the bit face equal to

the core diameter. The face bit not only drills the borehole but also trims the core prior to it entering the core barrel (Figure 4-1). The second type is referred to as a cutting shoe bit. The cutting shoe bit has a hole through the bit face large enough to allow the core barrel to extend through the bit face (Figure 4-1). The cutting shoe bit drills the borehole while a cutting shoe attached to the bottom of the core barrel trims the core prior to it entering the core barrel.

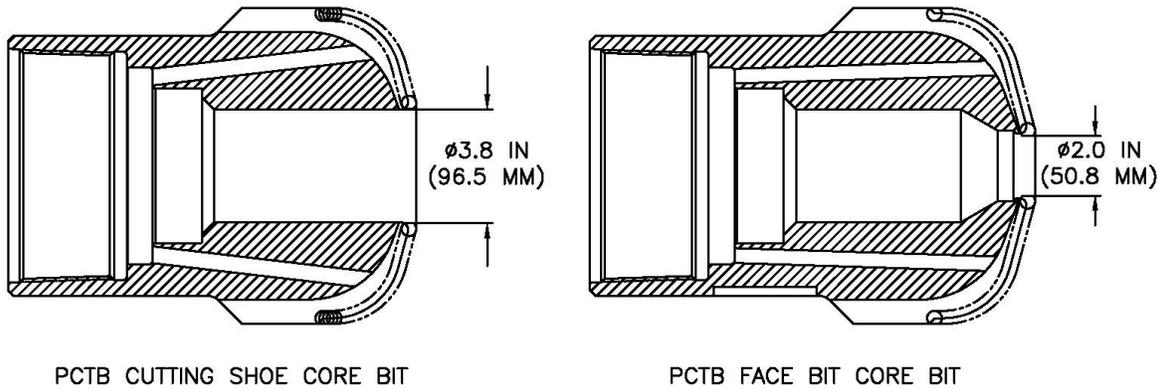


Figure 4-1. PCTB Coring Bit Configurations (Flemings et al., 2018)

4.2 Center Bit

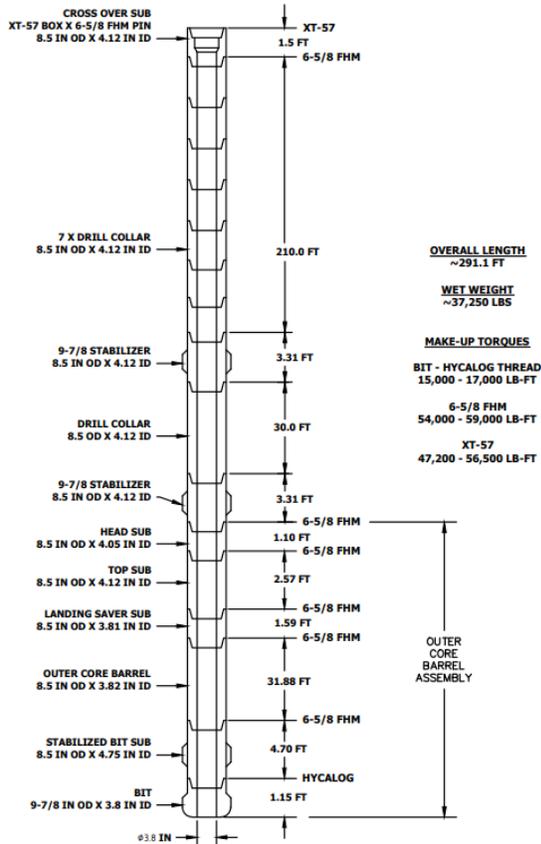
For drilling ahead in either coring bit configuration, a center bit is deployed via slickline which fills the hole through the coring bit face. The bottom end of the center bit incorporates PDC cutters so as to extend the coring bit cutting structure across the entire bit face.

4.3 Drill String

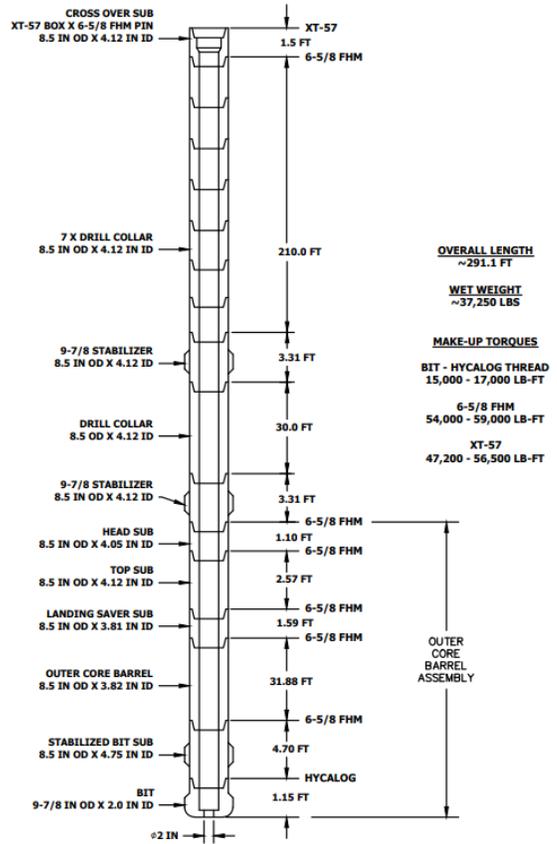
A cleaned, rattled, and rabbited (gauge-checked) drill string with a minimum 4-1/8 inch (104.8 mm) internal diameter is required to pass the coring tools which are deployed via slickline through the drill string. A 5-7/8 in, 28.3 ppf (adjusted weight), S-135 drill string with XT-57 connections (minimum drift diameter of 4.125 inches) will be used.

4.4 Bottom Hole Assembly

Two different bottom hole assemblies (BHA) referred to as the face bit BHA and cutting shoe BHA will be employed (Figure 4-2). As with the drill string, the BHA must have a minimum 4-1/8 inch (104.8 mm) internal diameter to pass the coring tools. The BHA provides weight and stiffness for drilling as well as a means for landing and latching the coring tools. The BHA is composed of custom 8-1/2 inch (215.9 mm) outside diameter by 4-1/8 inch (104.8 mm) inside diameter by 30 feet (9.1 m) long drill collars. Various subs for landing and latching the coring tools and attaching the coring bits are also included in the BHA. The face bit BHA and cutting shoe BHA are identical except for the type of coring bit attached. Both BHAs will have flapper valves installed to prevent back flow into the drill string when a coring tool or center bit is not in place.



PCTB CUTTING SHOE CONFIGURATION BHA SCHEMATIC



PCTB FACE BIT CONFIGURATION BHA SCHEMATIC

Figure 4-2. Drilling/Coring Bottom Hole Assemblies Configurations (Flemings et al., 2018).

4.5 Coring Tools

Several different types of coring tools will be employed as identified below. All of the coring tools are deployed via slickline and the compatibility of all tools with the PCTB-FB and PCTB-CS BHA's is outlined in Table 4-1.

Table 4-1. BHA to tool compatibility chart.

Coring Tools Compatibility Chart

Tool	Geotek PCTB-CS BHA	Geotek PCTB-FB BHA	IODP (USIO) APC/XCB BHA	IODP (USIO) RCB BHA	IODP (Japan) APC/XCB BHA	IODP (Japan) RCB BHA	Notes
APC (IODP USIO)	Yes	No	Yes	No	Yes	No	Geotek space out confirmation required.
XCB (IODP USIO)	No	No	Yes	No	No	No	Requires conversion to bottom drive to be compatible with PCTB-CS and IODP (Japan) APC/XCB BHA.
RCB (IODP USIO)	No	No	No	Yes	No	No	Requires conversion to bottom drive to be compatible with PCTB-FB and IODP (Japan) RCB BHA.
APC (IODP Japan)	Yes	No	Yes	No	Yes	No	Geotek space out confirmation required.
XCB (IODP Japan)	Yes	No	No	No	Yes	No	Geotek space out confirmation required.
RCB (IODP Japan)	No	Yes	No	No	No	Yes	Geotek space out confirmation required.
GAPC (Geotek)	Yes	No	Yes	No	Yes	No	Geotek space out confirmation required.
GXCB (Geotek)	Yes	No	No	No	Yes	No	Geotek space out confirmation required.
GRCB (Geotek)	No	No	No	No	No	Yes	May be compatible with PCTB-FB BHA in future.
PCTB-FB	No	Yes	No	No	No	Yes	Geotek space out confirmation required.
PCTB-CS	Yes	No	No	No	Yes	No	Geotek space out confirmation required.
T2P	Yes	No	Yes	No	Yes	No	T2P OD too large to pass through RCB/face bit.

GAPC: The Geotek Advanced Piston Corer is used to recover soft sediment cores unpressurized and requires the use of a cutting shoe BHA. Once the GAPC is landed in the BHA the drill string is pressurized until shear pins in the GAPC shear resulting in the GAPC core barrel being thrust through the coring bit and 31 feet (9.5 m) into the formation. After extraction of the GAPC the borehole is drilled down 31 feet (9.5 m) to undisturbed sediments (Figure 4-3). The GAPC will be fitted with the IODP APC temperature sensor ([APCT Tool Sheet \(tamu.edu\)](http://tamu.edu)).

GXCB: The Geotek eXtended Core Barrel is used to recover semi-indurated sediment core samples unpressurized and requires the use of a cutting shoe BHA. Once landed and latched in the BHA the GXCB rotates with the BHA while the borehole is advanced 31 feet (9.5 m) while capturing the core (Figure 4-4).

PCTB-FB: The Pressure Coring Tool with Ball Valve in the face bit configuration is used to recover pressurized core samples and requires the use of the PCTB-FB BHA. Once landed and latched in the BHA the borehole can be advanced up to 10 feet (3 m) while capturing the core. Upon recovery of the PCTB-FB, the ball valve is closed and the pressure chamber is sealed. The PCTB-FB is then recovered with the core maintained at near in situ pressure. (Figure 4-5, A and B)

PCTB-CS: The Pressure Coring Tool with Ball Valve in the cutting shoe configuration is used to recover pressurized hydrate core samples and requires the use of the PCTB-CS BHA. Once landed and latched in the BHA the borehole can be advanced up to 10 feet (3 m) while capturing the core. Upon recovery of the PCTB-CS, the ball valve is closed and the pressure chamber is sealed. The PCTB-CS is then recovered with the core maintained at near in situ pressure. (Figure 4-5, C and D).

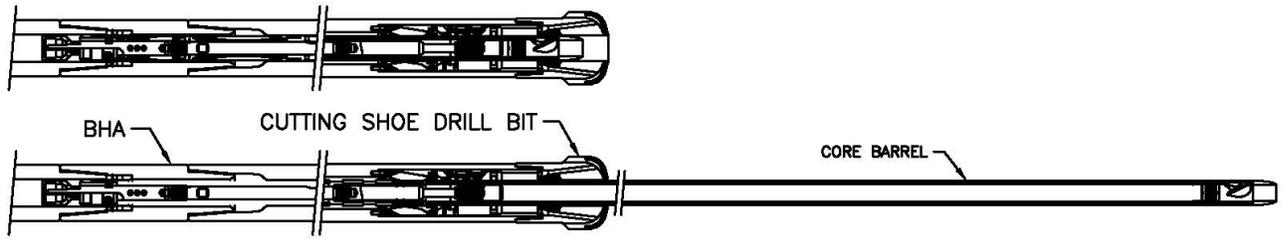


Figure 4-3. Geotek Advanced Piston Corer.

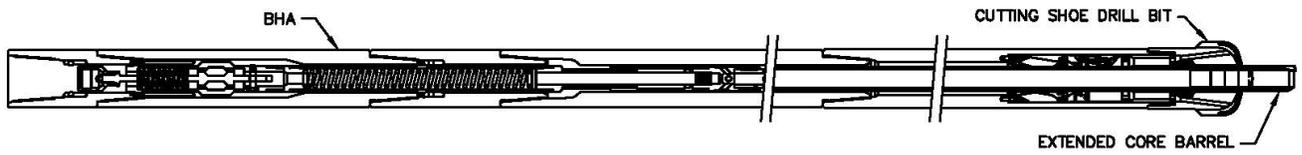


Figure 4-4. Geotek eXtended Core Barrel.

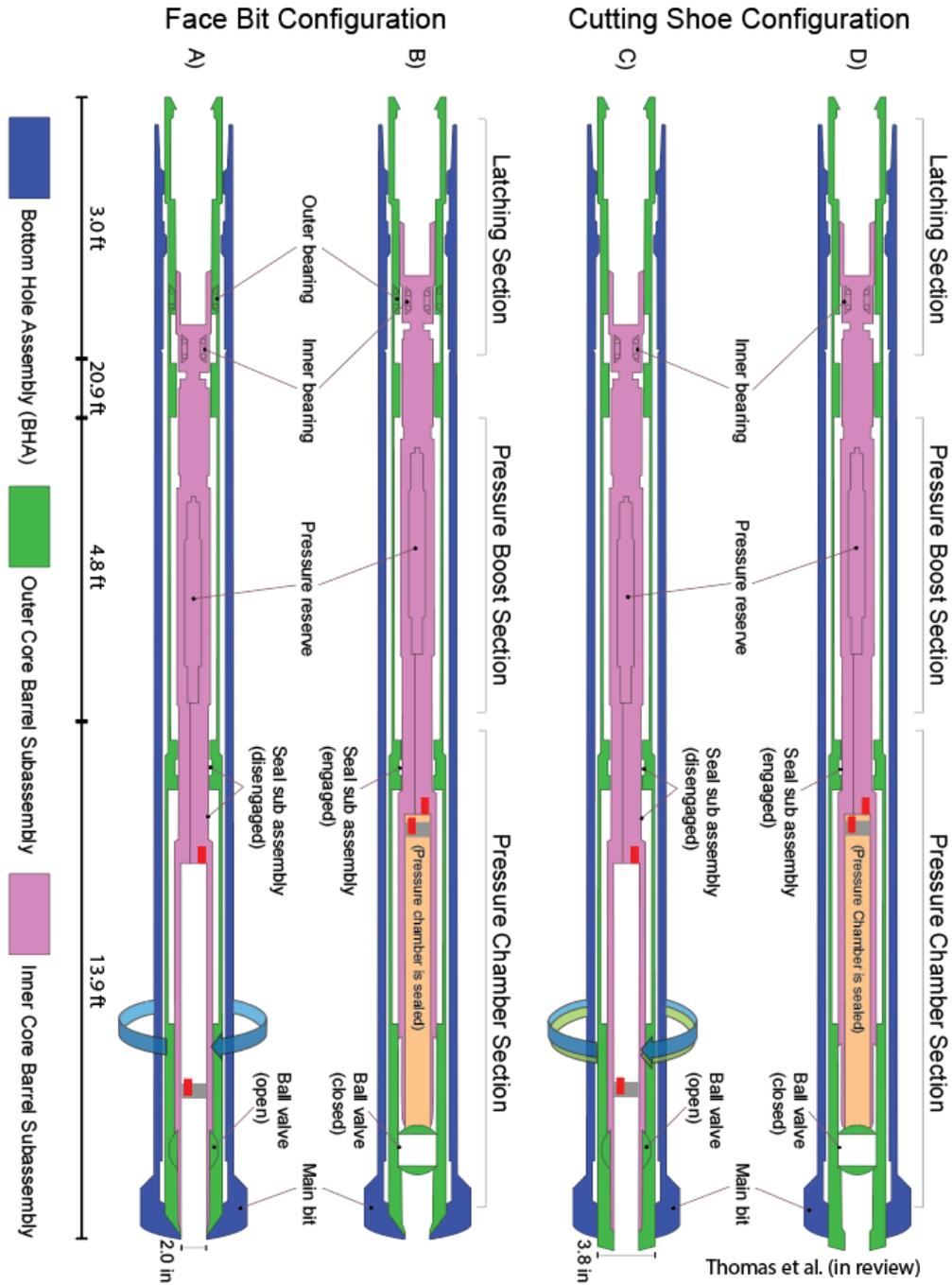


Figure 4-5. Pressure Coring Tool (PCTB) schematic Configurations. (A) PCTB-FB configuration during coring. In this configuration, the Outer (green) and Inner (pink) Core Barrel Subassembly move independently from each other and from the BHA. The blue arrow indicates direction of BHA rotation. (B) PCTB-FB during core retrieval. (C) PCTB-CS configuration during coring. In this configuration, only the Inner Core Barrel Subassembly moves independently from the BHA and the Outer Core Barrel Subassembly is locked to the BHA. The blue arrow indicates direction of BHA rotation and green arrow indicates that the Outer Core Barrel Subassembly rotates with the BHA. (D) PCTB-CS configuration during core retrieval. To initiate core retrieval the inner core barrel subassembly (in pink) is pulled up relative to the outer core barrel subassembly (in green). The locations of the Data Storage Tags are shown in red. The lower tag resides within a portion of the tool that moves up as the core fills the liner referred to as the rabbit. A third tag (not shown) is located in the pulling tool. The ratio of the width and length of the tool is not to scale; see scales (Thomas et al., 2020).

4.6 Slickline

A slickline is required for deployment of the coring tools, center bits, and survey tool. The slickline to be used is a 5/16 in (8 mm) diameter braided wireline with a safe working load capacity of 10,530 pounds. The slickline will be deployed through the top drive equipped with a line wiper such that any flow up the drill string can be controlled during coring operations. A third party slickline unit and appropriate operators will be supplied.

4.7 Borehole Inclination/Azimuth Surveys

All boreholes will be surveyed at least every 1000 feet of penetration and at total depth, for inclination and azimuth, using a third-party surveyor and gyroscopic survey tool deployed on slickline.

4.8 Rig Position Survey

Rig position surveys using a certified surveyor will be conducted prior to spudding to ensure proper location of the boreholes.

4.9 Site Surveys

Seafloor “as found” surveys will be conducted using an ROV at each location prior to spudding the boreholes to document condition of seafloor and to identify if any archaeological resources or obstructions are encountered. After abandonment, an “as left” site survey will be conducted using an ROV at each location and a clearance report will be prepared verifying that the site is clear of obstructions. All survey data will be archived electronically.

5 Mud Program

The UT-GOM2-2 Scientific Drilling Program operations will be carried out riserless resulting in all mud pumped out of the boreholes settling on the seafloor.

16 ppg water-based drilling mud will be delivered to the vessel via work boat. The 16 ppg working drilling mud will then be diluted onboard the vessel with water to achieve the desired weight. Chemicals will be added to the mud during the mixing process to achieve the desired viscosity and properties. A description of the various types of drilling mud anticipated to be used during the UT-GOM2-2 Scientific Drilling Program is given below.

5.1 Working Mud

16 ppg water-based mud will be delivered to the vessel via work boats and stored on board. The 16 ppg mud will be diluted with water to achieve the desired weight. Chemicals will be added to the mud during mixing process to achieve the desired viscosity and properties.

5.2 Kill Mud

2x deepest hole volume of 13.0 ppg mud will be held in reserve in the event that flow from a borehole occurs and heavy mud is required to stop the flow.

5.3 Drilling and Coring Mud

10.5 ppg mud will be continuously circulated while drilling and coring beginning prior to penetrating the uppermost hydrate zone with the potential to flow or reaching a maximum depth of 8103 fbsl (1640 fbsf).

5.4 Sweep Mud

10.5 ppg high viscosity mud will be mixed and stored for use in cleaning the borehole as required.

5.5 Pad Mud

11.5 ppg high viscosity pad mud, sufficient to support the planned cement column, will be mixed and used to displace the bottom of the borehole up to the depth at which the cement plug will be emplaced.

5.6 Abandonment Mud

11.0 ppg mud will be mixed and used to displace the borehole from the top of the cement plug to the sea floor.

6 Coring Program

The coring program reflects FY'23 funding.

6.1 Coring Plan Overview

At WR313, we will acquire pressure cores at WR313 H002 and H003 using the PCTB and PCTB bottom hole assembly (BHA), twinning the WR313 H001 location. Pressure cores will be acquired in the Orange sand, Blue sand, Red sand and at select locations to characterize the background mud. At WR313 H003, we will acquire conventional cores and in situ pressure/temperature measurements (Table 6-1) using the APC, XCB, and penetrometer with the PCTB-CS BHA.

6.1.1 WR313 H003

Using the Geotek Advanced Piston Corer (G-APC) tool, conventional-core will be taken from the seafloor to a depth where the APC Corer can no longer be used. Once the G-APC can no longer be used, conventional-core will be taken using the Geotek eXtended Core Barrel (G-XCB) to a depth of ~660 fbsf. PCTB-CS spot pressure cores will be acquired throughout the borehole from just below the Sulfate-Methane Transition (SMT) to 850 fbsf, followed immediately by a temperature and pressure penetrometer deployment (T2P). Continuous pressure-cores will be acquired in the Red sand (3 cores, complete interval), the Upper Blue sand (3 cores, partial interval), and the Orange sand (8 cores, complete interval). Additional pressure cores will be acquired above and below the Orange sand to total depth.

A total of 28 pressure cores are planned in this well. Additional pressure cores may be taken if time and resources permit (See Prospectus and Figure 6-1).

6.1.2 WR313 H002

Pressure cores will be acquired using the PCTB-FB tool. A center bit will be used to drill the borehole where pressure cores are not being taken.

Intermittent spot pressure-core pairs may be acquired above the Red sand to further develop a dissolved methane profile. PCTB-FB pressure core will be acquired in the Red sand (3 cores, complete interval). A total of 6 pressure cores are planned in this well. Additional pressure cores may be taken if time and resources permit. (see Prospectus and Figure 6-1).

Drilling

- PCTB-FB BHA w/ center bit
- PCTB-CS BHA w/ center bit

Tools and Coring

- APC conventional core
- XCB conventional core
- PCTB-FB pressure core (mud)
- PCTB-FB pressure core (sand)
- PCTB-CS pressure core (mud)
- PCTB-CS pressure core (sand)
- T2P penetrometer

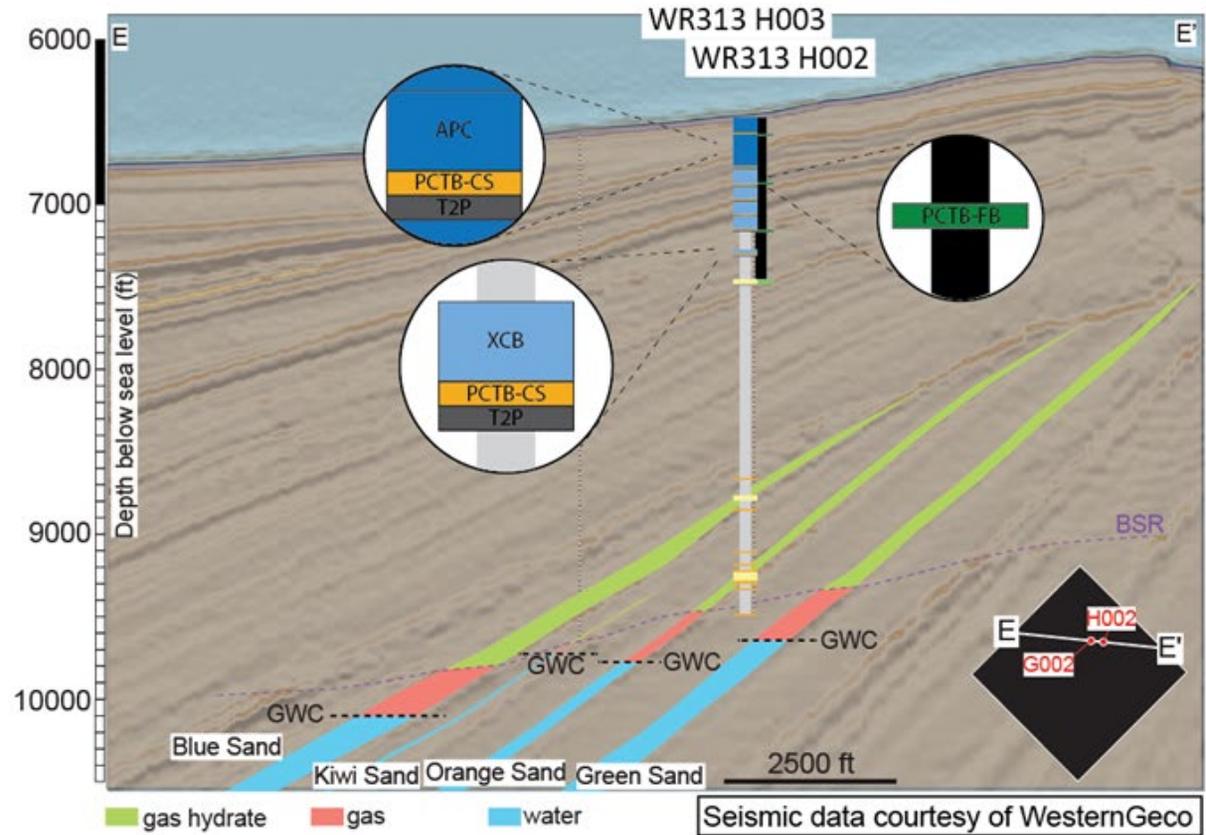


Figure 6-1. UT-GOM2-2 drilling and coring plan for WR313 H002 and WR313 H003. Not to scale.

The total length of pressure core recovered for WR313 H002 and WR313 H003, assuming 100% successful coring runs and 100% recovery with no fall-in, is 340 ft (103.6 m).

The total length of conventional core recovered for WR313 H002 and WR313 H003, assuming 100% successful coring runs and 100% recovery is 625 ft (190.5 m). This is the expected amount of core that will be logged using the Geotek IR and MSCL scanners. Table 6-1 outlines the various estimates of pressure and conventional core considering core type.

Table 6-1. Estimated total amount of pressure and conventional core based on core type, quality, pressure coring run success (core is sealed and held at a pressure within the hydrate stability zone) and core recovery (% of core barrel fill). Note that the amount of conventional core to process will increase assuming failed pressure coring runs produce depressurized core that can be treated as conventional core.

	Total Pressure Core		Total Conventional Core	
	ft	m	ft	m
TOTAL 2 HOLES (100% PC success, 100% recovery)	340	103.6	625	190.5
TOTAL 2 HOLES (70% PC success, 100% recovery)	272	82.9	693	211.2
TOTAL 2 HOLES (70% PC success, 80% recovery)	218	66.3	554	169.0

6.2 On-board Core Analysis

The UT-GOM2-2 core analysis program will focus on analysis of both pressurized and conventional cores. On-board core activities are summarized in Table 6-2. Details of the core analysis will be provided in the UT-GOM2-2 Science and Sample Distribution Plan.

Table 6-2. Summary of sample type, analysis type, with required laboratory space, equipment.

Sample Type	Activity	Where: Container or Lab	Equipment
Pressure core	Whole Core logging, CT scanning	PCATS11 + PCATS8	PCATS, PCATS water tank, supplies
Pressure core	Cryogenic degassing		Liquid Nitrogen chamber, Liquid Nitrogen, N2
Pressure core	Rapid depressurization		bags
Pressure core	Quantitative degassing w/ gas sampling	R17	4 degassing stations, SC120 storage racks, copper tubes, vacuum, other supplies
Gas samples	Hydrocarbons	Core Receiving	GC, computers, supplies
Whole round conventional core	Thermal imaging		MSCL-IR
Whole round core	Void gas collection; Cut whole round core into sections for pore water and microbiology; headspace gas sampling, Biostratigraphy sampling		Cutting tools and supplies, buckets, bags, etc.
Whole round core	sediment strength		hand vane and pocket penetrometers
Microbiology whole rounds	Processing microbiology samples	Core Processing	Cutting tools and supplies, N2 bag, -80 C Freezer, Whirlpaks, Flow hood, etc.
Headspace Gas sediment	Processing headspace gas samples		glass vial, cpas, crimpers
Void Gas	Tranferring gases to copper tubes		Copper tubes, vacuum
Pore Water whole rounds	Pore Water Extrusion and Squeezing	Pore Water Lab	4 squeezers and 2 glove bags
Pore Water	Time sensitive salinity and alkalinity		alkalinity titrator, refractometer, sampling bottles and preservation agents, freezer

6.2.1 Pressure Core Processing Flow

As time allows, pressure cores will be transferred to PCATS where they will get a “Quick scan” (1 cm resolution with 0-degree X-ray image) and/or a “Full scan” (0.5 cm resolution with 0- and 90-degree X-ray images) with CT imaging. Geotek will provide a recommendation, based on the Science Plan, for which sections should receive 3D imaging and which lengths will be cut. This recommendation will be reviewed by UT, with solicitation from others, and UT will make the final decision. When time is available, pressure cores from storage will be returned to PCATS for continued scanning, imaging, cutting, and transfer.

6.2.1.1 *PCATS: Quick Scan Analysis*

During the quick scan, cores will be logged (velocity, density) with 1 to 5 cm resolution and single scan 2D x-ray image will be taken. Then that core will be transferred to temporary storage in order to make PCATS available for the next core on deck. Fifteen temporary storage chambers capable of handling 10' long pressure cores will be available.

6.2.1.2 *PCATS: Full-Scan Analysis, Cutting, and Transfer*

Because pressure core should not be directly depressurized within the longer temporary storage chambers, all core that is stored in the temporary storage chambers must be cut into shorter sections in PCATS.

First, we will run full scans to obtain more accurate data with a higher sampling frequency (gamma density and P-wave data at a 0.5 cm resolution, 0- and 90-degree X-ray images) and acquire 3D X-ray computed tomography. We will use this data to make additional specific cuts. Secondly, sections of the core can be subsampled for quantitative degassing analysis. PCATS scans will allow the scientists to choose particular lithologies or zones within which to calculate dissolved methane in the pore water, hydrate concentration, and sample the resultant gasses. Thirdly, optimal 3.3' (1.0 m) subsections will be transferred to UT.

6.2.1.3 *Quantitative degassing*

Sections cut for degassing will be quantitatively degassed on board. Gases will be preserved and/or analyzed on-board, and the remaining core material will be treated as conventional core (see below).

6.2.1.4 *Cryogenic depressurization*

Sections cut will be cut, cryogenically frozen, and depressurized for microbiology studies.

6.2.1.5 *Rapid depressurization*

Sections cut will be cut and rapidly depressurized for pore water studies.

6.2.2 *Conventional Core Processing Flow*

Conventional cores will be IR-scanned and then cut into sections to be stored until dockside analysis. Some whole round sections will be cut for pore water squeezing, and ephemeral properties measured (alkalinity, pH, and salinity) on-board. Whole round sections will also be sampled and preserved for microbiology. Void gas samples will be collected. Sediment will be collected for headspace gas analysis. Hand vane and pocket penetrometers will be used as an initial estimate of sediment strength.

6.3 *Dockside Core Analysis*

The UT-GOM2-2 core analysis program is designed to meet the science objectives and will include the analysis of both pressurized and conventional core at Geotek Coring Inc (GCI), Salt Lake City.

Table 6-3 shows the core sample type required, activity, which container the activity will be either be performed, and the required equipment.

Table 6-3. Planned Analyses including sample type, analysis, location, and required equipment.

Sample Type	Activity	Where: Container or Lab	Equipment
Pressure core	Whole Core logging, CT scanning	PCATS11 + PCATS8	PCATS, PCATS water tank, supplies
Pressure core	Cryogenic degassing		Liquid Nitrogen chamber, Liquid Nitrogen, N2
Whole core sections	Whole core logging, CT scanning	MSCL	MSCL-S, CT scanner
Gas samples	Hydrocarbons	Core Receiving	GC, computers, supplies
Whole core sections	Cut whole round core into sections for microbiology, moisture and density, mechanical and physical properties		Cutting tools and supplies
Whole core sections	Thermal conductivity and Vane Strength		Thermal conductivity probe, Table Vane, Fall cone
Split core	Core splitting	Split Core	core cutters and supplies
Split core scanning	Linescan images, color reflectance scans, X-ray fluorescence (core scanning), near IR scan	MSCL Container	Split Core scanner
Split core	Visual description, and smear slide description	Geotek 40 ft Whole Core Processing Laboratory	Core splitter
Split core	Sample preservation for sedimentology (CHNS, TOC, grain size, isotopes), biostratigraphy, minerology, etc	TBD	sampling supplies

6.3.1 Dockside Pressure Core Processing Flow

Any cores that were not processed on-board will be processed dockside using ‘Full scan’ analysis, CT imaging, cutting, and transfer. Geotek will provide a recommendation based on the Science Plan for which sections should receive 3D imaging and which lengths will be cut. This recommendation will be reviewed by UT, with solicitation from others, and UT will make the final decision. All remaining pressure cores will be fully processed.

6.3.1.1 PCATS: Quick Scan Analysis

During the quick scan, cores will be logged (velocity, density) with 1 to 5 cm resolution and single scan 2D x-ray image will be taken.

6.3.1.2 PCATS: Full-Scan Analysis, Cutting, and Transfer

We will run full scans to obtain more accurate data with a higher sampling frequency (gamma density and P-wave data at a 0.5 cm resolution, 0- and 90-degree X-ray images) and acquire 3D X-ray computed tomography. We will use this data to make additional specific cuts. Secondly, sections of the core can be subsampled for quantitative degassing analysis. The PCATS scans will allow the scientists to choose particular lithologies or zones within which to calculate dissolved methane in the pore water, hydrate concentration, and sample the resultant gasses. Thirdly, optimal 3.3' (1.0 m) subsections can be chosen from the storage chambers and transferred UT.

6.3.1.3 Quantitative degassing

Sections cut for degassing will be quantitatively degassed on board. Gases will be preserved and /or analyzed dockside, and the remaining core material will be treated as conventional core (see below).

6.3.1.4 Cryogenic depressurization

Sections cut will be cut, cryogenically frozen, and depressurized for physical properties and microbiology studies.

6.3.2 Conventional Core Processing Flow

Conventional cores will be CT-scanned, logged using the MSCL-S. Whole round samples of core will be cut for moisture and density and mechanical measurements. Thermal conductivity and sediment strength will also be measured. The remaining core will be split into archival and working halves. Split core will be scanned (magnetic susceptibility, photo-scan, X-ray fluorescence, and color reflectance) and photographed. Sedimentology and Biostratigraphy Smear slides will be prepared and assessed. Discrete sediment samples will be collected for CHNS, TOC, grain size distribution, X-ray powder diffraction, and rock magnetism. Authigenic carbonate and sulfide will be collected if present. Additional samples for moisture and density and X-ray diffraction may be collected.

7 Plugging and Abandonment

The plugging and abandonment procedure employed will adhere to all applicable regulations for plugging and abandoning a borehole in the Gulf of Mexico. Several alternate compliances will be required, similar to the alternate compliances required for UT-GOM2-1. The final procedure will be reviewed by a third party registered professional engineer and all applicable regulatory bodies prior to initiating.

The Plugging and Abandonment Plan calls for emplacing a cement plug in the borehole beginning at approximately 150 feet above the upper most hydrate bearing zone with the potential to flow and extending upward for a minimum of 300 feet. Emplacement of the cement plug above the hydrate bearing zone, rather than across the zone, was chosen to prevent possible disassociation of the gas hydrate, due to the heat of hydration produced by the curing cement, that may lead to degradation of the cement plug integrity (Figure 7-1).

Prior to emplacement of the cement, the drill bit will be positioned near the bottom of the borehole, a cement liner inserted in the BHA, and the borehole displaced with an 11.5 ppg high viscosity (~100 lb/100 ft²) mud from total depth to approximately 150 feet above the upper most hydrate bearing zone with the potential to flow. The drill bit will then be raised to approximately 150 feet above the upper

most hydrate bearing zone with the potential to flow where sufficient 16.4 ppg Class H cement to fill 300 feet of the borehole plus 100 percent annular volume excess to account for any cement loss and borehole washouts will be pumped. The drill bit will then be carefully raised clear of the seafloor and flushed with seawater while waiting for the cement to cure.

After sufficient cement curing time as elapsed, the drill bit will be lowered in the borehole until the top of the cement plug is encounter. To confirm the top and integrity of the cement plug, 15,000 pounds weight on bit will be applied to the top of the cement plug. After confirming the top and integrity of the cement plug, the borehole will be displaced with 11.0 ppg mud and then the drill string will be recovered in preparation for abandonment of the borehole.

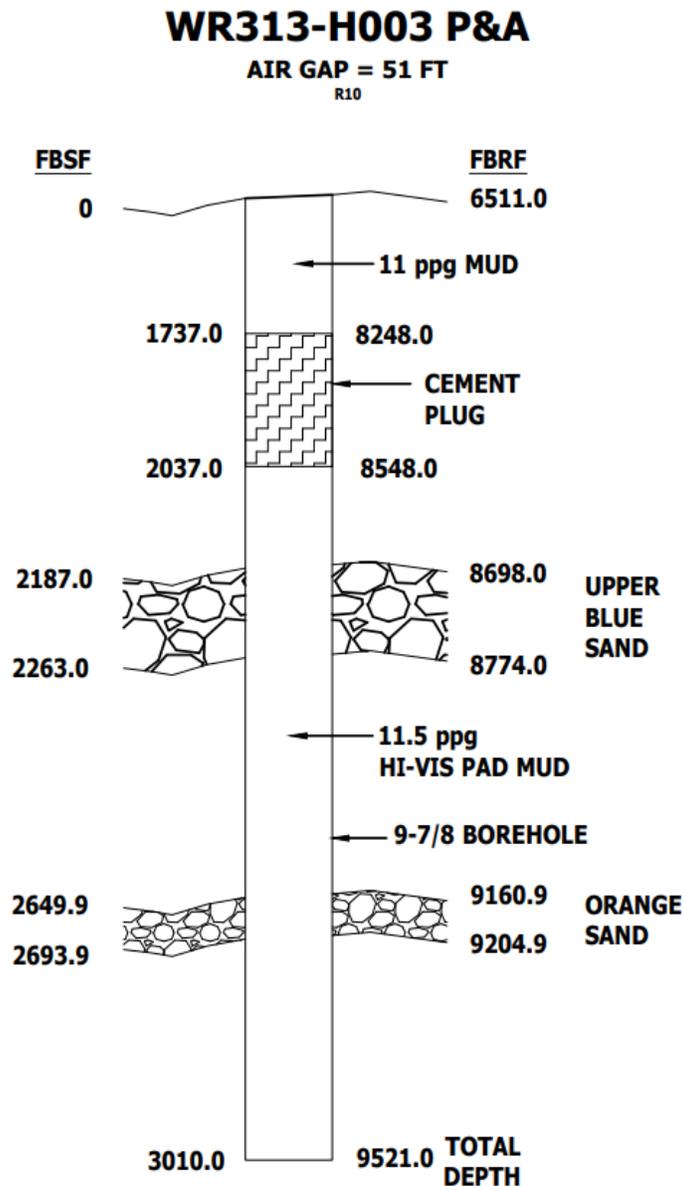


Figure 7-1. Plug and abandon cement plug emplacement hole schematic for H003.

8 Schedule

8.1 UT-GOM2-2 Hydrate Expedition Schedule

The UT-GOM2-2 Scientific Drilling Program is scheduled to commence during in spring of 2023. Mobilization, requiring 3.8 days, involves transporting the equipment from the port of embarkation to the vessel via work boats, loading the equipment onboard the vessel, and making all equipment ready for operations. Drilling and coring operations at sea require ~30 days to complete (Table 8-1, Table 8-2).

Demobilization, requiring 3.2 days, involves offloading all equipment from the vessel to work boats and transporting it to the port of debarkation. Once in the port of debarkation, most of the equipment will be shipped to Salt Lake City, UT where it will be used in dockside core analysis. Dockside core logging will take ~14 days to complete. Dockside core analysis by the UT Science Party will take 14 days to complete, after which all remaining equipment will be shipped back to its origin. Geotek will continue logging the split cores after the UT Science party has departed. The cores will then be shipped to various institutions for further analysis.

Total time to complete all operations is approximately 7.5 weeks.

Table 8-1. UT-GOM2-2 Scientific Drilling Program Overview

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
Mobilization	■	■							
UT-GOM2-2 Expedition	■	■	■	■	■	■	■	■	■
Demob				■	■				
Transit and Remobilization					■	■	■		
Dockside Core Logging						■	■	■	■
Dockside Science Party								■	■

Table 8-2. UT-GOM2-2 Scientific Drilling Program Offshore Operations Schedule

Task	On Site Operations Time incl 20% NPT (days)	Mob-Demob Time (days)
Rig mobilization (on location WR313-H003) and Full funtion tests		4.2
WR313-H003 coring operations. Transit to WR313-H002.	16.9	
WR313-H002 coring operations.	3.2	
Rig demobilization (on location WR313-H002)		3.2
Subtotals:	20.1	7.4
Total Expedition Time incl 20% NPT:	27.5	

8.2 Core Processing Schedule

8.2.1 PCATS pressure core acquisition time

The time to acquire one core using the PCTB can range from 3-6 hours. The assumed average rate is 5 hours.

8.2.2 Pressure Core Processing Time

Quick-scanning and transfer from the PCTB pressure chamber to temporary storage, in Geotek SC₃₅₀ chambers, takes 3.5 hours for a single 10' (3.1 m) pressure core. We assume that PCATS quick-scanning will be able keep up with the PCTB coring even during continuous coring operations. During intermittent pressure coring, there is sometimes enough time to completely process a pressure core in PCATS before the next one shows up.

There are four PCTB pressure chambers (autoclaves) and each pressure chamber must be emptied and cleaned before it is needed again at the rig floor. There are 15 SC₃₅₀ chambers each of which must be emptied and cleaned before it is needed again at PCATS. 35-41 SC₁₂₀ and 3-4 SC₃₀ pressure chambers will be available for storage and quantitative degassing.

Full-scanning can take up to 9.5 hours to for each 10' pressure core in PCATS depending on the number of cuts that will be made under pressure.

9 Risk Management

Risks are broken into 6 categories: Environmental, Personnel and Equipment, Meeting Science Objectives, Weather, Vessel Selection, and Cost Inflation.

9.1 Environmental

1. Release of fluids at the seafloor
 - a. In any riserless offshore drilling operation, there is the risk of the release of wellbore fluids to the water column if hydrostatic control is not maintained. There are two possible types of borehole fluid flows at the Walker Ridge 313 locations: 1) water flows and 2) gas flows.
 - b. Uncontrolled shallow flows can result in drilling delays or loss of well site.
 - c. The risk of these events is minimized in the following manner:
 - i. Avoid potential flow zones. Use seismic and previous well data to select surface locations and to design well paths that minimize the possibility of drilling into shallow formations with the potential of flowing fluids.
 - ii. Maintain hydrostatic control. Use appropriately weighted drilling fluids during drilling and in response to flow events to slow/stop the flow of fluids. Minimize lost circulation.
 - iii. Maintain visual observation of the wellbore returns at the seafloor via ROV camera for early detection of flow.
 - iv. Review of offset well data.
2. Release of pollutants from the rig
 - a. Spills can occur during transit (collision) or during transfer between rig & supply vessel. Spills of diesel fuel or other chemicals from the rig /supply vessel can also occur while on location.
 - b. Any releases of diesel are expected to evaporate and biodegrade within a few days.
 - c. Most chemicals used during the project will be either non-toxic or used in small quantities. Any spills are expected to have temporary localized impacts on water quality.
3. Operational discharges
 - a. Will be regulated as per the NPDES General Permit GMG290000.

- b. Are expected to only have short-term localized degradation of marine water quality.
- 4. Emissions impact on air quality
 - a. Emissions from routine activities are not expected to affect on shore air quality due to prevailing atmospheric conditions, emission heights, emission rates, distance of emissions from the coastline.
 - b. There are no plans for burning or flaring during this project.
- 5. Impact on marine life
 - a. Minimal to none expected.
- 6. Dissociation of gas hydrates
 - a. Hydrate dissociation can be either gradual or instantaneous when hydrates are heated or depressurized.
 - b. While drilling the boreholes, fluids cooler than the formation temperature will be introduced, which will act to further stabilize the hydrate zone.
 - c. Drilling-fluid weight will be controlled to maintain a positive pressure on the formation.
 - d. During P&A, the cement abandonment plug will be set above the hydrate zone to minimize destabilization concerns due to the cement heat of hydration while the plug sets.

9.2 Personnel and Equipment

- 1. During Drilling
 - a. Drilling involves dynamic use of heavy equipment, often under pressure, in a challenging and changing environment. There is risk to personnel and equipment inherent in this environment. Risks are mitigated by equipment & program design, preventative maintenance & inspections, strict adherence to procedure, job safety analyses, personnel competency & supervision, high quality safety culture, and use of a unified Safety Management System.
 - b. Loss of drill string during drilling or coring. The drill string can be dropped or become stuck in the borehole resulting in loss of the bottom-hole assembly (BHA) and part of the drill string. Mitigation includes drill string inspection prior to project commencement, operating within drill string & BHA design limitations, following good drilling practices and preventative equipment maintenance.
 - c. Loss of drill string due to geological event: It is possible, although very rare, that a submarine mass movement (e.g. landslide) could occur resulting in the loss of the drill string. Loss of equipment due to landslides is extremely rare. This risk is mitigated through location selection to avoid potential geological events.
- 2. While Handling High Pressured Samples
 - a. We will be recovering, transferring, and storing samples that are at significant pore pressures (up to 35 MPa).
 - b. The risk is mitigated in the following manner:
 - i. All pressure vessels are equipped with pressure release safety valves.
 - ii. Pressure cores will be transported by vehicle in 'over-pack' containers, a US DOT approved approach to transport of pressurized material.
 - iii. Strict adherence to proper procedure in the presence of pressurized containers.
 - iv. Hold pre-job safety discussions.

- v. Assure that personnel involved have been trained in the safe handling of pressurized samples.
- 3. While handling cores taken above and within the SMT zone in WR313 H003
 - a. Release of H₂S at the rig floor /core processing areas is not likely from H₂S entrained in cores taken above and in the SMT in WR313 H003.
 - b. Still the risks are mitigated in the following manner:
 - i. Strict adherence to proper procedure in the presence of cores potentially entrained with H₂S in WR313 H003.
 - ii. Assure that personnel involved have been trained in H₂S awareness and core-handling H₂S protocols.

9.3 Meeting Science Objectives

1. Table 9-1 lists the identified highest risks to not meeting the science objectives. Probability and Impact on meeting the science objectives were given a rating of 1 (lowest) to 3 (highest). Risk Rating is the product of the numerical values given to Probability and Impact. Risk Ratings correlate to the Risk Level as follows: 1-3 = Low, 4-6 = Med, 7-9 = High.

Table 9-1 Identified highest risks for meeting the Science objectives . A full list of all the identified risks and risk assessment for all the proposed objectives can be found at UT-GOM2-2_Risk_Analysis_2019-08-12.

UT-GOM2-2 Scientific Drilling Plan Identified Failures	Probability Rating	Impact Rating	Risk Rating	Risk Level
A1. Failure of the vessel operator to work with/understand requirements for pressure coring	1	3	3	Low
A2. Failure of the PCTB-FB to seal within the HSZ, tool error	1	3	3	Low
A4. Failure of the PCTB-CS to seal within the HSZ	2	1	2	Low
A6. Pressure Cores above 150-200m might not be good	2	1	2	Low
B2. G-RCB jams in the PCTB-FB BHA	2	2	4	Med
B6. Failure of the Geotek coring tool (G-RCB) to hold core	1	2	2	Low
E1. PCATS failure	1	3	3	Low
E2. Failure of any equipment on-board needed for ephemeral measurements	1	2	2	Low
E3. Failure of the T2P	2	2	4	Med
F0. Failure to secure a vessel	1	3	3	Low
F1. Failure to Secure Dockside rental space	1	2	2	Low
F2. Failure to Secure a location for conventional Core Analysis (e.g. Port Fourchon)	1	2	2	Low
H2. Bioactivity too low for any microbiology analyses	2	1	2	Low

9.4 Adverse Weather Conditions

1. During coring, bit bounce must be minimized/eliminated to allow successful recovery of the cored material. If the core bit lifts up off bottom before the core is completely cut; the core catcher will likely close on the core, making it impossible for more core to enter the inner tube. Keeping the bit on bottom is complicated by use of a floating drilling vessel which heaves in response to the sea state and other environmental conditions.
2. The maximum sea state for backloading and transporting pressured cores is 4 feet w/ wave heights up to 8.2 feet.
3. The risk is mitigated in the following manner:
 - a. Use active heave systems on the drilling vessel while coring
 - b. Schedule project to avoid hurricane season & minimize time during height of winter storm-season. The ideal weather window for coring activities in the Gulf of Mexico is April-May.

10 Drilling Vessel

A fit-for-purpose oil-industry deepwater drilling or intervention vessel has been contracted for 2023, the Helix Q-4000. Specific vessel requirements can be found in Appendix A.

11 Personnel

11.1 Project Organization

The UT-GOM2-2 Scientific Drilling Program will be managed by the University of Texas Institute for Geophysics (UTIG), an Organized Research Unit recognized by the University of Texas at Austin (UT). UTIG will manage and oversee all operations and analytical activities to ensure that project science objectives are accomplished.

There are six sub-recipient universities on this project: Ohio State University (Ohio State), Oregon State University (Oregon State), University of New Hampshire (UNH), University of Washington (UW), Tufts University, and Lamont-Doherty Earth Observatory at Columbia University (LDEO). Sub-recipients will participate in the UT-GOM2-2 Scientific Drilling Program to varying degrees according to their statements of work.

UT will contract subcontractors to fulfill various roles in the UT-GOM2-2 Scientific Drilling Program, including Pettigrew Engineering, Geotek, and Helix.

A project organization chart for the UT-GOM2-2 Scientific Drilling Program and core analysis activities is shown in Figure 11-1.

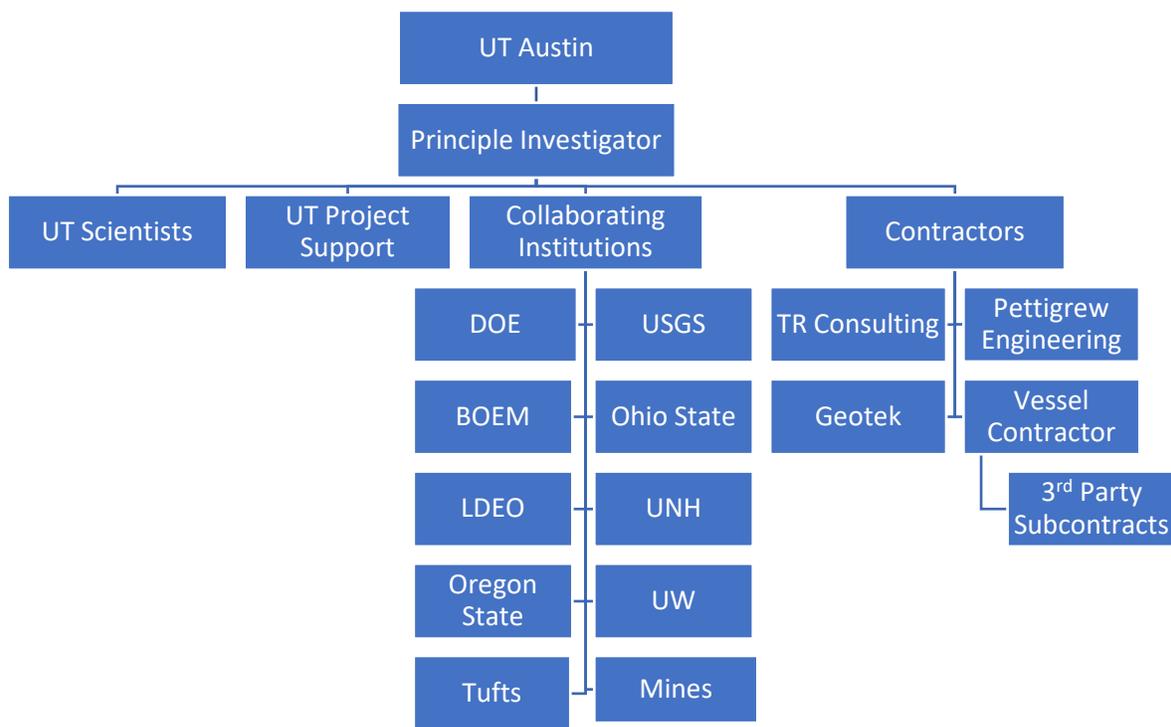


Figure 11-1. Personnel organization chart.

11.2 UT-GOM2-2 Scientific Drilling Program Personnel – Onboard

The roles, maximum number of persons, and anticipated institutions required to fulfill the UT-GOM2-2 Scientific Drilling Program, are shown in Table 11-1.

Table 11-1. UT-GOM2-2 onboard personnel

UT-GOM2-2 ONBOARD PERSONNEL			
ROLE / TASK	PERSONS H002	PERSONS H003	INSTITUTION
Company Man, Well Control / Safety Officer	2	2	TBD
Chief Scientist	1	1	UT
Staff Scientist	1	1	UT
Operations Reporting	1	1	USGS
Drilling Data and Core Log Integration	2	2	Ohio State
Pore Water Geochemistry	2	4	UW, others
Quantitative Degassing	4	4	UT, Geotek
Whole Core Processing	2	4	Oregon State, Ohio State
Pressure Coring/PCATS	12	12	Geotek, others
T2P	0	1	UT
Photography, Videography	2	0	TBD
TOTAL	30	32	

11.3 UT-GOM2-2 Scientific Drilling Program Personnel – Dockside Core Processing

The roles, number of persons, and anticipated institutions required to fulfill the UT-GOM2-2 dockside core analysis program, is shown in Table 11-2

Table 11-2. Dockside core analysis program personnel.

DOCKSIDE CORE ANALYSIS PROGRAM PERSONNEL		
ROLE / TASK	PERSONS	INSTITUTION
Chief Scientist	1	UT
Staff Scientist	1	UT
Pore Water Geochemistry	2	UW, others
Quantitative Degassing	4	UTIG, others
Whole Core Processing	2	Oregon State, Ohio State
Core Description	2	UNH
Biostratigraphy	1	UT
Physical Properties	1	UT, others
Whole Core Logging	2	Geotek
Core Splitting and Split Core Logging	2	Geotek
PCATS	4	Geotek
Degassing and Core Transfers	4	Geotek
TOTAL	26	

12 Permitting

Because the depth of penetration below the sea floor will be greater than 500 ft in each well, the wells will be considered “deep stratigraphic tests” per BOEM definition and permitted as such.

The UT-GOM2-2 Scientific Drilling Program will be drilled under the following permits and permissions:

- BOEM ‘Right of Use & Easement’
- BOEM ‘Exploration Plan’ including Coastal Zone Management ‘Federal-Consistency Certification’
- BOEM ‘Permit to Conduct Geological or Geophysical Exploration for Mineral Resources or Scientific Research on the Outer Continental Shelf (BOEM-0327)’
- BSEE ‘Permit to Drill’ (BSEE-0123)
- NPDES General Permit for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000).
- NEPA Categorical Exclusion Designation

13 Logistics

13.1 Designated Port and Heliport / Boat and Helicopter Services

Providers of port and helicopter services will be Bristow, based in Houma, Louisiana.

13.2 Mobilization / Demobilization Plans

UT will work with the Rig Contractor, Geotek, and port management to create Rig Mobilization and Demobilization logistics plans.

The Rig Mobilization Plan to include:

- Activities & Timeline
- Identification of Responsible Party
- Manifest
- Dimensions & weights of equipment to be transported to rig
- Equipment shipment-to-port transport notes
- Dock requirements (cranes, fork lifts, power, staging area, personnel)
- Supply Boats (vessel selection, sea-fastening requirements, service hook up, order for loading and unloading, and deck layout of containers on the supply boat)
- Deck Layout of the containers on the rig
- Personnel (numbers and departure schedule)

The UT Drilling Representative and Rig Contractor will coordinate port base logistics to ensure equipment arrives at the proper time and in the proper manner.

The Rig Demobilization Plan to include:

- Objectives of plan
- Activities & Timeline
- Identification of Responsible Party
- Manifest
- Dimensions & weights of equipment to be transported from rig

- Rig craneage required
- Dock requirements (cranes, fork lifts, power, staging area, container laydown area, personnel)
- Supply Boats (vessel selection, sea-fastening requirements, service hook up, order for back loading and unloading, and deck layout of containers on the supply boat)
- Dockside Geotek Site Plan (order of hook up and layout of the containers, etc.)
- Personnel (numbers and departure schedule)

13.3 Customs

UT, Geotek, and 3rd party members subcontracted by UT will work through UT with the Rig Contractor to ensure all personnel and equipment are properly documented and abide by US customs laws. Third party services subcontracted by the Rig Contractor will coordinate same through the Rig Contractor.

13.4 Trucking/Transport/Shipping

Arrangement for trucking of containers and equipment to/from the port will be the responsibility of the equipment owner/subcontractor. Prior to trucking; containers & contents will be properly secured for shipment and for offshore lifting. Loose equipment and materials are to be secured and transported in an offshore-rated basket. Mud materials are to be shrink-wrapped and palletized to protect materials during transport & storage. UT equipment and tools not stored in a container (e.g. BHA components) will be secured and transported in an offshore-rated basket. Third-party services subcontracted by the Rig Contractor will coordinate trucking delivery with the Rig Contractor, with input from the UT Drilling Representative. Return of containers, baskets, etc. will occur in a manner similar to delivery. All lifting elements (containers, slings, pad-eyes, etc.) will maintain current inspection and certification for offshore lifting (DNV) for the duration of the expedition.

13.5 Port Support

Shipment of supplies and equipment will be coordinated between the Rig Contractor and the Port Dispatcher with input from the UT Drilling Representative.

13.6 Supply Vessels and Crew Boats

Supply vessels and crew boats will be contracted by the logistics management provider (most likely the Rig Contractor) as required during execution.

13.7 Supplies and Equipment

13.7.1 Equipment

Sourcing and mobilization of 3rd party equipment subcontracted by the Rig Contractor will be handled by the 3rd party and the Rig Contractor with input from the UT Drilling Representative and UT.

All Geotek container/van logistics will be handled by Geotek; this includes but is not limited to shipping from UK, customs, storage, inspection, marking, and security. Geotek will also be responsible for the shipment and delivery of the PCTB storage van and heavy tools van to the port. Geotek will also manage the movement of Geotek and UT equipment from the port to the vessel and laydown of the equipment on the vessel. Timing for mobilization will be developed in conjunction with Rig Contractor, UT Drilling Representative, UT, and Geotek.

UT will be responsible for:

- Shipping Vans and equipment related to whole round core sampling to the port

- Shipment of all UT-supplied materials required by science team onboard the vessel during the expedition (e.g. RAID storage devices, printer, office supplies, etc.).
- Supplies and equipment related to Pore Water sampling; including providing a safe container lab with fridge, freezer, power, water, and drainage for the pore water sampling work.

All UT equipment removed from a container while onboard will be stamped/stenciled/painted with "Property of UT." All non-UT equipment and materials shall be stamped/stenciled/painted with the owner's name as per Title 30 CFR 250.300 (c).

13.7.2 Baskets & Containers

Baskets will be required for pipe and collars.

Pressure core operations and analysis will require a total of 4 containers - a 40-ft container for the PCTB, 40+20 ft containers for PCATS operations, and a 20-ft container for pressure core storage and degassing.

Conventional core operations will require an additional 7 containers on-board. Geotek will provide a 20-ft size container for conventional coring tools (which needs to be placed next to the PCTB Tools Van), a 20-ft container for storage, and a 40-ft container for MSCL-IR for cutting core into 1.5 m sections (which will be repurposed during demobilization for core splitting and curation). UT will provide a 20-ft container for whole round core (for microbiology, pore water, and physical properties) sampling; and two 10-ft containers for porewater squeezing and analysis. Geotek will provide a 20-ft container for conventional core storage and additional pressure core storage.

A 20-30 ft container will be provided by Helix for onboard science party office space. This container will provide countertop space for users and workstations, chairs, outlets, full network capabilities (either wired or wireless) that is both reliable and with internet access. It will need reliable climate control with ambient noise level in a range that is safe without hearing protection.

Expected basket & container requirements for the coring operations are summarized in Table 13-1 below.

Table 13-1. Name, type and size, container description, comparison to the previous expedition, container activities, mobilization location, and required hook-up, and required hook-up. Zoom in to read table.

Name	Type	Description	Reuse or New	Required Vessel Hook-up	Laydown Notes	Activities	Mobilization/ demobilization notes
Basket 1	40' basket	6 collars	Same as GOM2 1	None	Only required for supply boat transfer		Only required for supply boat transfer
Work Basket	40' basket	Collars and BHA subs	Same as GOM2 1	None	Work basket	Sub storage	Onboard, via supply boat
Nitrogen Pack	TBD						
Cold Shuck	NA	Cold Shuck	Same as GOM2 1	None	Only required for supply boat transfer		
Chillers	NA	Chillers on rig floor	Same as GOM2 1	Power 480 V 3 phase 30 amp			
Frame	20' Frame	Geotek large glycol chillers	Same as GOM2 1	Power 480 V 3 phase 200 amp water (1", 50 gpm) air (1", 110 psi) LAN jack (CAT6)	Will be used as a distribution point for other units		
PCTB Van	40' container	PCTB coring	Same as GOM2 1	From Geotek Utility Frame	Minimum laydown area 10 x 20'; under hoist that extends from PCTB Van	PC pressure checks, Some PCTB assembly, autoclave extraction, collect loose sediment	
CC Tools	20' container	Conventional Coring	NEW DNV	None	Required laydown area 10' x 60' to allow APC laydown and extraction of core; must be in-line with Core Receiving Lab	Geotek-APX/XCB handling, parts and supplies	
Storage	20' container	Tools Storage	NEW DNV	None			
PCATS11	40' container	PCATS Analysis	Same as GOM2 1	From Geotek Utility Frame	Attached to PCATS 8	Pressure core imaging, scanning, cutting, and transfer	
PCATS8	20' container	PCATS Autoclave and storage vessel handling	Same as GOM2 1	From Geotek Utility Frame	Attached to PCATS 11	Autoclave and PC storage handling, pressure core storage	
R17	20' container	Pressure Core storage and degassing	Same as GOM2 1	From Geotek Utility Frame		Pressure Core Storage, quantitative degassing	Powered on Supply boat during demobilization
Core Storage	20' container	Pressure and Conventional Core Storage	NEW DNV reefer	Power 480 V 3 phase 30 amp	*Or within crane access, level walking access preferred	Pressure Core Storage, Conventional core storage racks, and core transport	Powered on Supply boat during demobilization
Core Receiving Lab	40' container	Geotek Whole Core Processing Laboratory	NEW DNV	Power 480 V 3 phase 60 amp water (0.5", 5-15 gpm) air (0.5", 110 psi) LAN jack (CAT6)	Use same laydown area as CC Tools	MSCL-IR scanning, Void gas sampling, core sectioning, headspace gas sampling, sediment strength, Gas Chromatography, Data Processing	
Core Processing Lab	20' container	Microbiology, Headspace gas	Same as GOM2 1	Power 240/480 V 1 phase 50 amp water (0.5", 5-10 gpm) air (0.5", 110 psi)		Microbiology sub sampling, headspace gas processing	Powered on Supply boat during demobilization
Pore Water Lab	10' container	Pore Water Laboratory	NEW	Power 240/480 V 1 phase 50 amp water (0.5", 5-10 gpm) air (0.5", 110 psi)		Pore water, squeezing, analysis, and storage	
Pore Water Reefer	10' reefer			Power 480 V 3 phase 30 amp		Sediment extrusion and sample storage	
Q-4000 3 rd Party Conex	20' container	UT Office Space	Same as GOM2 1	None		Writing, Data Analysis	
T2P	Laydown Area	Wireline Pressure and Temperature Probe	NEW	None	Required laydown area 10 x 10 ft	T2P and PDT assembly	

13.7.3 Personnel

13.7.3.1 Training

All personnel, prior to arriving on the vessel, will have completed all training and certifications required by their company and the Rig Contractor (e.g. Well Control, HUET, Rig Pass). The science team, Geotek, and the UT Drilling Representative(s) shall provide a copy of training/certification documentation and passport to UT the Project Manager prior arriving at the heliport for travel to the rig.

13.7.3.2 Travel to Heliport

Travel of all science team members to/from the heliport will be coordinated by UT. Travel of Rig Contractor, Geotek, and third-party personnel will be the responsibility of the company involved.

13.7.3.3 Travel to/from Rig

Transport of personnel between the heliport facility and the rig will be coordinated between the UT Drilling Representative and the Rig Contractor. Transport of personnel will be primarily by helicopter. Helicopter trips will be scheduled/coordinated at maximum efficiency to reduce costs. At times, travel on crew boats or supply vessels may be required.

13.7.3.4 Passports / USCG Letter of Determination

All personnel will have a valid passport. Non-US citizens will also be required to have a USCG Letter of Determination allowing permission to work on the Outer Continental Shelf.

13.7.3.5 Rig Pass cards

Documentation denoting completion of the Rig Pass training program to be supplied by all personnel to the Rig Contractor, as required.

13.7.3.6 Luggage limits

All personnel will limit the size and weight of luggage under the assumption that they be transiting via helicopter.

13.7.3.7 Safety Management System

All personnel on-board the vessel will follow the Rig Contractor's Safety Management System. A bridging document will be prepared to identify and clarify which procedures/policies to follow if there are differences in policy between the Rig Contractor and UT. The highest standard will be followed.

13.7.3.8 Incident Notification

UT will prepare an Incident Notification document with flow chart and call list of contact names/numbers for Regulatory Agencies, UT Management, Geotek, UT Drilling Representative(s), and Science Team. BSEE notifiable incidents include: Fatalities, injuries that require evacuation, loss of well control, fires and explosions, spills > 1 bbl, reportable releases of hydrogen sulfide, collisions (equipment damage greater than \$25,000), incidents involving crane or personnel/material handling operations, and incidents involving damage or disable safety systems or equipment including firefighting systems.

13.7.3.9 Shifts

All personnel will work a 12-hour shift. Shifts for the science team and Geotek will be coordinated prior to deployment. Rig Contractor and Third-Party Supervisors typically work a 6-6 shift (6 am to 6 pm or 6 pm to 6 am); with vessel and third-party crews working a 12-12 shift (noon to midnight or midnight to

noon). The UT Drilling Representative(s), Principal investigator, and staff scientist will most likely work a 6-6 shift with the science team and Geotek will working on a 12-12 shift.

13.8 Demobilization from Rig

13.8.1 Materials and Equipment

13.8.1.1 Disembarking Materials and Equipment

The Rig Contractor will work with third party services, Geotek, the UT Drilling Representative, and the port to ensure all supplies and equipment are removed from the vessel, delivered to the port, and loaded on trucks for transit at the port. Prior to backloading any Geotek equipment, Geotek will lead and UT will support a complete inventory of all Geotek and UT equipment. Geotek to provide supervisory oversight while their equipment is being backloaded to the demobilization vessel. Third party providers are responsible for securing and supervising the backloading of their equipment. A list of cement and mud products to be returned is to be provided to the UT Drilling Representative prior to the third-party representative leaving the drilling vessel.

13.8.1.2 Equipment left onboard

Should equipment be accidentally left onboard the drilling vessel; UT will work with the Rig Contractor to ensure timely delivery to the port.

13.8.1.3 New Equipment

Any newly acquired UT-owned equipment (e.g. BHA subs delivered from factory directly to Rig Contractor) will be properly catalogued and prepared for demobilization along with existing equipment.

13.8.1.4 Waste

The Rig Contractor will backload mud and cement waste and coordinate disposal in an accredited onshore disposal site. The Rig Contractor will also coordinate the cleaning of the bulk tanks on the demobilization vessel after equipment and waste has been removed.

13.8.2 Personnel

13.8.2.1 Science Team and Third Party

Transport of personnel to the heliport will be coordinated between the UT Drilling Representative and the Rig Contractor. Helicopter flights will be scheduled/coordinated at maximum efficiency to reduce costs.

13.8.2.2 Pressure Core Observers

Geotek will elect two personnel to accompany the pressure cores on the demobilization vessel to ensure proper temperature and pressure is maintained in the transport containers at all times.

13.9 Remobilization Dockside (Salt Lake City, UT)

Pressure and conventional core processing will continue 'dockside' at Goetek Coring, Inc (GCI), Salt lake City. The processing area will be set-up using a number of containers demobilized from the rig. Additional containers and equipment will be mobilized to the processing area to complete the site.

13.9.1 Geotek Site Plan

Container layout & hook-up will be as per the Geotek Site Plan. Geotek will be responsible for coordinating the order of hook up & deck layout of the containers at the dock. Hook-up includes

appropriate dunnage, inclement weather engineering controls, power generators, fuel bowsers, air, water, etc.

13.9.2 Dockside Containers

Pressure core operations and analysis will require 4 containers to be remobilized at Geotek Coring Inc (GCI). Geotek will have a 40+20-ft container (for PCATS operations and storage chamber storage), a 20-ft container for pressure core storage and degassing, and PTRANS36 for pressure core transport.

Conventional core operations will require 3 containers, 2 remobilized and 1 new. Geotek will provide a new (not from the vessel) 20-ft trailer for MSCL scanning and CT imaging. The Geotek 40-ft container for whole core receiving and 20-ft container for core storage will be remobilized. UT's 20-ft container for whole round sampling will need to be remobilized. Geotek will also provide a permanent laboratory for split core scanning, layout, and analysis. They will provide an exterior covered lay down area for core splitting.

Expected container requirements for the dockside core-processing operations are summarized in Table 13-2 below.

Table 13-2. Dockside Container - name, type and size, container description, comparison to the previous expedition, container activities, mobilization location, and required hook-up

Name	Type	Description	Reuse or New	Activities	Mobilization/ demobilization notes
PCATS11	40' container	PCATS Analysis	Same as GOM2-1	Pressure core imaging, scanning, cutting, and transfer	Transport from rig to dock, hook-up at GCI
PCATS8	20' container	PCATS Autoclave and storage vessel handling	Same as GOM2-1	Autoclave and PC storage handling, pressure core storage	Transport from rig to dock, hook-up at GCI
R17	20' container	Pressure Core storage and degassing	Same as GOM2-1	Pressure Core Storage, quantitative degassing, gas sampling	Powered during transport from rig to GCI
Core Storage	20' container	Pressure and Conventional Core Storage	NEW	Pressure and Conventional core storage racks, and core transport	Powered during transport from rig to GCI
Core Receiving Lab	40' container	Geotek Whole Core Processing Laboratory	NEW DNV	Thermal Conductivity, Table Vane and Fall Cone, Whole round cutting	Transport from rig to dock, hook-up at GCI
Core Processing Lab	20' container	Microbiology, headspace gas	Same as GOM2-1	Microbiology sub sampling, headspace gas processing	Powered during transport from rig to GCI, No power required for transport back to Pro-Log
Geotek Office	40' container	UT Office Space	Same as GOM2-1	Writing, Data Analysis	NA - on site at GCI
MSCL /X-ray	20' container	Core Scanning, Core imaging	NEW	Whole core scanning	NA - on site at GCI
Split Core Tent	Tent	Core Splitting	NEW	Whole Core splitting	NA - on site at GCI
Split Core Lab	Permanent lab at GCI	Split Core Analysis	NEW	Split core scanning, layout, M&D weights, smear slide prep and sample preservation	NA - on site at GCI
Overpack - TRANS36	40' Reefer Truck	Overpack reefer truck	Same as GOM2-1	Pressure Core Transport over land	Powered during transport from port to GCI and GCI to UT

13.10 Dockside Core Processing

13.10.1 Samples and Cores

Detailed movement and processing of samples and cores will be as outlined in the UT-GOM2-2 Science and Distribution Plan.

13.10.2 Reporting

UT will provide a daily update to the UT-GOM2-2 Advisory Team with additional updates as required. UT will maintain close contact with GOM2 project manager, program manager, and IT support team.

13.10.3 Personnel

13.10.3.1 Room and Board

UT personnel will coordinate room and board for the science team. Third party members (e.g. Geotek) will be responsible for coordinating their own accommodations.

13.10.3.2 Shifts

Shift duration and timing will be decided by PI, staff scientist, and Geotek leads.

13.10.3.3 Supplies and Equipment

Shipment of supplies and equipment will be coordinated between UT, Geotek, and the Dock Dispatcher.

13.10.3.4 Safety Management System

All personnel will follow the port safety procedures. A bridging document will be prepared to identify and clarify which procedures/policies to follow if there are differences in policy between the Vessel Operator and UT. The highest standard will be followed.

13.10.3.5 Incident Notification

UT will prepare an Incident Notification document with flow chart and call list of contact names/numbers for Regulatory Agencies, UT Management, Geotek, and Science Team.

13.11 Demobilization from Dockside

Demobilization will be coordinated by Geotek, UT, and the Port Management. Exact division of responsibility will be agreed upon prior to departure but is dependent on yet to be decided factors, e.g. dockside location.

14 List of Acronyms

Table 14-1. List of Acronyms

ACRONYM	DEFINITION
°C	degrees Celsius
3D	3-Dimensional
AOM	Anaerobic Oxidation of Methane
APC	Advanced Piston Corer
APCT	APC temperature sensor
API	American Petroleum Institute radioactivity unit
ASTM	American Society for Testing and Materials
bbl	barrel
BHA	Bottom Hole Assembly
BHSZ	Base of Hydrate Stability Zone
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
BSR	Bottom Simulating Reflector
C1-C5	hydrocarbons methane, ethane, propane, butanes, and pentanes
CC	Conventional Core
cm	centimeter
C/N	Carbon to Nitrogen
CPP	Complimentary Project Proposal
CRS	Constant Rate of Strain
CT	Computed Tomography
DIC	Dissolved Inorganic Carbon
DOC	Dissolved Organic Carbon
DNA	Deoxyribonucleic Acid
DNV	De Norske Veritas AS
DOE	Department of Energy
DOT	Department of Transportation
DTS	data storage tag, wireless sensor with timestamped data storage (usually time, depth, pressure, and temperature)
fbsf	feet below sea floor
fbsl	feet below sea level
FBSS	feet below sea level (measurement includes depth of water)
ft	feet
ft ²	square feet
g/cm ³	gram per cubic centimeter
G001	first hole at location "G"

ACRONYM	DEFINITION
GAPC	Geotek Advanced Piston Corer
GC	Gas Chromatography
GCI	Geotek Coring Inc.
GHSZ	Gas Hydrate Stability Zone
GR	Gamma Ray
GRMA	Gamma Ray, Average
GWC	gas-water contact
GXCB	Geotek eXtended Core Barrel
HRZ	Horizon
HUET	Helicopter Underwater Escape Training
IEU	Internal-External Upset
IR	Infrared
JIP	Joint Industry Project
JR	JOIDES Resolution
LA	Louisiana
lb	pounds
LDEO	Lamont-Doherty Earth Observatory
LWD	Logging While Drilling
m	meter
m/s	meter per second
MD	Measured Depth
mm	millimeter
MODU	Mobile Offshore Drilling Unit
MSCL	Multi-Sensor Core Logger
msl	mean sea level
MTD	Mass Transport Deposits
NAD	North American Datum
NE	Northeast
NEPA	National Environmental Policy Act
NNE	North-Northeast
NPDES	National Pollutant Discharge Elimination System
PC	Pressure Core
PC	Pressure Core
PCATS	Pressure Core Analysis and Transfer System
PCTB	Pressure Coring Tool with Ball-Valve
PCTB-CS	Pressure Coring Tool with Ball-Valve - Cutting Shoe
PCTB-FB	Pressure Coring Tool with Ball-Valve - Face Bit
PDC	Polycrystalline Diamond Compact
PI	Principle Investigator
PPG	Pounds Per Gallon
psi	pounds per square inch
psi/ft	pounds per square inch, per foot
RAID	Redundant Array of Independent Disks
RES	Resistivity
RKB	Rotary Kelly Bushing (depth reference point)

ACRONYM	DEFINITION
RNA	Ribonucleic Acid
ROP	Rate of Penetration
ROV	Remotely Operated Vehicle
S _h	Hydrate Saturation (expressed as a % of pore volume)
sks	sacks
SMT	Sulfate-Methane Transition
SSW	South-Southwest
SW	Southwest
T2P	Temperature to Pressure Probe
TBD	To Be Determined
TD	Total Depth
TVD	Total Vertical Depth
UNH	University of New Hampshire
US	The United States of America
USCG	United States Coast Guard
USGS	United States Geological Survey
UT	The University of Texas at Austin
UTIG	The University of Texas at Austin Institute for Geophysics
UTM	Universal Transverse Mercator
UW	University of Washington
V _p	P-Wave Velocity
WBM	Water Based Mud
WR	Walker Ridge
XCB	eXtended Core Barrel
XCT	X-ray Computed Tomography

15 References

- Boswell, R., Collett, T. S., Frye, M., Shedd, W., McConnell, D. R., and Shelander, D., 2012a, Subsurface gas hydrates in the northern Gulf of Mexico: *Marine and Petroleum Geology*, v. 34, no. 1, p. 4-30.
- Boswell, R., Frye, M., Shelander, D., Shedd, W., McConnell, D. R., and Cook, A., 2012b, Architecture of gas-hydrate-bearing sands from Walker Ridge 313, Green Canyon 955, and Alaminos Canyon 21: Northern deepwater Gulf of Mexico: *Marine and Petroleum Geology*, v. 34, no. 1, p. 134-149.
- Boyer, T. P., Baranova, O. K., Coleman, C., Garcia, H. E., Grodsky, A., Locarnini, R. A., Mishonov, A. V., O'Brien, T. D., Paver, C. R., Reagan, J. R., Seidov, D., Smolyar, I. V., Weathers, K., and Zweng, M. M., 2018, *World Ocean Database 2018*, NOAA Atlas NESDIS 87: Silver Spring, MD, NOAA.
- Collett, T. S., Boswell, R., Frye, M., Shedd, W., Godfriaux, P., Dufrene, R., McConnell, D., Mrozewski, S., Guerin, G., Cook, A., Jones, E., and Roy, R., 2009, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Operational Summary.
- Collett, T. S., Boswell, R., Frye, M., Shedd, W. W., Godfriaux, P. D., Dufrene, R. S., McConnell, D. R., Mrozewski, S., Guerin, G., Cook, A., Jones, E., and Roy, R., 2010, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Logging-While-Drilling Operations and Challenges, Offshore Technology Conference, Offshore Technology Conference.
- Cook, A. E., Anderson, B. I., Malinverno, A., Mrozewski, S., and Goldberg, D. S., 2010, Electrical anisotropy due to gas hydrate-filled fractures: *Geophysics*, v. 75, no. 6, p. 13.
- Cook, A. E., Goldberg, D. S., and Malinverno, A., 2014, Natural gas hydrates occupying fractures: A focus on non-vent sites on the Indian continental margin and the northern Gulf of Mexico: *Marine and Petroleum Geology*, v. in press, p. doi:10.1016/j.marpetgeo.2014.1004.1013.
- Eaton, B. A., 1969, Fracture gradient prediction and its application in oil field operations: *Journal of Petroleum Technology*, v. 21, no. 10, p. 1353-1360.
- Flemings, P. B., Phillips, S. C., Collett, T. S., Cook, A. E., Boswell, R., and Scientists, U.-G.-E., 2018, UT-GOM2-1 Hydrate Pressure Coring Expedition Methods, *in* Flemings, P. B., Phillips, S. C., Collett, T. S., Cook, A. E., and Boswell, R., eds., *Proceedings of the UT-GOM2-1 Hydrate Pressure Coring Expedition*: Austin, TX, University of Texas Institute for Geophysics.
- Frye, M., Shedd, W., and Boswell, R., 2012, Gas hydrate resource potential in the Terrebonne Basin, Northern Gulf of Mexico: *Marine and Petroleum Geology*, v. 34, no. 1, p. 150-168.
- Hillman, J. I. T., Cook, A. E., Daigle, H., Nole, M., Malinverno, A., Meazell, K., and Flemings, P. B., 2017, Gas hydrate reservoirs and gas migration mechanisms in the

- Terrebonne Basin, Gulf of Mexico: *Marine and Petroleum Geology*, v. 86, no. Supplement C, p. 1357-1373.
- Shedd, W., Frye, M., Godfriaux, P., Dufrene, R., McConnell, D., Boswell, R., Collett, T., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., and Dai, J., 2010, Gulf of Mexico Gas Hydrates Joint Industry Project Leg II: Results from the Walker Ridge 313 Site, Offshore Technology Conference.
- Thomas, C., Phillips, S. C., Flemings, P. B., Santra, M., Hammon, H., Collett, T. S., Cook, A. E., Pettigrew, T., Mimitz, M., Holland, M., and Schultheiss, P., 2020, Pressure coring operations during The University of Texas-Gulf of Mexico 2-1 (UT-GOM2-1) Hydrate Pressure Coring Expedition in Green Canyon Block 955, northern Gulf of Mexico: *AAPG Bulletin*, v. 104, no. 9, p. 1877-1901.