Integrated Ocean Drilling Program
Expedition 308 Scientific Prospectus

Gulf of Mexico Hydrogeology

Overpressure and fluid flow processes in the deepwater Gulf of Mexico: slope stability, seeps, and shallow-water flow

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This IODP Scientific Prospectus is based on precruise Science Advisory Structure panel discussions and scientific input from the designated Co-Chief Scientists on behalf of the drilling proponents. During the course of the cruise, actual site operations may indicate to the Co-Chief Scientists and the Operations Superintendent that it would be scientifically or operationally advantageous to amend the plan detailed in this prospectus. It should be understood that any proposed changes to the science deliverables outlined in the plan presented here are contingent upon the approval of the IODP-USIO Science Services, TAMU, Deputy Director of Science Services in consultation with IODP-MI.

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ABSTRACT

Integrated Ocean Drilling Program Expedition 308 is an abbreviated form of Proposal 589-Full 3 entitled "Overpressure and Fluid Flow Processes in the Deepwater Gulf of Mexico: Slope Stability, Seeps, and Shallow Water Flow." We will explore the coupling of overpressure, flow, and deformation in passive margin settings. We will test a multidimensional flow model by examining how physical properties, pressure, temperature, and pore fluid composition vary within low-permeability mudstones that overlie a permeable and overpressured aquifer. Drilling, logging, and in situ measurements will be performed in the Brazos-Trinity #4 minibasin and in the Ursa region of the northern Gulf of Mexico. These basins are 300 km apart and have experienced very different Pleistocene sedimentation histories. Brazos-Trinity #4 will serve as a reference location because its low sedimentation rate generated little overpressure. In contrast, Ursa experienced extreme sedimentation rates, has high overpressures, and will serve as a type location to study overpressure and flow. Drilling and consequent postcruise studies will illuminate controls on slope stability, seafloor seeps, and large-scale crustal fluid flow.

Two key components of the experimental plan are to take substantial whole-core geotechnical samples for later shore-based analysis and to deploy a tapered penetrometer, the T2P probe (developed jointly between the Massachusetts Institute of Technology [MIT; USA], the Pennsylvania State University [USA], and IODP) to measure in situ pressure and temperature. Expedition 308 science will meet many of the objectives proposed in the original IODP Proposal 589-Full3 and will provide the foundation to implement long-term in situ monitoring experiments in the aquifer and bounding mudstones in a future expedition to meet the full objectives of IODP Proposal 589-Full3.

SCHEDULE FOR EXPEDITION 308

Integrated Ocean Drilling Program Expedition 308 is an abbreviated form of Integrated Ocean Drilling Program (IODP) drilling proposal number 589-Full 3 entitled "Overpressure and fluid flow processes in the deepwater Gulf of Mexico: slope stability, seeps, and shallow water flow" (available at **www.iodp-mi-sapporo.org/scheduled.html**). Following ranking by the IODP Scientific Advisory Structure, the expedition was scheduled by the IODP Operations Committee for the research vessel *JOIDES Resolution,* operating under contract with the U.S. Implementing Organization (USIO). The expedition is currently scheduled to begin in Mobile, Alabama (USA) on 31 May 2005, departing after a 5 day port call (or when ready). The expedition concludes in Balboa, Panama, on 6 July 2005 (for the current detailed schedule, see **www.iodp.tamu.edu/scienceops**). A total of 21 days will be available for the drilling, coring, and downhole measurements described in this report. Further details on the *JOIDES Resolution* can be found at **iodp.tamu.edu/publicinfo/drillship.html.**

INTRODUCTION

Hydrodynamics of Overpressure

Rapid sediment loading (>1 mm/y) drives overpressure (P^*, pressure in excess of hydrostatic) in basins around the world (Fertl, 1976; Rubey and Hubbert, 1959). Sedimentation is so rapid that fluids cannot escape, the fluids bear some of the overlying sediment load, and pore pressures are greater than hydrostatic (Fig. **F1**).

Recent work has focused on how sedimentation and common stratigraphic architectures couple to produce two- and three-dimensional flow fields. For example, if a permeable sand is rapidly loaded by a low-permeability mud of varying thickness, fluids flow laterally to regions of low overburden before they are expelled into the overlying sediment (Fig. **F2**). This creates characteristic distributions of rock properties, fluid pressure, effective stress, temperature, and fluid chemistry in the aquifers and bounding mudstones (Fig. **F2**). This simple process can cause slope instability near the seafloor (e.g., Figs. **F1, F2, F3**) (Dugan and Flemings, 2000; Flemings et al., 2002); in the deeper subsurface, this process drives fluids through low-permeability strata to ultimately vent the seafloor (Fig. **F3**) (Boehm and Moore, 2002; Davies et al., 2002; Seldon and Flemings, 2005).

Expedition 308 will document the spatial variation in pressure, stress, and rock properties in a flow-focusing environment. We will compare our observations to the model predictions. We will first establish rock and fluid properties at a reference location (Brazos-Trinity). We will then drill multiple holes along a transect in the overpressured Ursa system to characterize spatial variation in rock properties, temperature, pressure, and chemistry.

BACKGROUND

Geological Overview: The Gulf of Mexico

The Gulf of Mexico is a type location for a shallow drilling campaign aimed at understanding how sedimentation drives compaction and fluid flow (Fig. **F4**). Sedimentation, deformation, hydrodynamics, slope stability, and biological communities are interwoven in the Pleistocene strata of the Gulf of Mexico. Rapid sedimentation upon a mobile salt substrate is the driving force behind many of the active processes present (Worrall and Snelson, 1989). Bryant et al. (1990) describe the physiographic and bathymetric characteristics of this continental slope (Fig. **F4**). In the region of offshore Texas and western Louisiana, individual slope minibasins are surrounded by elevated salt highs (Pratson and Ryan, 1994) producing a remarkable hummocky topography. This morphology is obscured in the eastern Gulf, where sedimentation has been very rapid and more recent than the region of offshore Texas and Louisiana. To evaluate the impacts of different depositional settings and rates on sediment properties and fluid flow, Pleistocene sediments will be drilled in the Brazos-Trinity Basin #4 and the Ursa Basin (Fig. **F4**).

Geological Setting: Brazos-Trinity Basin #4

The Brazos-Trinity Basin #4 is 200 km due south of Galveston, Texas (USA) in ~1400 m water depth (Figs. **F4, F5**). The basin is one of a chain of five basins that are connected by interbasinal highs. It is a classic area for analysis of turbidite depositional environments because it is used as a modern analog to describe the formation of deepwater turbidite deposits (Anderson and Fillon, 2004; Badalini et al., 2000; Beaubouef and Friedmann, 2000; Fraticelli, 2003; Morton and Sutter, 1996; Satterfield and Behrens, 1990; Suter and Berryhill, 1985; Winker, 1996; Winker and Booth, 2000).

The primary data set used to evaluate the well locations is a high-resolution two-dimensional (2-D) seismic survey shot by Shell Exploration and Production Company to image the turbidite stratigraphy (Fig. F6). The line spacing is ~300 m. The four proposed drilling locations are shown on dip seismic Line 3020 (Fig. F7). A strike line through proposed Site BT4-2A is also illustrated (Fig. F8).

Proposed Site BT4-2A (Figs. F5, F6, F7, F8) is located where the turbidite deposits are thickest, whereas proposed Site BT4-4A (Figs. F5, F6, F7) is along the southern flank of the basin where there are almost no turbidite deposits. Shell drilled the Brazos-Trinity Basin #2 and encountered basinal turbidites composed of interbedded sands and mudstones and an underlying hemipelagic mudstone. Recovery may be difficult in the poorly consolidated turbidite sands at Site BT4-2A. Alternate sites BT4-3A and BT4-4A will have drilling conditions similar to BT4-1B, as they are located on the basin flank.

Geological Setting: Ursa Basin

Ursa Basin (~150 km due south of New Orleans, Louisiana [USA]) lies in ~1000 m of water (Figs. F1, F9). The region is of economic interest because of its prolific oilfields that lie at depths greater than 4,000 meters below seafloor (mbsf). Mahaffie (1994) described the geological character of the Mars oilfield. The Ursa field is in Mississippi Canyon Blocks 855, 897, and 899 and is 11.9 km east of the Mars tension leg platform (TLP).

We are interested in the sediments from 0 to 1000 mbsf. Four extraordinary three-dimensional (3-D) seismic data sets are available for the Ursa Basin (Fig. F9). Shell and industry partners shot the Ursa exploration survey for exploration purposes. The high-resolution surveys were shot by Shell for shallow hazards analysis.

Winker and Booth (2000) described deposition of Pleistocene and Holocene sediments in the Ursa region. The Mississippi Canyon Blue Unit is a late Pleistocene, sand-dominated, “ponded fan” that was deposited in a broad topographic low that extended in an east-west direction for as much as 200 km and a north-south direction for as much as 100 km. The Blue Unit is overlain by a leveed-channel assemblage that was mud dominated and had dramatic along-strike variation in thickness. Pulham (1993) described a similar facies assemblage for this region.

Seismic Line A–A′ (Fig. F10) illustrates the proposed boreholes. The sedimentary section is composed of a 300 m thick overburden that is predominantly mudstone. Beneath the overburden lies the first significant sand: the Blue Unit. The Blue Unit has a relatively flat base. Its upper boundary has relief, which most likely reflects postdepositional erosion. The Blue Unit is composed of interbedded sand and mudstone (Figs. **F10, F11**). A leveed-channel facies overlies the Blue Unit: it has a sand-cored channel that is flanked by mud-prone levee deposits. A mudstone package that thickens to the west overlies this sand assemblage. This mudstone package has numerous detachment surfaces that record slumping. The overlying mudstone is the eastern margin of a larger levee channel system formed to the west.

Shell made downhole pressure measurements with a pore-pressure penetrometer (piezoprobe) at the Ursa platform (Eaton, 1999; Ostermeier et al., 2000; Pelletier et al., 1999) (Fig. **F11**). They also acquired whole-core samples and performed consolidation experiments to evaluate preconsolidation stress and estimated overpressure. Piezoprobe measurements (circles) and maximum past effective stresses interpreted from consolidation experiments (triangles) indicate that (1) overpressure begins near the seafloor and (2) the pore pressure is ~50% of the way between the hydrostatic (P_h) and the lithostatic (σ_v) (Fig. **F11**).

SCIENTIFIC OBJECTIVES

We list six specific scientific objectives of Expedition 308.

1. Document how pressure, stress, and geology couple to control fluid migration on passive margins.

We hypothesize that flow-focusing is present at Ursa (Fig. **F3**). This results in a characteristic spatial distribution of fluid pressure and rock properties (e.g., consolidation, permeability, and shear strength) in the mudstone overlying the Blue Unit. By measuring fluid pressure, logging, and coring in the mudstone above the Blue Unit, we will establish the vertical and lateral variation in pressure and rock properties above the Blue Unit. This will provide a first-order test of the flow-focusing model and will image the flow system within the shale bounding the permeable sand unit.

2. Establish reference properties at Brazos-Trinity.

A critical goal of the research is to establish a reference log and core properties where overpressure is not present at a range of effective stresses. These data will serve as a baseline against which the properties measured at Ursa can be compared, allowing us to establish the deviation in sediment and fluid properties caused by flow-focusing, fluid overpressure, and low effective stress.

3. Illuminate the controls on slope stability.

Massive paleolandslides are present at Ursa. Determination of pore pressure, rock properties, and overburden stress will allow prediction of the potential for slope failure in the present and will allow estimation of the conditions that drove previous slope failures. The measured geotechnical properties are critical inputs of numerical models used to estimate what drives slope failure and when slope failure occurs.

4. Understand timing of sedimentation and slumping.

A growing issue of contention is just how rapid the sedimentation rate was in the Ursa Basin, what the age of slumping was, and how this ties to the sea level cycle. A successful drilling campaign integrated with existing well and seismic data will allow these issues to be evaluated with complete data sets.

5. Establish geotechnical and petrophysical properties of shallow sediments.

We desire to understand the state and evolution of geotechnical and petrophysical properties of mudstone at effective stresses encountered from the seafloor to 600 mbsf. We will derive a complete logging suite, in situ measurements of permeability and pressure, and core samples, which will allow us to understand the compaction process near the seafloor. These data will provide unparalleled insight into mudstone permeability. Permeability, compressibility, and sedimentation rate are the key parameters to understand the generation of overpressures. This study will illuminate how permeability of fine-grained mudstones evolves through time and changes in effective stress.

6. Provide extraordinary data set to observe ponded and channelized turbidite systems.

Brazos-Trinity and Ursa are foci of study for turbidite depositional systems.

IODP Expedition 308 is an abbreviated form of Proposal 589-Full3 entitled "Overpressure and Fluid Flow Processes in the Deepwater Gulf of Mexico: Slope Stability, Seeps, and Shallow Water Flow." The abbreviated program was originally described in addendum 589-Add, submitted to IODP on 22 October 2004. Two components of 589-Full3 will not be accomplished: (1) measurement of in situ pressure within the Blue Unit and (2) long-term monitoring of pressure using CORKS in the mudstone above the Blue Unit and in the Blue Unit. Subsequent to submission of 589-Add, the number of operational days was reduced to 21 from the 30 days envisioned in the addendum. As a result, double-coring at each site will not be possible and there will be only limited wireline logging.

DRILLING STRATEGY

We will complete two primary sites in the Brazos-Trinity Basin (proposed Sites BT4-2A and BT4-4A) and three primary sites at Ursa (proposed Sites URS-1B, URS-2C, and URS-3C) (Table **T1**). The overall strategy is to complete continuous coring, wireline logging, in situ measurements, and measurement-while-drilling (MWD) operations at each primary site (Tables **T2, T3, T4**). Operations will begin with advanced piston corer (APC) coring and in situ measurements at Site BT4-4A followed by APC coring and in situ measurement at Site BT4-2A. We will then complete MWD operations at Sites BT4-2A, BT4-4A, URS-3C, URS-2C, and URS-1B, respectively. MWD operations at the Ursa sites will include pressure while drilling (PWD) to determine the annulus pressure in the boreholes. Drilling operations will be completed with APC coring and in situ measurements at Sites URS-1B, URS-2C, and URS-3C, respectively. Upon completion of operations, all holes will be filled with heavy mud prior to abandonment. When moving between the proposed BT4 sites, the ship will move in dynamic positioning (DP) mode. DP mode will also be used to move between the proposed URS sites. Detailed operational times are provided in Table **T5.**

We expect problems with hole stability at Brazos-Trinity Basin #4, where we are drilling interbedded turbidite sands and hemipelagic mudstone. In these locations it is critical to have a full logging suite, and we will run both MWD and wireline logs. Hole stability may also be a problem at Ursa when drilling overpressured levee channel sands (interbedded sands and shales above the Blue Unit). To minimize risks of flow into the borehole, heavy mud will be used to drill and core portions of Sites URS-1B and URS-2C. The heavy mud will maintain the borehole pressure. The operational plan will include decision points and contingency plans detailing procedures to be followed in the event that unexpected hole conditions are encountered.

PROPOSED DRILL SITES

Primary Sites

Site BT4-2A

Primary proposed Site BT4-2A is located in the center of the Brazos-Trinity Basin #4 (Fig. **F7**). The site has 155 m of basinal turbidites underlain by 110 m of hemipelagic drape. Hole A will be drilled and cored to 340 mbsf with APC drilling with drillover. Extended core barrel (XCB) coring will be used if APC refusal is reached before 340 mbsf. Hole A will include three APC temperature (APCT) and one Davis-Villinger Temperature-Pressure Probe (DVTPP) temperature measurements and two temperature/dual pressure probe (T2P) deployments and will be the wireline logging/vertical seismic profile (VSP) hole. Hole A will be filled with heavy mud after operations. Site BT4-2A Hole B will be the dedicated MWD hole. Hole B will be offset 20 m from Hole A.

Site BT4-4A

Primary proposed Site BT4-4A is near the southern termination of Brazos-Trinity Basin #4 (Fig. **F7**). The site has a thin veneer of basin fill sediments (23 m) that is underlain by 128 m of hemipelagic mudstone. Site BT4-4A Hole A will be drilled and cored to 230 mbsf. APC drilling with drillover to refusal will be used. XCB coring will be used if APC operations do not reach 230 mbsf. Hole A will include three APCT and one DVTPP temperature measurements and two T2P deployments and will be used for wireline logging and VSP if time is available. Heavy mud will be used to fill Hole A. Hole B, the dedicated MWD hole, will be offset 20 m from Hole A.

Site URS-1B

Primary proposed Site URS-1B has the shallowest water depth (1057 m water depth) and the deepest penetration (612 mbsf) (Fig. **F10**). The anticipated lithology is hemipelagic mud. Interbedded levee sands may be encountered below 481 mbsf. A total depth of 612 mbsf completes drilling and operations 20 m above the top of the Blue Unit (632 mbsf). Hole A will be used for MWD measurements to include PWD (safety panel requirement). Hole B will be the drilling and coring hole, completed with APC drilling with drillover; XCB will be used if APC refusal occurs above 612 mbsf. Three APCT and one DVTPP temperature measurements will be made in the hole. Heavy mud will be used for coring from 481 to 612 mbsf to minimize risk of flow from levee sands. Wireline logging and VSP will be completed in Hole B. Site URS-1B Hole C will be used for five T2P deployments. APC half-cores will be collected before each T2P deployment. No additional coring is planned for Hole C. The hole will be filled with heavy mud. The offset between the holes will be about 20 m in a direction away from any channel fill.

Site URS-2C

The hemipelagic mudstones and levee sands at primary proposed Site URS-2C are 378 m thick above the Blue Unit (Fig. **F10**). We will drill to 358 mbsf, 20 m above the Blue Unit. Hole A will be used for MWD measurements including PWD (safety panel requirement). Hole B will be cored with APC drilling with drillover; XCB will be used if APC refusal occurs above 358 mbsf. Three APCT and one DVTPP temperature measurements will be made in the hole. Heavy mud will be used for coring from 328 to 358 mbsf to minimize the risk of sand flow from the levee sands. Wireline logging and VSP will be completed in Hole B if time is available. Site URS-1B Hole C will be used for five T2P deployments. APC half-cores will be collected immediately before each T2P deployment. No other coring is planned for Hole C. The offset between the holes will be about 20 m in a direction away from any channels.

Site URS-3C

Primary proposed Site URS-3C is located where the hemipelagic mud is thin (258 m) (Fig. **F10**). The drilling plan will penetrate to 238 mbsf to prevent any communication with the Blue Unit. Hole A will be used for MWD measurements. We will core Hole B with APC drilling with drillover; XCB will be used if APC refusal occurs above 238 mbsf. Three APCT and one DVTPP temperature measurements will be made in the hole. One deployment of the T2P will be made in Hole B. At 238 mbsf, the hole will be filled with heavy mud. The offset between the holes will be about 20 m. No wireline logging is planned at Site URS-3C.

Alternate Sites

Site BT4-1B

Alternate proposed Site BT4-1B is on the northern flank of the Brazos-Trinity Basin #4 where basin-filling turbidites overlie hemipelagic mudstone (Fig. **F7**). A drilling depth of 300 mbsf is proposed for this site in 1405 m of water. Hole B will be for MWD operations. Hole A will employ APC drilling with drillover and will include three APCT and one DVTPP temperature measurements. Two T2P deployments will occur in Hole B. Hole A and Hole B will be offset by 20 m.

Site BT4-3A

Alternate proposed Site BT4-3A is located on the southern flank of the Brazos-Trinity Basin #4 (Fig. F7) within a thin section of basin turbidites (87 m) that is underlain by a thicker section of hemipelagic mud (115 m). The site will be drilled through the hemipelagic drape to 280 mbsf. Hole B will be for MWD operations. Hole A will employ APC drilling with drillover and include three APCT and one DVTPP temperature measurements. Two T2P deployments are planned for Hole B. Hole A and Hole B will be offset by 20 m.

Site URS-4A

Alternate proposed Site URS-4A is similar to Site URS-3C with thin hemipelagic mudstone (257 m) above the Blue Unit, and overpressures are expected (Fig. F10). Drilling, coring, logging, and measurement operations are identical to those designed for Site URS-3C with a shift in total depth to 237 mbsf to allow 20 m between the base of the hole and the top of the Blue Unit (257 mbsf).

LOGGING AND DOWNHOLE MEASUREMENTS PLAN

The main objectives of the downhole measurements program will be to assess how pressure, stress, and geology control fluid migration on a passive margin; establish reference geotechnical and petrophysical properties at a site where overpressures are not present as well as in an overpressure zone; learn about factors controlling slope stability; determine major depositional events and timing of landslides; and provide information about turbiditic processes that occur along the continental slope. In addition, the downhole measurements plan will attempt to define structural and lithologic boundaries as a function of depth, establish site-to-site correlations to seismic and lateral lithostratigraphic variations, produce direct correlations with discrete laboratory data, and identify potential conduits that may serve as pathways for fluid migration. Finally, downhole measurements will complement core measurements by filling gaps in downhole stratigraphy, determining the thickness of lithological units in intervals where poor core recovery is prevalent, and provide the means for potential correlation with the extensive seismic data grid that is available over these areas. Both MWD and wireline logging tool deployments will be used to obtain the downhole measurements proposed for this expedition; the operational plans are described below.

Measurement While Drilling

At the conclusion of coring activities at the Brazos-Trinity sites, the operational plan will shift to logging activities with MWD capabilities at the two main sites, BT4-2A and BT4-4A (Table **T2**). These sites will serve as a reference location for physical and chemical properties. Site BT4-2A is located in the section of greatest overburden thickness above the hemipelagic shales. Site BT4-4A is located along the southern flank of the basin where there is almost no turbidite overburden above the hemipelagic shales. MWD operations will then follow at the three Ursa sites (URS-3C, URS-2C, and URS-1B). At the conclusion of the MWD operations, the tools and the MWD engineer will be offloaded to a transfer boat (Table **T5**). Overall, MWD data will provide information throughout the drilling depth on physical properties that will be used to test spatial variation in rock properties associated with the flow-focusing model. The MWD tools and measurements will include Resistivity-at-the-Bit GeoVision resistivity (GVR), Azimuthal Density Neutron (ADN), and measurements of pressure (annulus pressure while drilling; APWD). The GVR provides azimuthal resistivity images of the borehole and gamma ray measurements; the ADN provides azimuthal borehole compensated formation density, neutron porosity, and photoelectric factor measurements; and the APWD will provide measurements of annulus pressure for identifying potential shallow flow and overpressure conditions.

Wireline Logging and Vertical Seismic Profile

A series of three tool string deployments are planned for the Brazos-Trinity and Ursa sites. These tool strings include the triple combination (triple combo), the Formation MicroScanner (FMS)-Dipole Sonic Imager (DSI), and a zero-offset VSP. Detailed descriptions of all wireline tools and applications are provided at **iodp.ldeo.columbia.edu/TOOLS_LABS/index.html.** A detailed time estimate for the wireline logging can be seen in Table **T3.**

The triple combo with caliper measurements will be used to assess the initial postdrilling borehole conditions such as hole size and postdrilling fluid temperatures. In addition, this tool string will obtain potassium, uranium, and thorium concentrations as well as formation density, photoelectric effect, electrical resistivity, and porosity in situ profiles as a function of depth. The FMS will provide high-resolution borehole images of lithostratigraphic sequences and boundaries, oriented fracture patterns, and information regarding hole stability. The DSI will produce a full set of compressional and shear waveforms, cross-dipole shear wave velocities and amplitudes measured at different azimuths, and Stoneley waveforms. The zero-offset VSP will provide the shallow sediment velocity gradient information and interval velocity that will be necessary for potential core-log-seismic correlations.

These measurements will be utilized for characterization of stratigraphic sequences; determination of potential geological factors that may influence fluid migration; establishing geotechnical and petrophysical properties at these sites; and providing information about the depositional events, timing of landslides, and turbiditic processes along the continental slope. These types of measurements can be used to determine preferred fracture orientations and fracture densities, paleostress directions, and permeability estimates, all required to accurately model the hydrological characteristics of this passive margin system. The velocity gradient, sonic velocities, and densities could be used for the calculation of synthetic seismogram models and a direct correlation with high-resolution seismic data that have been obtained for these sites.

In Situ Measurements

Pressure, hydraulic conductivity, and temperature will be measured in the mudstones with the T2P designed by the Massachusetts Institute of Technology (MIT; USA), the Pennsylvania State University (USA), and IODP-Texas A&M University (TAMU; USA). These data will help constrain the rock properties and flow field in the sediments. The tapered probe measures pressure and temperature at the narrow tip of the probe; a second pressure measurement is collected slightly up-probe from the sensors at the tip (Fig. **F12**). The design allows for rapid measurement (~190 min total operational time) (Table **T6**) of high-quality pressure and temperature in low-permeability sediments. During penetration of the probe (<5 min), we will not circulate. However, during the pressure measurement, circulation is possible.

The T2P delivery and drive assembly interfaces with the drill string and is integrated into the IODP operational protocols. We will use the existing colleted delivery system (CDS) now used to deploy the DVTPP, to deploy the T2P. The drill string is first raised several meters off the bottom of the borehole. The probe is then lowered down the drill string in the extended configuration (stroke = ~3.3 m) and engages the bottom-hole assembly (BHA). The drill string is then lowered to insert the probe into the foundation. Once the force of penetration exceeds the weight of the telescoping section of the CDS, the section retracts with little change in force until it engages the collet. With the section fully retracted, the weight of the drill string is used to force the probe into the foundation. The CDS has 53 kN (12,000 lb) driving force capacity controlled by a safety mechanism. Following penetration (controlled by lowering the string a specified distance), the drill string is raised 2 m to extend the telescope and decouple the probe from the drill string. This prevents drill string movement (due to ship heave) from disturbing the probe during dissipation.

A second component of in situ measurements is routine temperature measurements at each site. Temperature measurements will be made during APC operations using the APCT tool. We have allocated time to make three APCT measurements and one DVTPP measurement per coring hole (Table T5). Each measurement will take ~15 min.

SAMPLING STRATEGY

Shipboard and shore-based researchers should refer to the interim IODP Sample, Data, and Obligations policy posted on the World Wide Web at **iodp.org/data_samples.html.** This document outlines the policy for distributing IODP samples and data to research scientists, curators, and educators. The document also defines the obligations that sample and data recipients incur. Access to data and core sampling during Expedition 308, or within the 1 y moratorium, must be approved by the Sample Allocation Committee (SAC). The SAC (composed of Co-Chief Scientists, Staff Scientist, the IODP Curator on shore, and the Curatorial Representative on board ship) will work with the Shipboard Scientific Party to formulate a formal expedition-specific sampling plan for shipboard and postcruise sampling.

Shipboard scientists are expected to submit sample requests 2 months before the beginning of the expedition. Sample requests may be submitted at **iodp.tamu.edu/curation/samples.html.** Based on sample requests (shore-based and shipboard), the SAC and Shipboard Scientific Party will prepare a working cruise sampling plan. This plan will be subject to modification depending upon the actual material recovered and collaborations that may evolve between scientists during the expedition. Modifications to the sampling plan during the expedition require the approval of the SAC.

All sample frequencies and sizes must be justified on a scientific basis and will depend on core recovery, the full spectrum of other requests, and the cruise objectives. Some redundancy of measurement is unavoidable, but minimizing the duplication of measurements among the shipboard party and identified shore-based collaborators will be a factor in evaluating sample requests.

Cruise-Specific Sampling Needs

One critical component of Expedition 308 is establishing the in situ fluid pressure, effective stress, and hydrologic properties of the sediments from the seafloor to 1000 mbsf. To accomplish these goals, it is critical that 10–20 cm long whole-round samples be taken at regular intervals and sealed for shore-based geotechnical measurements. In addition to the routine whole rounds, it is mandatory that whole rounds be taken at the depth of each T2P measurement.

The whole-round samples are required to calibrate the in situ measurements, to constrain sediment properties for hydrogeologic models, and to measure the strength of the sediments for stability analyses.

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Table T1. Site locations for IODP Expedition 308, Gulf of Mexico hydrogeology.

Site	Latitude, longitude	UTM X (zone)	UTM Y (zone)	Seismic lines	Shotpoint	Water depth (m)
BT4-1B	27.36771232°N, 94.35774732°W	1199872.75 (15)	9933466.00 (15)	Rudder 2-D dip 3020; Rudder 2-D cross 3019	284.00	1405
BT4-2A	27.30136298°N, 94.38753682°W	1189937.75 (15)	9909458.00 (15)	Rudder 2-D dip 3020; Rudder 2-D cross 3045	220.76	1476
BT4-3A	27.27568317°N, 94.39891740°W	1186138.00 (15)	9900166.00 (15)	Rudder 2-D dip 3020; Rudder 2-D cross 3055	196.36	1459
BT4-4A	27.26628028°N, 94.40315809°W	1184722.38 (15)	9896764.00 (15)	Rudder 2-D dip 3020	187.27	1435
URS-1B	28.07974007°N, 89.13930517°W	950725.60 (16)	10195883.60 (16)	Morgus HR Line 150; Morgus HR Trace 1100		1057
URS-2C	28.09124346°N, 89.07252124°W	972332.69 (16)	10199693.00 (16)	Morgus HR Line 150; Morgus HR Trace 2170		1262
URS-3C	28.09937740°N, 89.02520153°W	987639.20 (16)	10202393.10 (16)	Morgus HR Line 150; Morgus HR Trace 2928		1321
URS-4A	28.10025610°N; 89.02008217°W	989295.00 (16)	10202685.10 (16)	Morgus HR Line 150; Morgus HR Trace 3010		1325

Notes: UTM = universal transverse Mercator. Conversion to/from UTM and latitude/longitude use NAD27 and Clarke 1866 ellipsoid. UTM coordinates are in U.S. survey feet.

Table T2. Stage 1 measurement-while-drilling operations summary for primary sites.

Proposed site	Water depth (m)	MWD depth (mbsf)	Operational time (days)	Total time (days)
BT4-2A	1476	340	1.2	1.2
BT4-4A	1435	230	1.0	1.0
Transit 2				2.0
URS-3C	1321	238	1.0	1.0
URS-2C	1262	358	1.2	1.2
URS-1B	1057	612	1.9	1.9
			Total:	8.3

Notes: MWD = measurement while drilling. The time estimates include rig-up through rig-down and stow.

Table T3. Wireline logging measurements and time estimates.

Site*	Water depth (m)	Logged interval (m)	Measurements	Time (h)†
BT4-2A	1476	260	Temperature; caliper; spectral gamma ray; electrical resistivity; density; photoelectric effect; porosity; compressional-, shear-, and stoneley-wave velocities; borehole resistivity imaging; and vertical seismic profile	22.8
BT4-4A	1435	150	Same as Site BT4-2A.	19.8
URS-1B	1057	532	Same as Site BT4-2A	26.2
URS-2C	1262	278	Same as Site BT4-2A	21.3

Notes: * = Prioritization of sites for wireline logging operations may depend on overall expedition time constraints. † = Time estimates assume setting drill pipe at 80 mbsf, 20 m station spacing for vertical seismic profile, and compliance with the IODP marine mammal guidelines.

Table T4. Depth to critical surfaces at each Expedition 308 site.

Proposed site	Water depth		Drilled depth		Top hemipelagic depth		Bottom hemipelagic depth	
	(m)	TWT (ms)	(mbsf)	TWT (ms)	(mbsf)	TWT (ms)	(mbsf)	TWT (ms)
BT4-1B	1405	1.907	300	2.264	118	2.051	310	2.276
BT4-2A	1476	1.972	340	2.374	185	2.196	434	2.476
BT4-3A	1459	1.949	280	2.284	101	2.072	338	2.350
BT4-4A	1435	1.918	230	2.195	37	1.962	275	2.247
					Top Blue		Base Blue	
URS-1B	1057	1.419	612	2.122	632	2.168	722	2.264
URS-2C	1262	1.695	300	2.071	358	2.161	558	2.363
URS-3C	1321	1.773	240	2.079	238	2.101	483	2.359
URS-4A	1325	1.780	240	2.085	237	2.106	474	2.355

Note: TWT = two-way traveltime.

Table T5. Operations plan and time estimate.

Primary site	Location (lat/long)	Water depth (mbrf)	Operations description (mbsf)	Transit (days)	Drilling (days)	Logging (days)
Mobile, Alabama			Transit 448 nmi at 10.5 kt to Site BT4-4A	1.8		
BT4-4A	27.26628°N, 94.40316°W Normal Pressure Brazos-Trinity Basin flank E. Breaks Blk. 735	1435	**<u>Hole A</u>:** APC/XCB core to 230 mbsf; fill hole with heavy mud (includes 3 APCT and 1 DVTPP measurements, plus 2 T2P deployments).		1.6	
			Move 2.5 nmi at 1.5 kt in DP mode to Site BT4-2A	0.1		
BT4-2A	27.30136°N, 94.38754°W Normal Pressure Brazos-Trinity Basin center E. Breaks Blk. 692	1476	**<u>Hole A</u>:** APC/XCB core to 340 mbsf; fill hole with heavy mud (includes 3 APCT and 1 DVTPP measurements, plus 2 T2P deployments).		1.8	
			Wireline logging (including hole preparation): - Triple combo/FMS-sonic/VSP (20 m stations/5 min per station)			1.5
			<u>Hole B</u>: MWD at 25 m/h ROP to 340 mbsf; fill hole with heavy mud.			1.1
			Move 2.5 nmi at 1.5 kt in DP mode to Site BT4-4A	0.1		
BT4-4A	27.26628°N, 94.40316°W	1435	**<u>Hole B</u>:** MWD at 25 m/h ROP to 230 mbsf; fill hole with heavy mud.			0.9
			Transit 283 nmi at 10.5 kt to Site URS-3C	1.1		
URS-3C	28.09938°N, 89.02520°W	1321	**<u>Hole A</u>:** MWD at 25 m/h ROP to 238 mbsf; fill hole with heavy mud. Top of "Blue" sand projected at 258 mbsf			0.9
			Move 3.4 nmi at 1.5 kt in DP mode to Site URS-2C	0.1		
URS-2C	28.09124°N, 89.07252°W	1262	**<u>Hole A</u>:** MWD at 25 m/h ROP to 358 mbsf; fill hole with heavy mud. Top of "Blue" sand projected at 378 mbsf			1.1
			Move 3.4 nmi at 1.5 kt in DP mode to Site URS-1B	0.1		
URS-1B	28.07974°N, 89.13931°W Abnormal Pressure Mars-Ursa Basin Miss.Canyon Blk. 897	1057	**<u>Hole A</u>:** MWD at 25 m/h ROP to 612 mbsf; fill hole with heavy mud. Top of "Blue" sand projected at 632 mbsf			1.1
			Rendezvous with work boat to offload MWD tools	0.1		
			<u>Hole B</u>: APC/XCB core to 612 mbsf; fill hole with heavy mud (includes 3 APCT and 1 DVTPP measurements)		3.2	
			- Wireline logging (including hole preparation): Triple combo/FMS-sonic/VSP (20 m stations/5 min per station)			1.5
			<u>Hole C</u>: Drill; 5 T2P deployments plus allowance for 5 APC half-cores. Fill hole with heavy mud. *Note: Core with heavy mud from 481 mbsf to TD (last 130 m).* Top of "Blue" sand projected at 632 mbsf		1.7	
			Move 3.4 nmi at 1.5 kt in DP mode to Site URS-2C	0.1		
URS-2C	28.09124°N, 89.07252°W Abnormal Pressure Mars-Ursa Basin Miss.Canyon Blk. 899	1262	**<u>Hole B</u>:** APC/XCB core to 358 mbsf; fill hole with heavy mud (includes 3 APCT and 1 DVTPP measurements)		1.5	
			<u>Hole C</u>: Drill; 5 T2P deployments plus allowance for 5 APC half-cores. Fill hole with heavy mud. *Note: Core with heavy mud from 328 mbsf to TD (last 30 m).* Top of "Blue" sand projected at 378 mbsf		1.6	
			Move 3.4 nmi at 1.5 kt in DP mode to Site URS-3C	0.1		
URS-3C	28.09938°N, 89.02520°W Abnormal Pressure Mars-Ursa Basin Miss.Canyon Blk. 855	1321	**<u>Hole B</u>:** APC/XCB core to 238 mbsf; fill hole with heavy mud (includes 3 APCT and 1 DVTPP measurements, plus 1 T2P deployment). Top of "Blue" sand projected at 258 mbsf		1.4	
Balboa, Panama			Transit 1374 nmi T 10.5 kt to Balboa, Panama thorough Canal	6.5		
			Subtotal:	10.1	12.8	8.1
			Total operating days:	31.0		

Notes: APC = advanced piston coring, XCB = extended core barrel. APCT = APC temperature tool, DVTPP = Davis-Villinger Temperature-Pressure tool, T2P = temperature/dual pressure tool. FMS = Formation MicroScanner, VSP = vertical seismic profile. MWD = measurement while drilling. ROP = rate of penetration. TD = total depth.

Table T6. T2P tapered probe measurement times.

Event	Event time (min)	Cumulative time (min)
Tool in pipe	0	0
Lower tool to 1 m above base of hole	45	45
Take hydrostatic pressure	5	50
Lower tool to base of hole	5	55
Stop pumping	5	60
Push tool into formation	5	65
Start pumping	5	70
Measure pressure	90	160
Pull tool from formation	5	165
Pull tool to top of pipe	25	190

Figure F1. **A.** Overpressure (P^*) results when sedimentation occurs more rapidly than fluids can be expelled by compaction. **B.** This is recorded by an "undercompacted" porosity profile. **C.** Overpressure is often interpreted from the undercompacted profile. A suite of models describes how overpressure is generated during rapid deposition (Bethke, 1986; Bredehoeft and Hanshaw, 1968; Gibson, 1958; Koppula and Morgenstern, 1982; Osborne and Swarbrick, 1997; Swarbrick and Osborne, 1996).

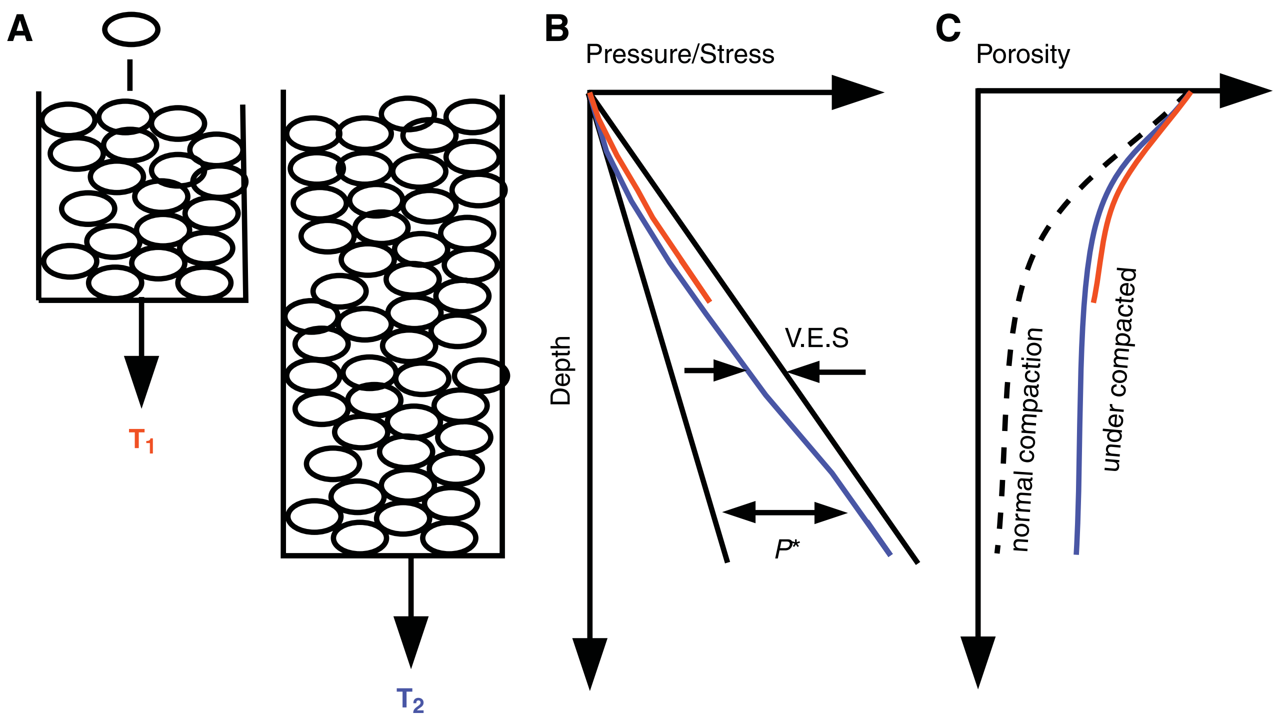


Figure F2. A. Low-permeability sediments are rapidly deposited on a high-permeability aquifer (outlined in white). The sedimentation rate decreases from left to right, resulting in the final wedge-shaped geometry. Rapid sedimentation generates overpressures (P^*, color contours) that are greatest on the left (red). Flow is driven laterally (left to right) along the aquifer and expelled at the toe of the slope where the aquifer ends (white arrows). The vertical effective stress (black contours) is a minimum on the right end of the aquifer. **B.** Model predictions for URS-1B (dashed line in A and B) and URS-3C (solid line in A and B); drilling and measurement will provide direct tests of these predictions. (**1**) Predicted overpressure profiles where overburden is thick (dashed = URS-1B) and thin (solid = URS-3C). Overpressure at URS-3C is greater at the same depth than overpressures at URS-1B. (**2**) The effective stress (σ_v') is much lower at URS-3C than at URS-1B. (**3**) Porosities are much higher at URS-3C than URS-1B at equivalent depths. (**4**) Pore pressures (P) equal the overburden stress (σ_v) at URS-3C. (**5**) Infinite slope analyses (FS; relates the failure-driving stress to the available shear strength for shallow failures) predict unstable conditions (FS < 1) for URS-3C. (**6**) Simulated vertical fluid velocity is higher at URS-3C than at URS-1B. At URS-1B we predict upward flow for most of the section but downward flow (velocity < 0) just above the aquifer. Model parameters: low permeability $k_v < 5 \times 10^{-18}$ m^2 and $k_h < 5 \times 10^{-16}$ m^2; aquifer permeability $k_h = k_v$ 5×10^{-14} m^2; maximum sedimentation rate = 3.5 mm/y; minimum sedimentation rate = 0.8 mm/y.

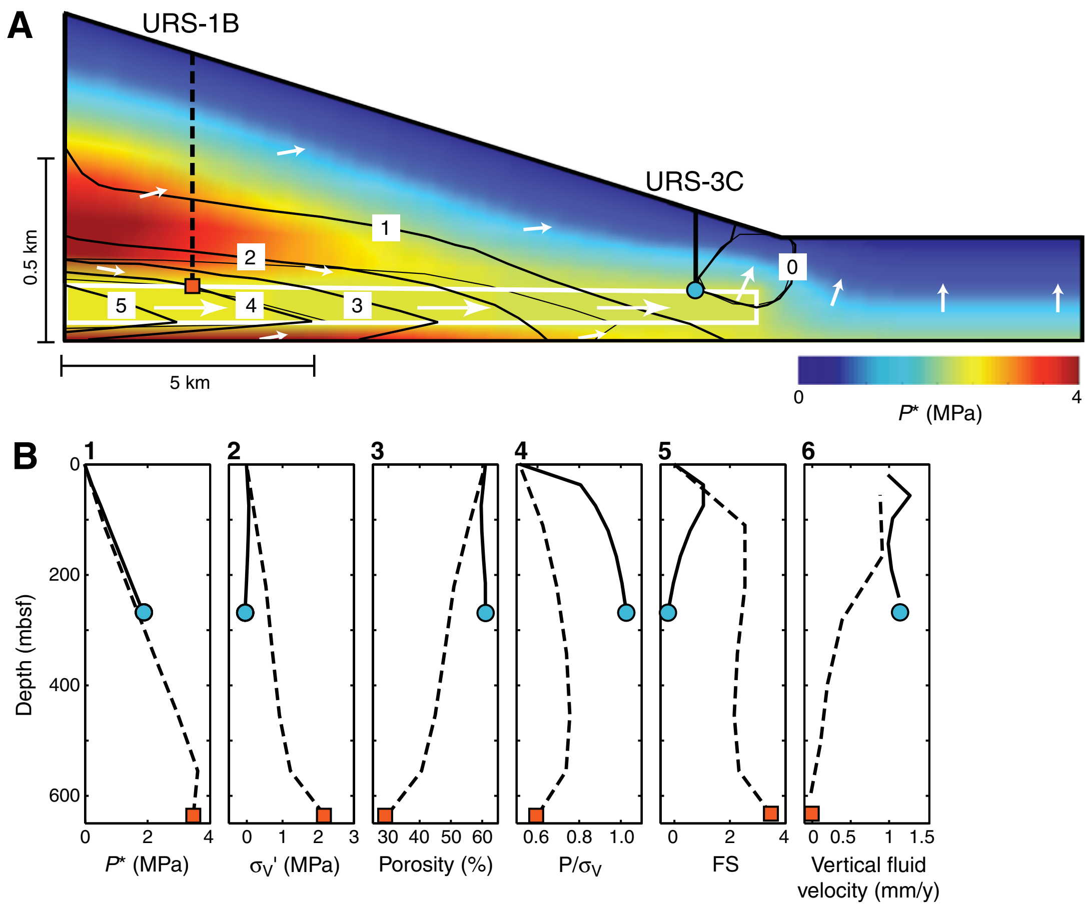


Figure F3. Flow focusing drives (**A**) slope instability and (**B**) fluid migration.

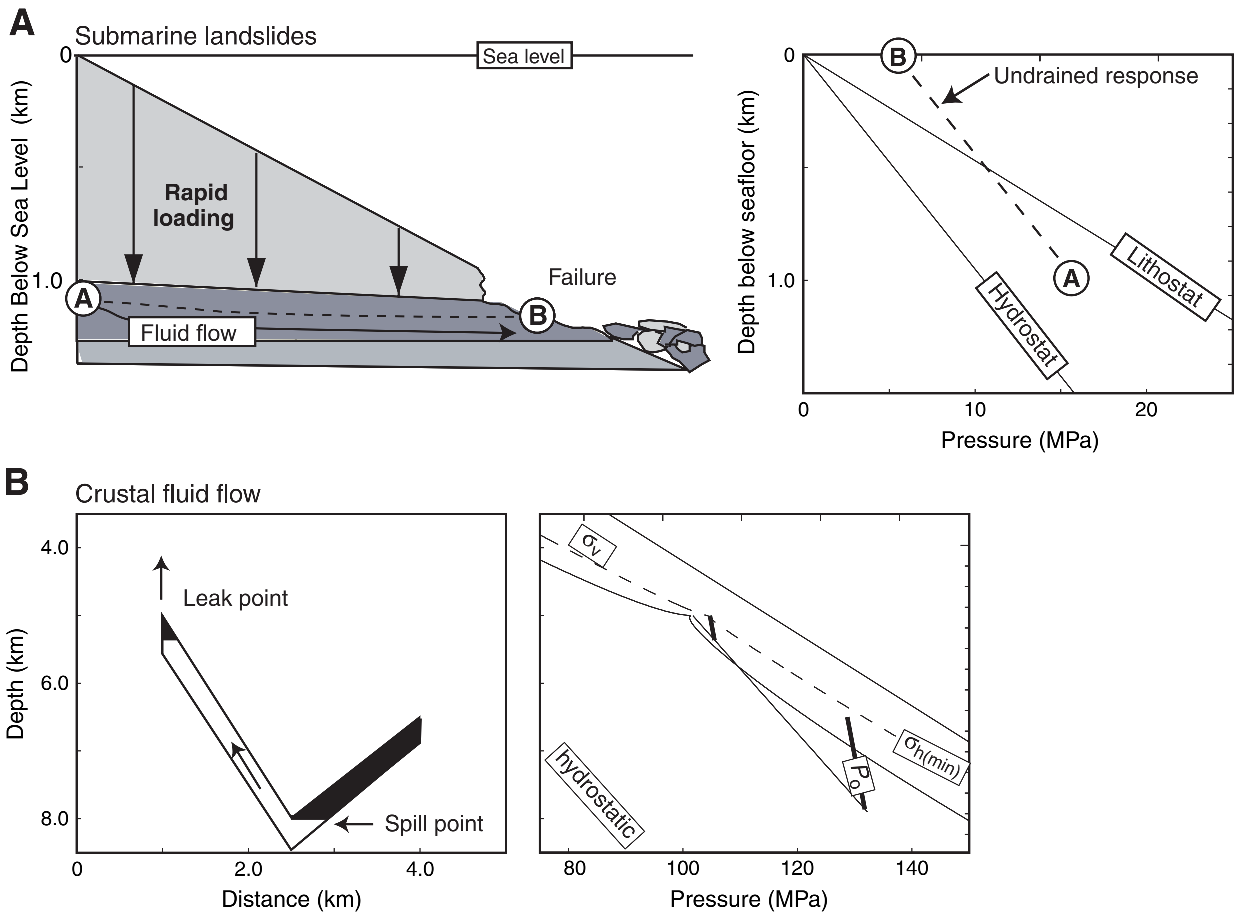


Figure F4. Bathymetric image of the continental slope of the Gulf of Mexico. The Brazos-Trinity Basin contains four proposed sites (BT4-1B to BT4-4A) and the Ursa Basin also contains four proposed sites (URS-1B to URS-4A). Pleistocene sedimentation rates are low at the BT4 sites and high at the URS sites.

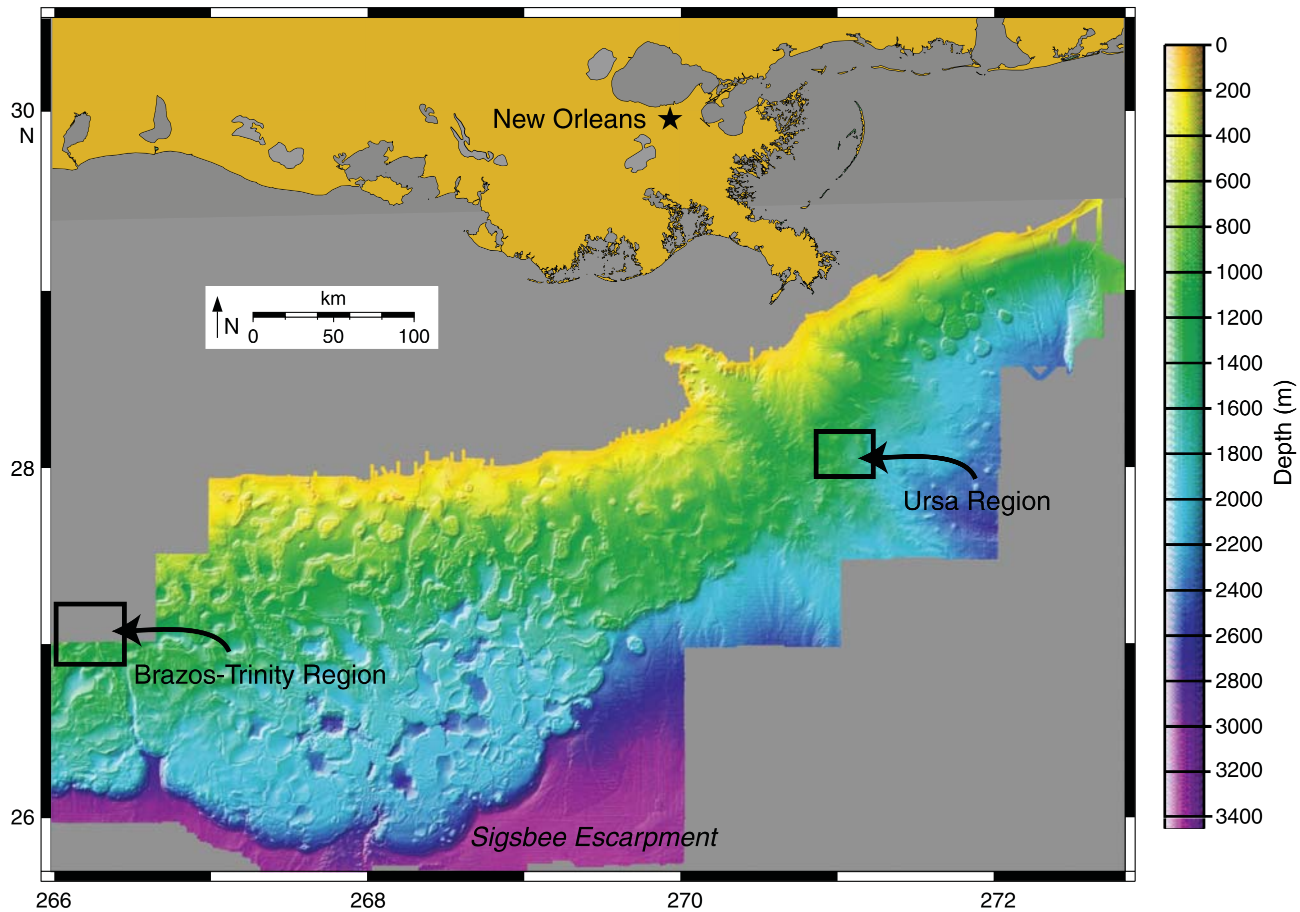


Figure F5. Brazos-Trinity Basin #4. Infrastructure (wells and pipelines), salt distribution (green and gray), locations of steep bathymetry (yellow), and East Breaks block numbers are shown.

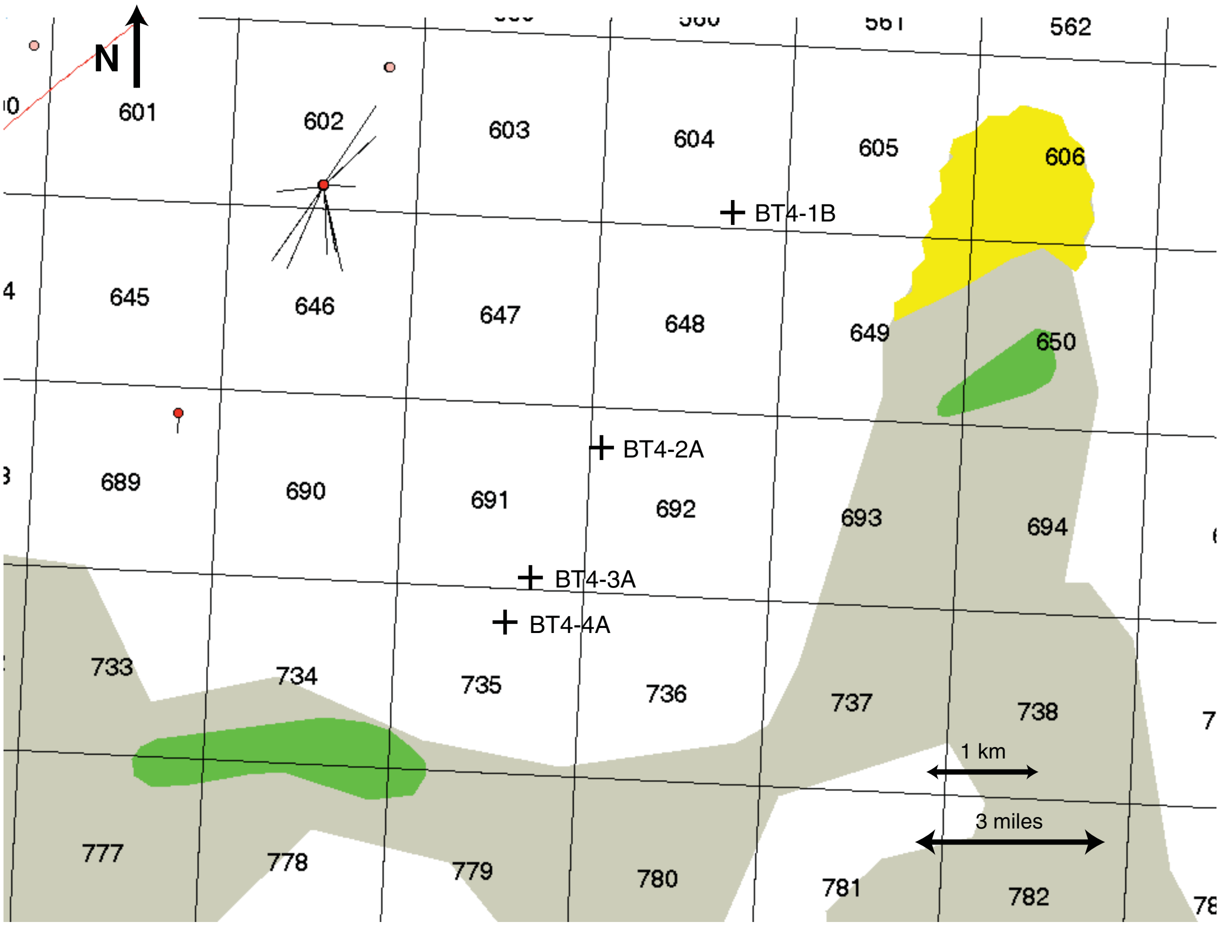


Figure F6. Two-dimensional high-resolution seismic data basemap. Proposed Sites BT4-1B to BT4-4A are shown on the map along Line 3020.

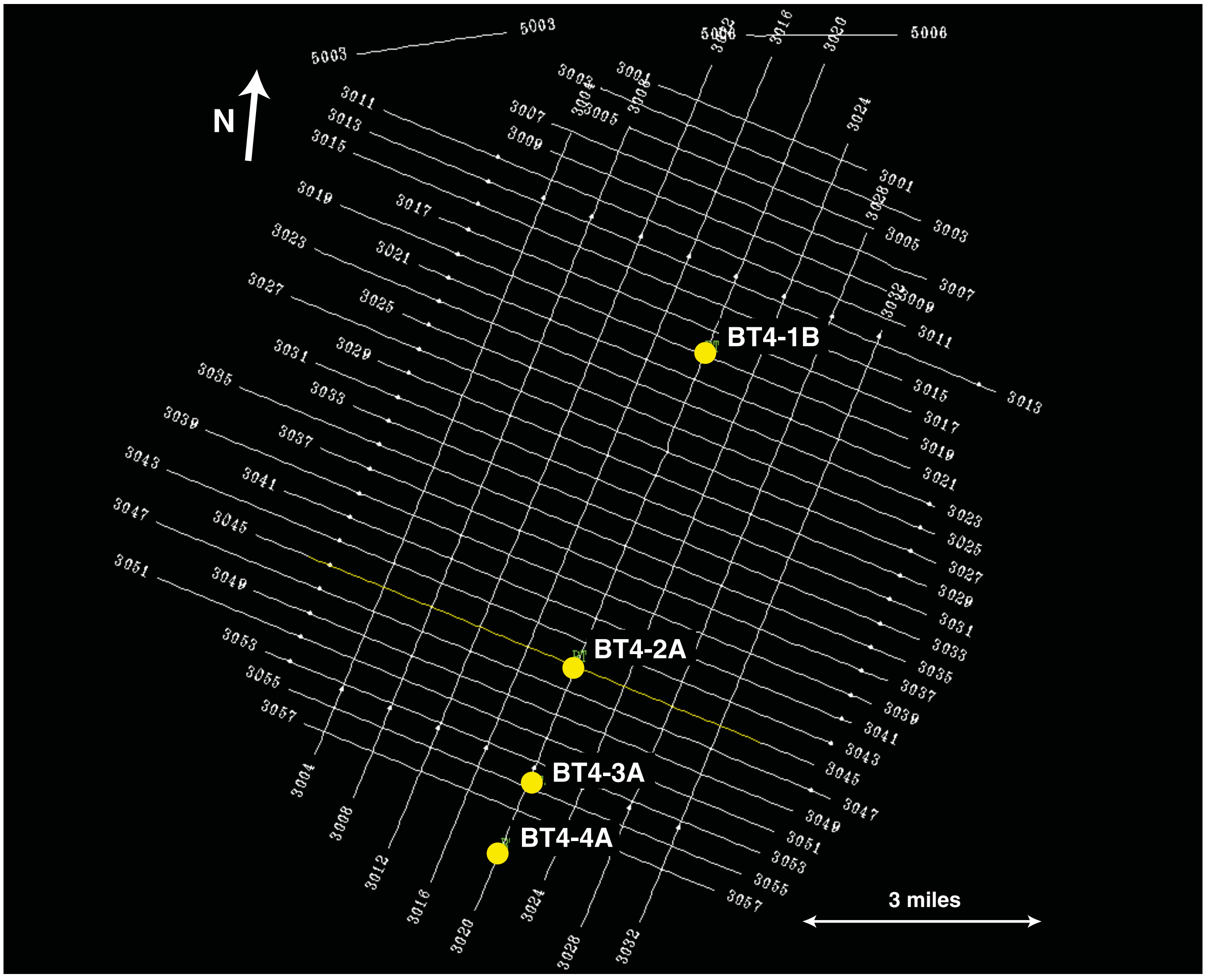


Figure F7. Dip seismic section 3020. Specific sites are located at the cross-tie with strike Lines 3019 (BT4-1B), 3045 (BT4-2A), and 3055 (Site BT4-3A) and at the southern limit of Line 3020 (Site BT4-4A). Primary sites for Brazos-Trinity include BT4-2A and BT4-4A. Secondary sites include BT4-1B and BT4-3A. Seismic reproduced with permission of Shell Exploration and Production Company.

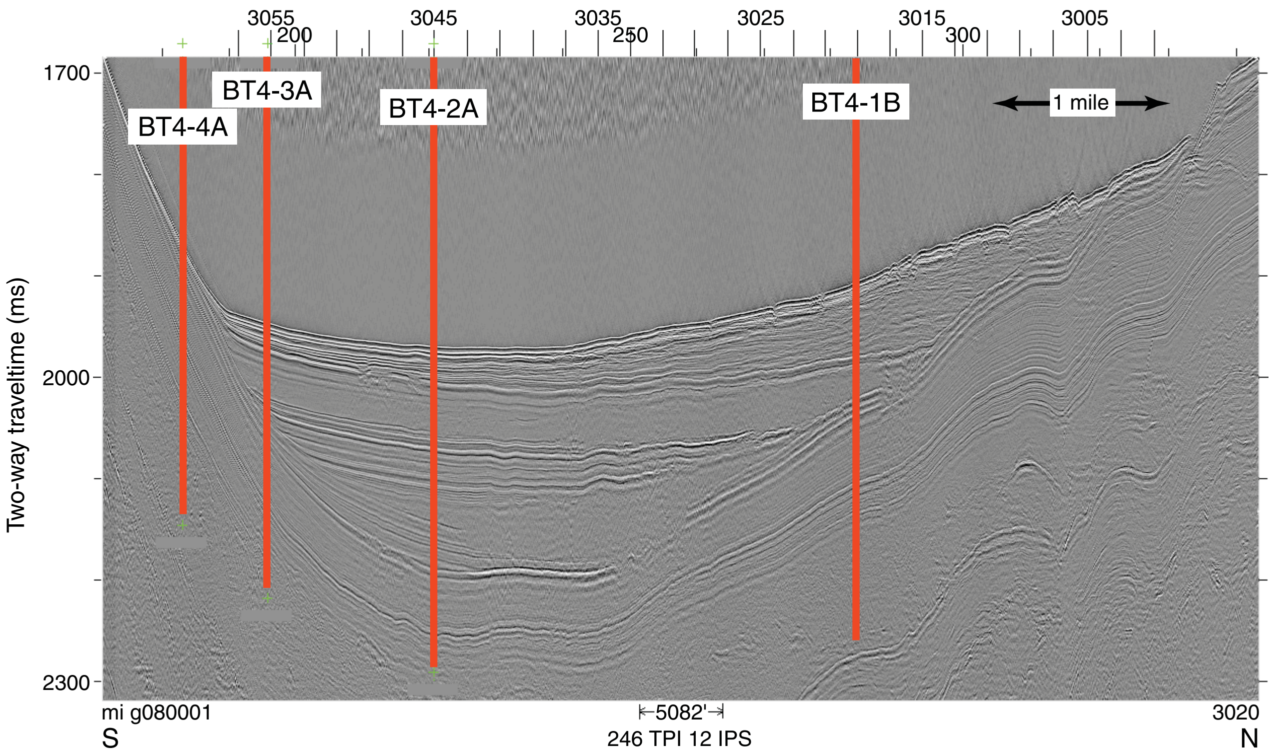


Figure F8. Strike seismic Line 3045. Primary Site BT4-2A is located at the intersection of Line 3020 and 3045. Seismic reproduced with permission of Shell Exploration and Production Company.

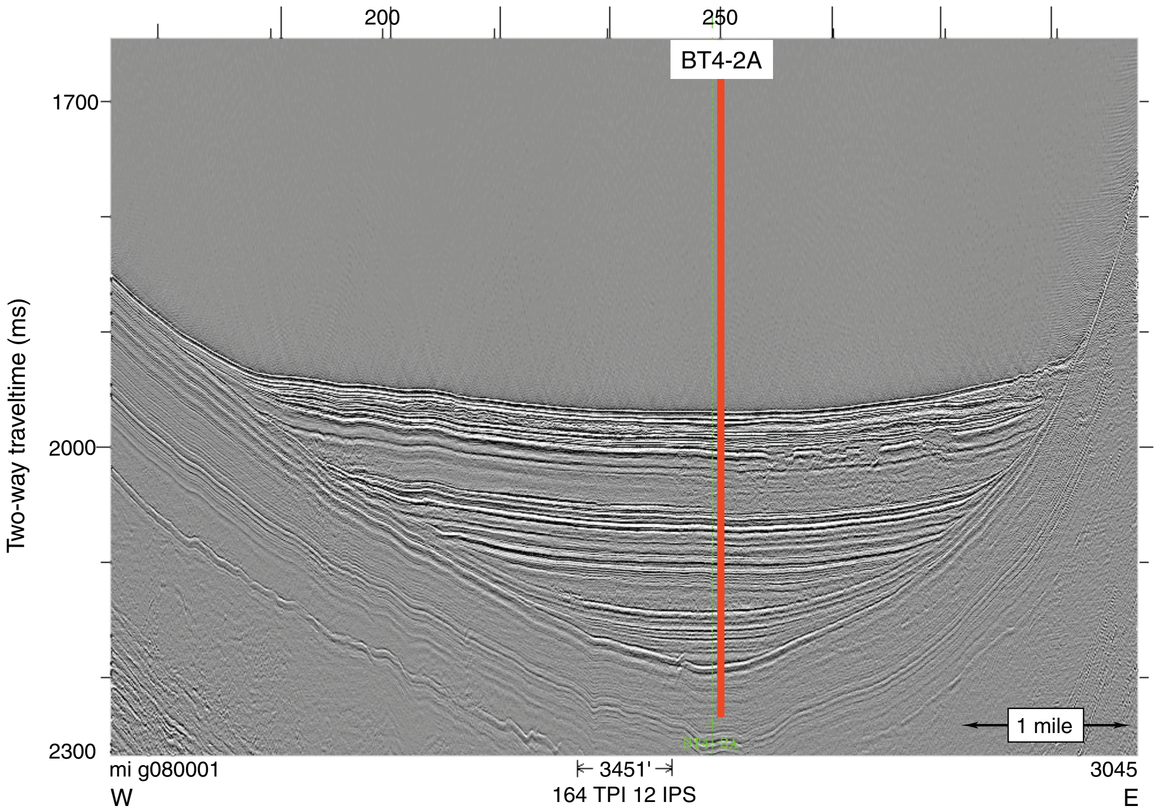


Figure F9. A. Ursa Basin is located 200 km south of New Orleans, Louisiana (USA). **B.** Bathymetry in the Ursa region (m). Open circles = proposed IODP boreholes, solid circles = logging data are available, solid rectangles = geotechnical wells where whole core was taken and pressure was directly measured. “MARS” and “URSA” delineate locations of the tension leg platforms producing oil from these fields. The square grid and associated numbers delineate Mississippi Canyon lease blocks that are 3 miles × 3 miles (e.g., the Ursa TLP is in Block M.C. 809).

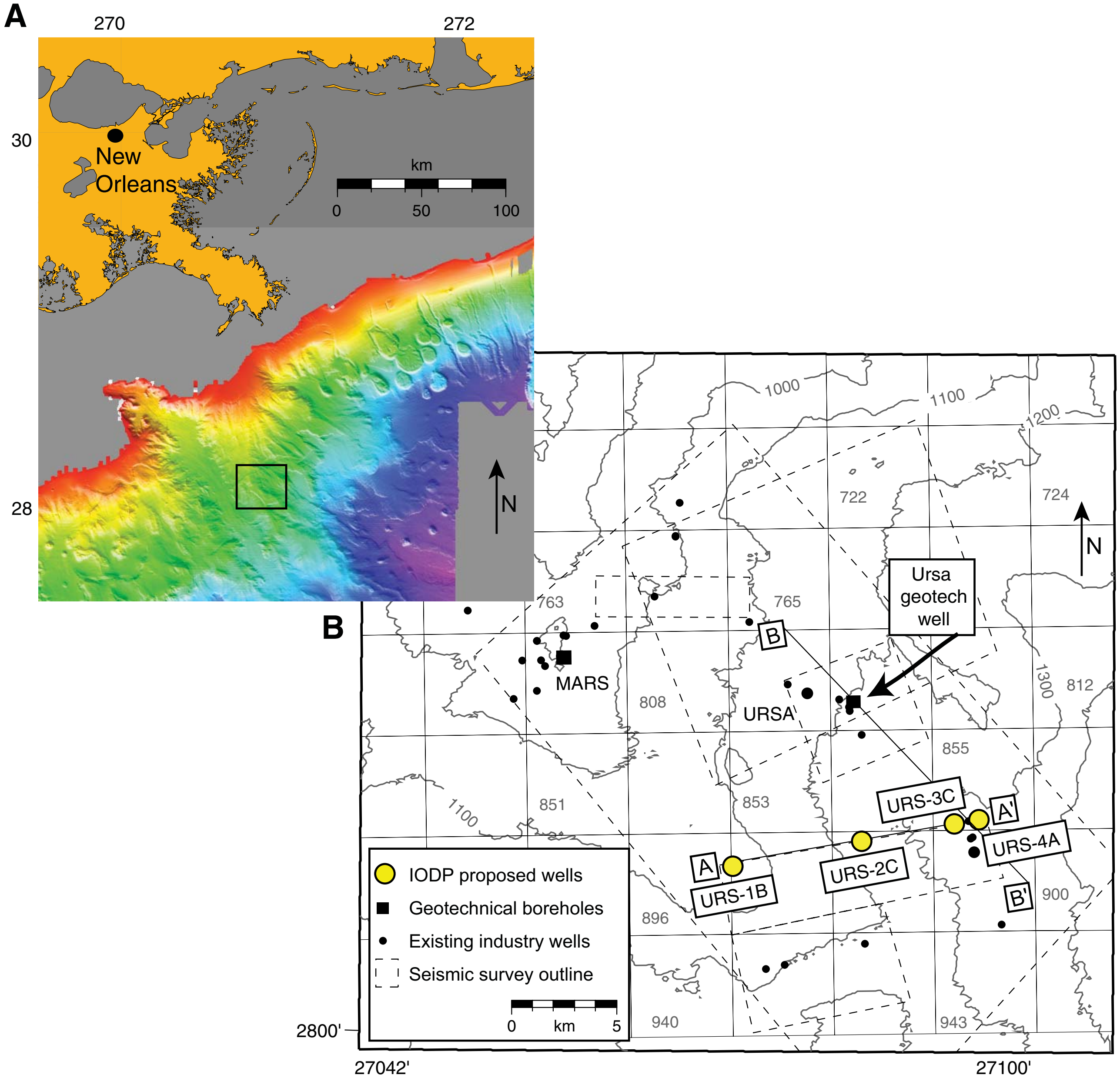


Figure F10. A. Seismic cross section A–A′ . **B.** Interpreted cross section A–A′ . The sand-prone Blue Unit has been incised by a channel-levee complex and then overlain by a thick and heavily slumped hemipelagic mudstone wedge that thickens to the west (left). The Blue Unit sands are correlated to a distinct seismic facies. Seismic reproduced with permission of Shell Exploration and Production Company.

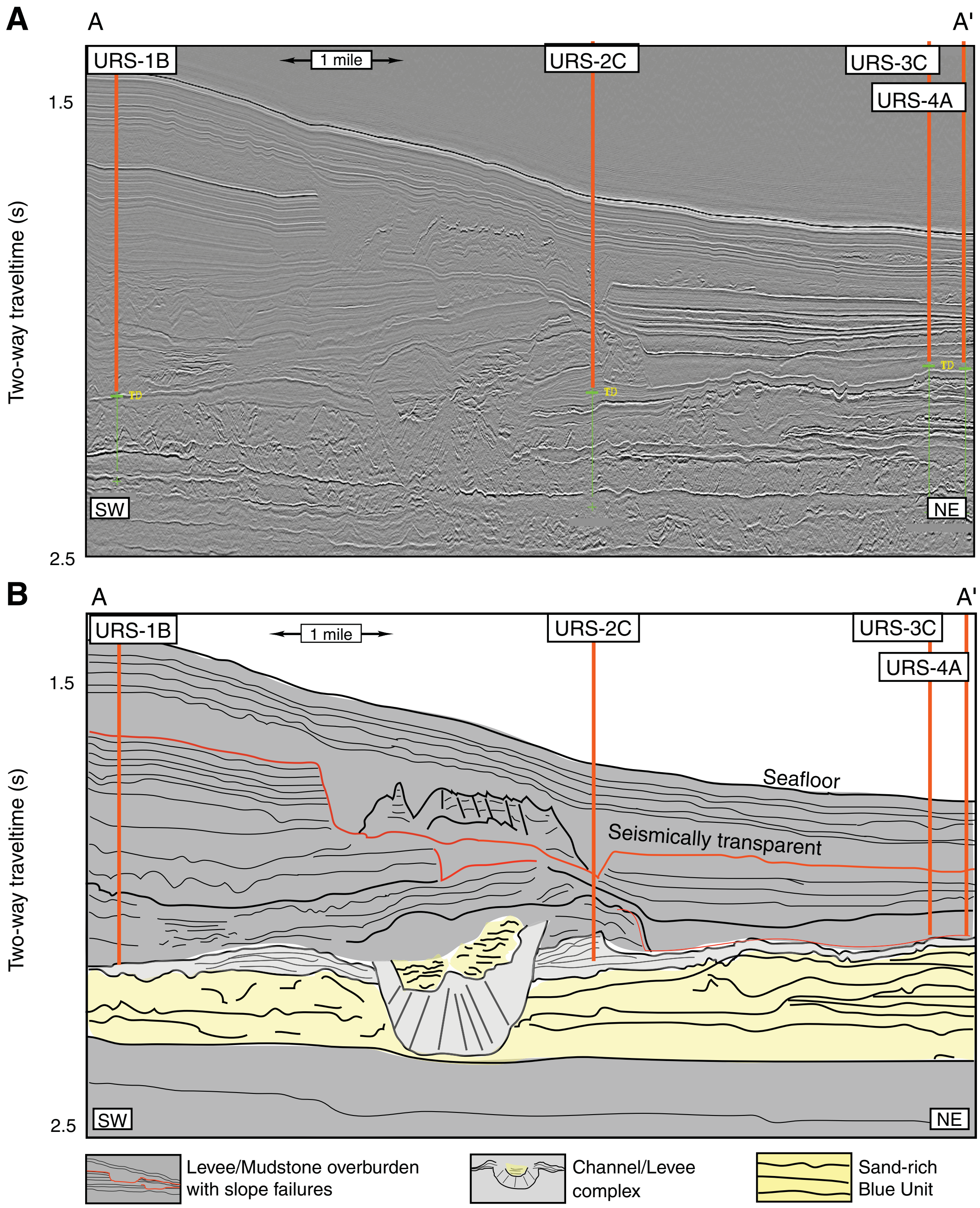


Figure F11. Gamma ray and resistivity logs, core and logging porosities, and in situ pressures at M.C. 810 Ursa geotechnical well #1 (located in Fig. F9). The Blue Unit (light gray bars) lies between 300 and 550 mbsf and is composed of interbedded sandstone and mudstone layers. Core porosity (ϕ core) declines rapidly with depth to 200 mbsf and thereafter is constant. Overpressure ($P^* = P - P_h$) is plotted; thus the vertical axis is hydrostatic pressure (P_h) and the right boundary of the plot is the reduced lithostatic pressure ($\sigma_v^* = \sigma_v - P_h$). Circles = piezoprobe pressures, triangles = preconsolidation pressures from uniaxial consolidation tests of core, stars = pressure measurements inferred from pressure while drilling (PWD) in the Blue Unit. Ostermeier et al. (2000) and Eaton (1999) further describe these data.

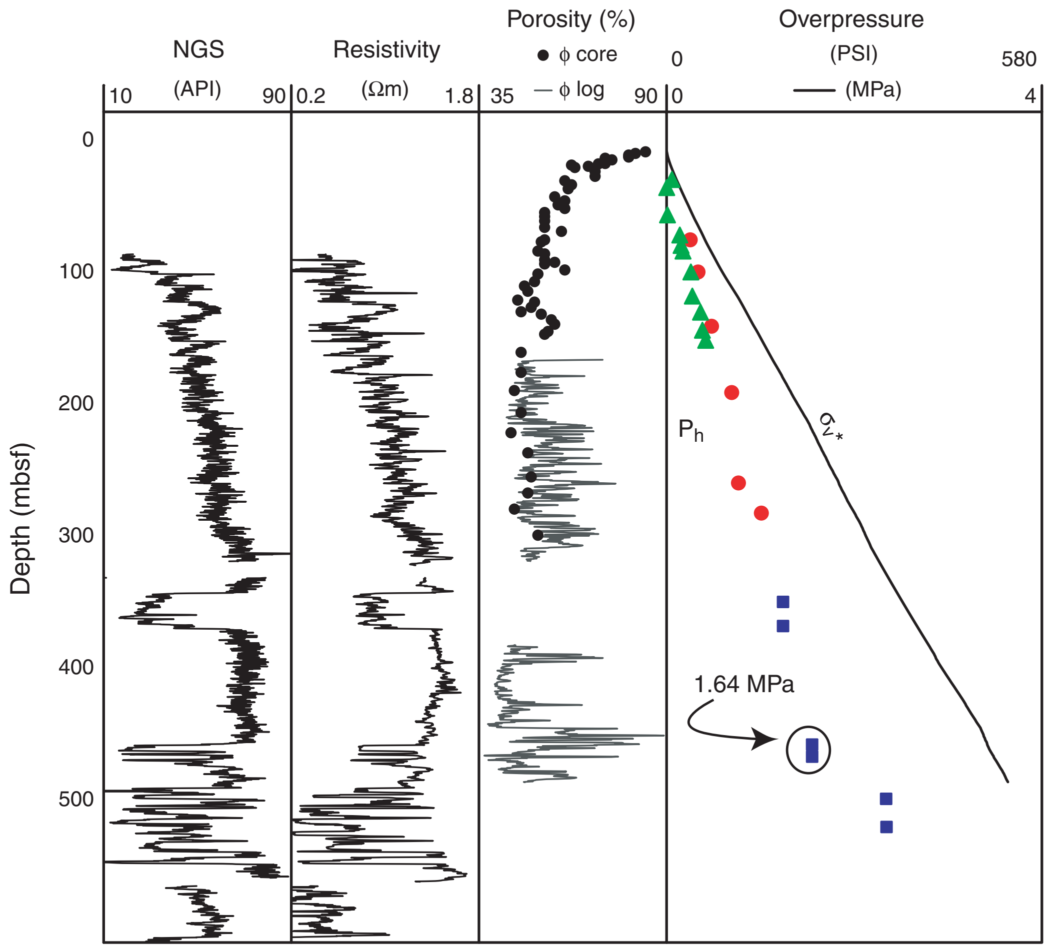
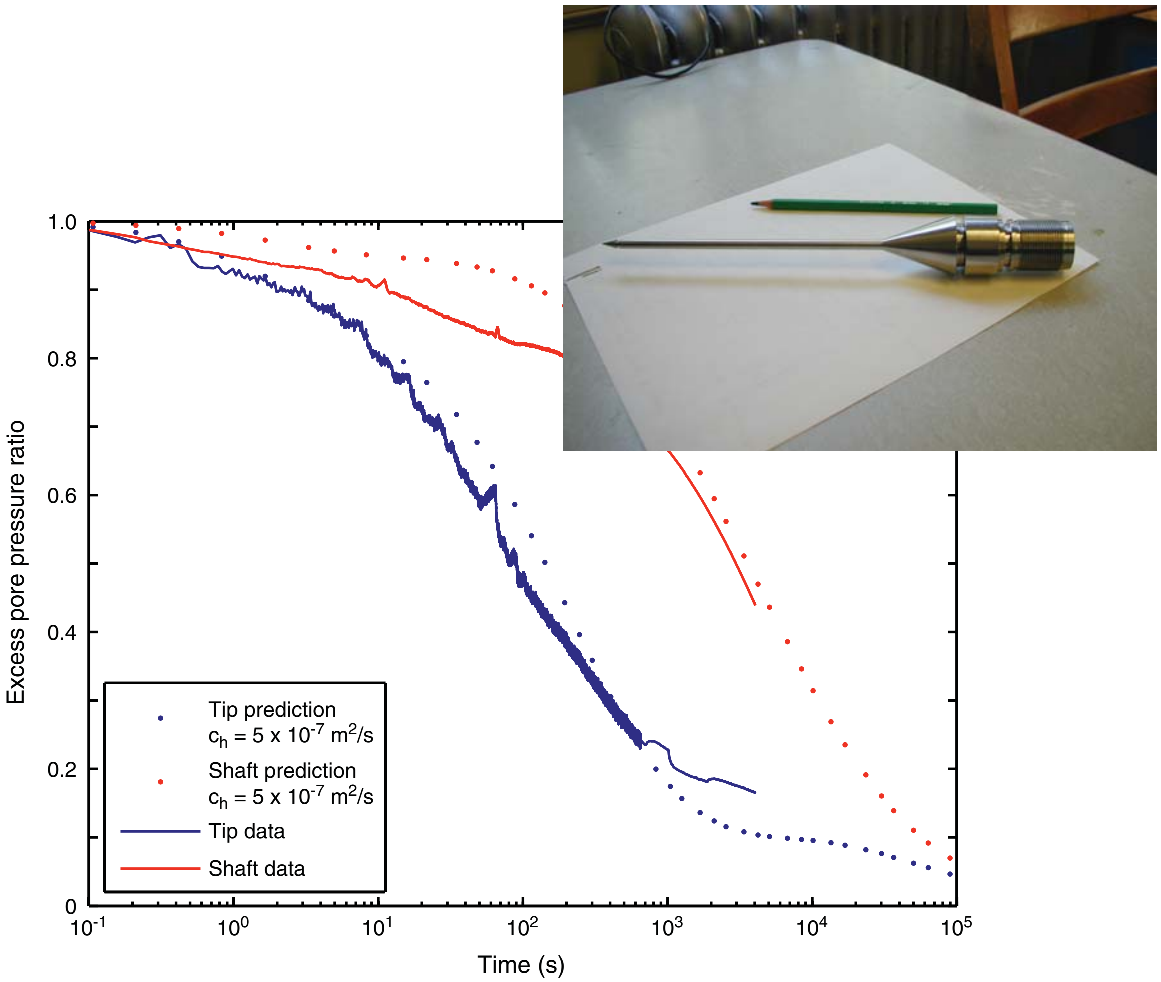


Figure F12. The T2P penetrometer is being co-developed at MIT, Penn State, and IODP-TAMU. It is designed to measure pore pressure and hydraulic conductivity in mudstones. The plot illustrates the dissipation at both the tip and the shaft after penetration in a December 2004 land deployment in Boston Blue Clay in Newburyport, Massachusetts (USA). Excess pore pressure ratio = $(u - u_h)/(u_i - u_h)$. u = pore pressure, u_h = hydrostatic pressure, u_i = peak insertion pressure.



SITE SUMMARIES

Site: BT4-2A

Priority:	Primary
Position:	27.30136298°N, 94.38753682°W
Water depth (m):	1476
Target drilling depth (mbsf):	340
Approved maximum penetration (mbsf):	340
Survey coverage:	• Rudder 2-D dipline 3020 • Shotpoint 220.76 • Rudder 2-D crossline 3045
Objectives:	Hydrodynamic analysis of a passive margin. Brazos-Trinity Basin #4 sites are to serve as a reference location to establish basic rock and fluid properties over a range of effective stresses in a normally pressured section.
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	Triple combo, FMS-sonic, VSP
MWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone with some unconsolidated turbidite sand

Site: BT4-4A

Priority:	Primary
Position:	27.26628028°N, 94.40315809°W
Water depth (m):	1435
Target drilling depth (mbsf):	230
Approved maximum penetration (mbsf):	230
Survey coverage:	• Rudder 2-D dipline 3020 • Shotpoint 187.27
Objectives:	Hydrodynamic analysis of a passive margin. Brazos-Trinity Basin #4 sites are to serve as a reference location to establish basic rock and fluid properties over a range of effective stresses in a normally pressured section.
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	Triple combo, FMS-sonic, VSP
MWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone with some unconsolidated turbidite sand

SITE SUMMARIES (CONTINUED)

Site: BT4-1B

Priority:	Secondary
Position:	27.36771232°N, 94.35774732°W
Water depth (m):	1405
Target drilling depth (mbsf):	300
Approved maximum penetration (mbsf):	300
Survey coverage:	• Rudder 2-D dipline 3020 • Shotpoint 284.00 • Rudder 2-D crossline 3019
Objectives:	Hydrodynamic analysis of a passive margin. Brazos-Trinity Basin #4 sites are to serve as a reference location to establish basic rock and fluid properties over a range of effective stresses in a normally pressured section.
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	Triple combo, FMS-sonic, VSP
MWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone with some unconsolidated turbidite sand

Site: BT4-3A

Proposed Site	BT4-3A
Priority:	Secondary
Position:	27.27568317°N, 94.39891740°W
Water depth (m):	1459
Target drilling depth (mbsf):	280
Approved maximum penetration (mbsf):	280
Survey coverage:	• Rudder 2-D dipline 3020 • Shotpoint 196.36 • Rudder 2-D crossline 3055
Objectives:	Hydrodynamic analysis of a passive margin. Brazos-Trinity Basin #4 sites are to serve as a reference location to establish basic rock and fluid properties over a range of effective stresses in a normally pressured section.
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	Triple combo, FMS-sonic, VSP
MWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone with some unconsolidated turbidite sand

SITE SUMMARIES (CONTINUED)

Site: URS-1B

Priority:	Primary
Position:	28.07974007°N, 89.13930517°W
Water depth (m):	1057
Target drilling depth (mbsf):	612
Approved maximum penetration (mbsf):	612
Survey coverage:	• Morgus HR line 150 • Morgus HR trace 1100
Objectives:	Hydrodynamic analysis of a passive margin. Ursa sites will test the flow-focusing model by drilling to 612 mbsf (20 m above the predicted top of the Blue Unit) in an overpressured region where overburden is thick (URS-1B) and where it is thinner (URS-2C, URS-3C).
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	Triple combo, FMS-sonic, VSP
MWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone with some interbedded levee sands

Site: URS-2C

Priority:	Primary
Position:	28.09124346°N, 89.07252124°W
Water depth (m):	1262
Target drilling depth (mbsf):	358
Approved maximum penetration (mbsf):	358
Survey coverage:	• Morgus HR line 150 • Morgus HR trace 2170
Objectives:	Hydrodynamic analysis of a passive margin. Ursa sites will test the flow focusing model by drilling to 358 mbsf (20 m above the predicted top of the Blue Unit) in an overpressured region where overburden is thick (URS-1B) and where it is thinner (URS-2C, URS-3C).
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	Triple combo, FMS-sonic, VSP
MWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone with some interbedded levee sands

SITE SUMMARIES (CONTINUED)

Site: URS-3C

Priority:	Primary
Position:	28.09937740°N, 89.02520153°W
Water depth (m):	1321
Target drilling depth (mbsf):	238
Approved maximum penetration (mbsf):	238
Survey coverage:	• Morgus HR line 150 • Morgus HR trace 2928
Objectives:	Hydrodynamic analysis of a passive margin. Ursa sites will test the flow focusing model by drilling to 238 mbsf (20 m above the predicted top of the Blue Unit) in an overpressured region where overburden is thick (URS-1B) and where it is thinner (URS-2C, URS-3C).
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	None
MLWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone

Site: URS-4A

Priority:	Secondary
Position:	28.10025610°N, 89.02008217°W
Water depth (m):	1325
Target drilling depth (mbsf):	237
Approved maximum penetration (mbsf):	237
Survey coverage:	• Morgus HR line 150 • Morgus HR trace 3010
Objectives:	Hydrodynamic analysis of a passive margin. Ursa Sites will test the flow focusing model by drilling to 237 mbsf (20 m above the predicted top of the Blue Unit) in an overpressured region where overburden is thick (URS-1B) and where it is thinner (URS-2C, URS-3C, URS-4A).
Drilling program:	APC to refusal with drillover and XCB
Wireline logging program:	None
MWD program:	GVR, ADN, APWD
Nature of rock anticipated:	Hemipelagic mudstone

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