

IODP Proposal Cover Sheet

637 - Add 7

New England Shelf Hydrogeology

Received for:

Title	A Shallow Drilling Campaign to Assess the Pleistocene Hydrogeology, Geomicrobiology, Nutrient Fluxes, and Fresh Water Resources of the Atlantic Continental Shelf, New England		
Proponents	Brandon Dugan, Mark Person, Daniel Lizarralde, Rob Evans, Kerry Key, Deborah Hutchinson, Henk Kooi, Boris van Breukelen, Jennifer McIntosh, Peter Sauer, Kathy Licht, Aaron Micallef, Robert van Geldern, Susanne Stadler		
Keywords	Pleistocene, Hydrogeology, Submarine Groundwater Discharge	Area	New England continental shelf

Proponent Information

Proponent	Brandon Dugan
Affiliation	Colorado School of Mines
Country	United States

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Abstract

In many coastal settings worldwide, the distribution of freshwater within continental shelf sediments is far out of equilibrium with modern sea level. One of the most remarkable examples is found on the Atlantic continental shelf off New England where groundwater within shallow Pliocene-Pleistocene sand aquifers over 100 km offshore has low salinity (3000 mg/l or less). On Nantucket Island, a 514m deep borehole penetrating the entire Cretaceous-Tertiary sedimentary package shows considerable variations in salinity with extremely fresh (<1000 mg/l) water in sand aquifers, higher salinity (30-70% of seawater) in thick clay/silt layers, and intermediate-to-low salinity in thin confining units. IODP Expeditions 313 and 317 also showed abrupt freshwater-saltwater boundaries linked to lithology. This demonstrates the disequilibrium nature of such systems; diffusion tends to eliminate such patterns. Pore fluid within Pleistocene to upper Cretaceous sands beneath Nantucket Island is also found to be modestly overpressured, ~4m relative to the local water table.

We hypothesize that the rapid incursion of freshwater on the continental shelf in New England could have been caused by one or more of the following mechanisms: (1) meteoric recharge during Pleistocene sea-level lowstands including vertical infiltration of freshwater associated with local flow cells on the shelf; (2) sub-ice-sheet recharge during the last glacial maximum; and (3) recharge from pro-glacial lakes. We further hypothesize that the overpressures could be due to: (1) Pleistocene sediment loading; or (2) fluid density differences associated with emplacement of a thick freshwater lens over saltwater (analogous to excess pressures in the gas legs of petroleum reservoirs). We argue these different recharge mechanisms and overpressure models can be distinguished through drilling, coring, logging, and fluid sampling. Noble gas and environmental isotope data will be necessary to completely evaluate recharge models.

This work will extend our understanding of the current and past states of fluid composition, pressure, and temperature in continental shelf environments. It will help better constrain rates, directions, and mechanisms of groundwater flow and chemical fluxes in continental shelf systems. It will contribute to the development of new tools for measuring freshwater resources in marine environments. The apparent transient nature of continental shelf salinity patterns could have important implications for microbial processes and long-term fluxes of carbon, nitrogen, and other nutrients to the ocean. Successful drilling will test process-based models for shelf freshwater off New England. These models can then be applied to other shelf freshwater systems around the world.

Scientific Objectives

We argue that targeted drilling and coring including hydrogeochemical, microbiological, isotopic, and noble gas analysis and measurement of hydraulic properties and fluid pressures will yield a process-based understanding for the origin and volumes of offshore freshwater, how these fluids influence local and global biogeochemical cycles, and how they record climate cycles.

We propose a three site, shallow-water drilling campaign on the Atlantic continental shelf off Martha's Vineyard, MA, USA to test our hypotheses and to map offshore freshwater resources. Our transect takes advantage of boreholes on Martha's Vineyard (ENW-05) and Nantucket (6001), builds on previous AMCOR and IODP analyses, and is motivated by geophysical observations (stratigraphy, resistivity). Our transect will provide samples from the freshwater, freshwater-seawater transition, and seawater zones allowing complete characterization of the system. Based on paleohydrologic reconstructions, we have developed 2D and 3D models of the freshwater distribution and have predicted the freshwater-seawater transition is <30km offshore. Electromagnetic data suggest the transition may extend approximately 40km offshore. Drilling will directly test these geophysical interpretations and provide additional constraints for hydrogeological models.

Our drilling campaign will require one MSP. We propose a program similar to IODP Exp. 313 to increase recovery in unconsolidated sand units and a casing/screening program to facilitate collection of pristine pore fluid samples for geochemical and microbiological analyses. Post-expedition numerical models will include simulation of groundwater residence time and noble gas transport for comparison with field measurements. This highly interdisciplinary work will be one of the first focused hydrogeological-biogeochemical-microbiological studies of shelf systems.

Non-standard measurements technology needed to achieve the proposed scientific objectives

Well tests in cased/screened sites, collection of noble gas samples

Proposed Sites (Total proposed sites: 4; pri: 4; alt: 0; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
MV-08A (Primary)	40.9976 -70.3334	41	550	0	550	MV-8A will characterize the freshwater endmember.
MV-04C (Primary)	40.6185 -70.1370	52	650	0	650	MV-4C will characterize the freshwater-to-seawater transition zone or the seawater endmember of the transect.
MV-03C (Primary)	40.8746 -70.2697	42	550	0	550	MV-3C will characterize the freshwater-to-seawater transition zone of the transect.
MV-05B (Primary)	40.3771 -70.0119	79	650	0	650	MV-5B will characterize the seawater endmember of the transect.

Contact Information

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E-mail/Phone:	dugan@mines.edu; Phone: 3032733512

Proponent List

First Name	Last Name	Affiliation	Country	Role	Expertise
Brandon	Dugan	Colorado School of Mines	United States	Principal Lead and Data Lead	Hydrogeology, Geomechanics, Geohazards
Mark	Person	New Mexico Tech	United States	Other Lead	Hydrogeology, Basin-scale Flow Modeling
Daniel	Lizarralde	Woods Hole Oceanographic Institution	United States	Other Proponent	Marine Geophysics, Margin Processes
Rob	Evans	Woods Hole Oceanographic Institution	United States	Other Proponent	Electromagnetic Methods, Marine Geophysics
Kerry	Key	Lamont-Doherty Earth Observatory	United States	Other Proponent	Electromagnetic Methods, Marine Geophysics
Deborah	Hutchinson	US Geological Survey	United States	Other Proponent	Marine Geology and Geophysics
Henk	Kooi	VU University	Netherlands	Other Proponent	Hydrogeology, Offshore Freshwater
Boris	van Breukelen	Delft University of Technology	Netherlands	Other Proponent	Contaminant Hydrology, Biogeochemistry
Jennifer	McIntosh	University of Arizona	United States	Other Proponent	Aqueous Geochemistry, Isotope Geochemistry
Peter	Sauer	Indiana University	United States	Other Proponent	Biogeochemistry, Paleoclimatology
Kathy	Licht	Indiana University-Purdue University	United States	Other Proponent	Glacial Geology, Quaternary Geology
Aaron	Micallef	University of Malta	Malta	Other Proponent	Geomorphology, Seafloor Exploration
Robert	van Geldern	Friedrich-Alexander-Universität Erlangen-Nürnberg	Germany	Other Proponent	Isotope Hydrology, Biogeochemical Cycles
Susanne	Stadler	Bundesanstalt für Geowissenschaften und Rohstoffe	Germany	Other Proponent	Isotope Hydrogeology, Hydrobiogeochemistry

IODP Proposal 637 Addendum (Fall 2017)
Science Lead: Brandon Dugan (dugan@mines.edu)
Data Lead: Brandon Dugan (dugan@mines.edu)

Summary

This addendum summarizes the results of the drilling workshop (22-23 May 2017) sponsored by IODP (USSSP) and ICDP. The overall objectives of the workshop were to develop a new operational plan for IODP Proposal 637 that addresses fiscal constraints identified by the ECORD Facilities Board and to establish the value of an onshore component of the project. The workshop included input and participation from 32 researchers from academia, government, industry, IODP (ESO), and ICDP (CDSCO).

The following are the key outcomes of the workshop:

- 1) Three offshore sites (MV-8A, MV-4C, and MV-3C or MV-5B), with one site per hole for coring, wireline logging, and sampling, can meet all of the science objectives of IODP Proposal 637.
- 2) Dating of waters and geochemical analyses can mostly be completed by standard IODP porewater sampling. Pump tests are desired to collect sufficient hydrogeological information (hydraulic conductivity, storativity) and large enough water volumes for krypton age dating.
- 3) A separate proposal will be submitted to ICDP to collect onshore data that define stand-alone science but are also complementary to the objectives of IODP Proposal 637.

Key Outcomes and Operational Updates

Below we provided detailed information on key operational decisions and justification based on the workshop.

Sites Needed and Operational Strategy

A significant component to IODP proposal 637 is drilling and sampling the freshwater endmember, the seawater endmember, and the transition between the endmembers. The original plan was to drill six sites, each consisting of three holes, to ensure we could capture the spectrum of conditions and could collect sufficient samples for hydrogeology, sedimentology, and biogeochemistry. The number of days required for this was cost prohibitive so a primary objective of the workshop was to re-evaluate the science questions in light of new numerical models and electromagnetic and magnetotelluric data both of which help constrain the freshwater-seawater distributions. These discussions facilitated defining the minimum number of sites and holes required to meet the science objectives. The numerical models [Siegel et al., 2014] were helpful and suggested that three sites could accomplish the drilling objectives. The electromagnetic and magnetotelluric data (Figures 1, 2) helped decide which three sites and depths to meet the science objectives.

The new proposed drilling strategy is to drill MV-8A first to 550 mbsf (Figures 1,2). This will sample the freshwater endmember which is predicted to be bounded on top and bottom by seawater. MV-8A has been approved by EPSP to 350 mbsf, so the depth extension needs to be reviewed by the EPSP. The second site to be drilled will be MV-4C to 550 mbsf (Figures 1,2). This could be the seawater endmember based on numerical modeling results or the freshwater-

seawater transition based on electromagnetic and magnetotelluric data. MV-4C has been approved by EPSP to a depth of 650 mbsf. If MV-4C is the seawater endmember, the third site to be drilled would be MV-3C to 550 mbsf (Figures 1,2) to sample the seawater-freshwater transition. MV-3C has been approved to 550 mbsf by the EPSP. If MV-4C sample the freshwater-seawater transition, the third site to be drilled would be MV-5B to 550 mbsf (Figures 1,2) to sample the seawater endmember, as predicted by numerical models and electromagnetic and magnetotelluric data. MV-5B has been approved to a depth of 650 mbsf by the EPSP.

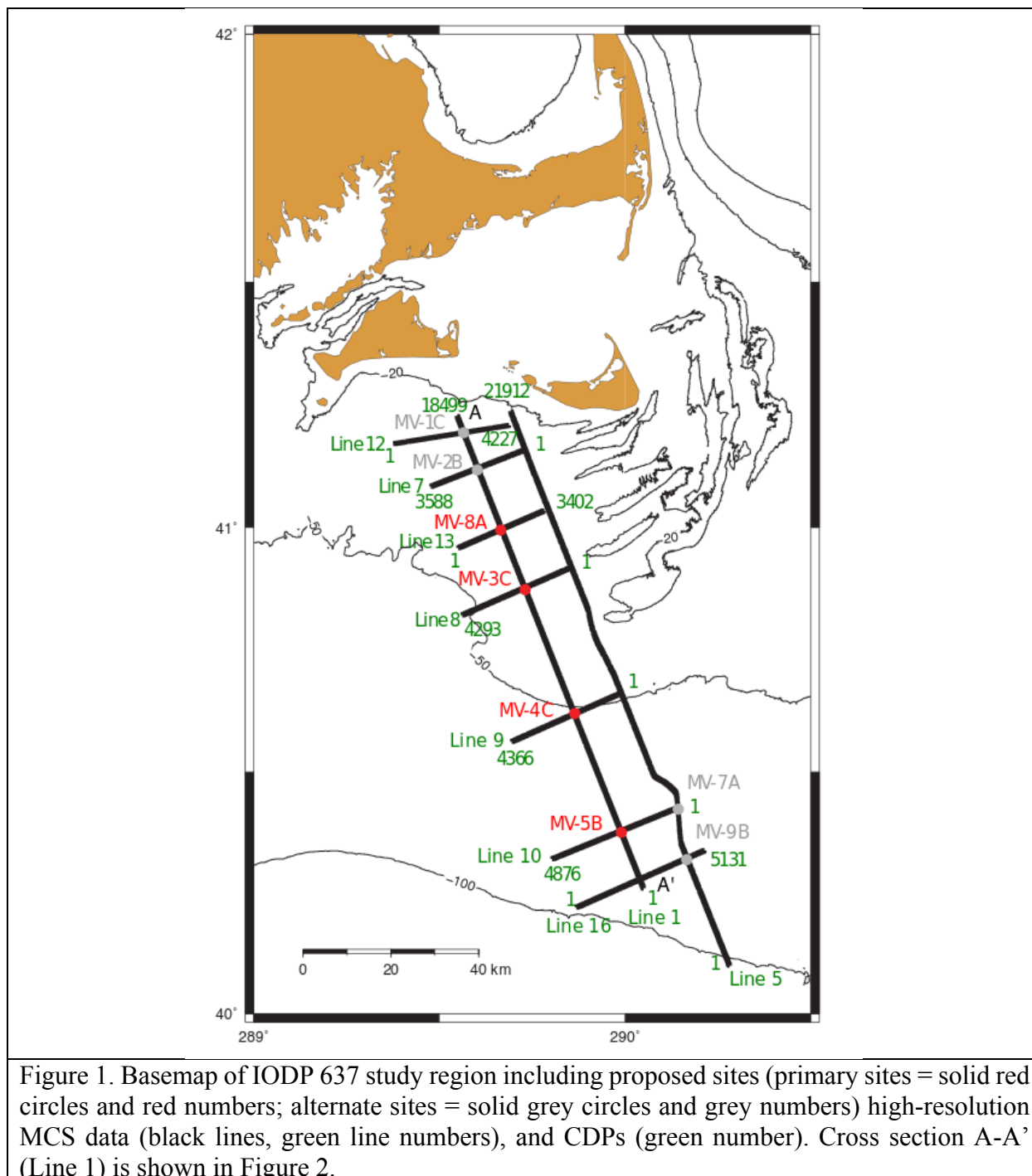
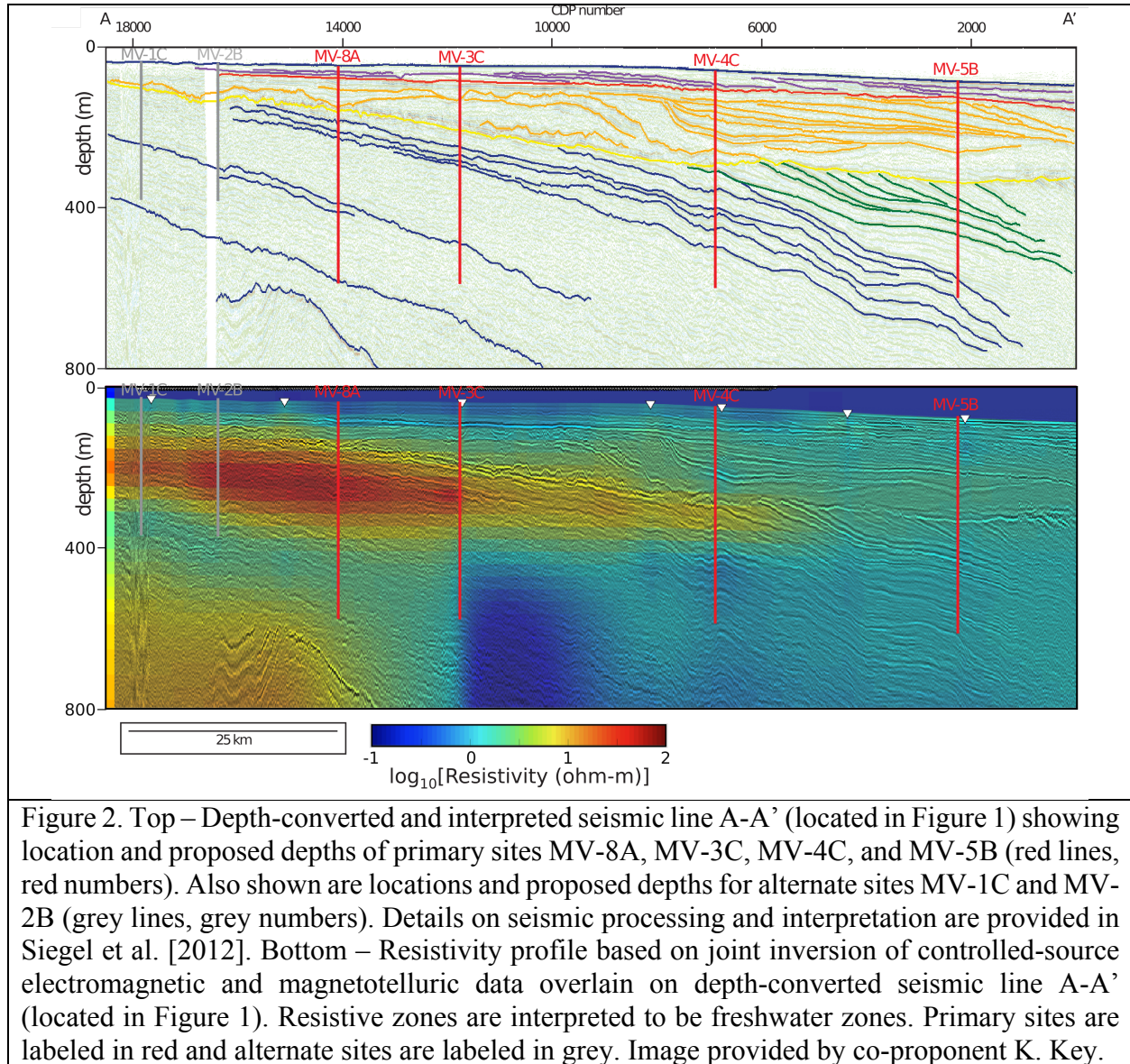


Figure 1. Basemap of IODP 637 study region including proposed sites (primary sites = solid red circles and red numbers; alternate sites = solid grey circles and grey numbers) high-resolution MCS data (black lines, green line numbers), and CDPs (green number). Cross section A-A' (Line 1) is shown in Figure 2.



After deciding on the operational strategy that allows for three sites, we also determined that each site objectives could be accomplished in a single hole. This hole would be used for coring and logging as was done on Expedition 313 [Mountain et al., 2010]. Microbiological/biogeochemical samples could be taken in this hole as is commonly employed within IODP. Additionally, we determined that with appropriate scoping, a casing plan could be developed that would allow pump tests to be completed in the coring and logging hole. Thus the proponent team is optimistic that all operations can be completed in a total of three sites with one hole at each site.

Wireline Logging and Pump Tests

The original proposal requested the use of logging while drilling (LWD) to obtain the highest quality petrophysical data in the shelf sediments as traditional wireline logging has been

problematic in shelf sediments, such as documented on ODP Leg 174A [Austin et al., 1998]. Of particular importance is getting high quality density, porosity, and resistivity logs for assessing transport properties and for ground-truthing the electromagnetic and magnetotelluric surveys. While LWD data would provide high quality downhole data, the costs of LWD tools are high.

IODP Exp. 313 [Mountain et al., 2010] demonstrated that a drilling-coring-wireline logging-casing plan provides useful logging data and maintains the integrity of the hole for deeper drilling, sampling, and logging. The workshop team determined that standard core measurements of moisture and density and porewater analyses for water chemistry coupled with wireline logging for resistivity and density provide more than sufficient information to ground-truth the electromagnetic and magnetotelluric data as the core and porewater data will provide regular and precise porosity and chemistry data that can be enhanced by wireline logs. The porosity and chemistry data also provide essential constraints for numerical models again that will be augmented by wireline logging data. Thus the team concluded that standard coring, sampling and wireline logging will provide the required data.

In association with the logging discussion, the workshop team also addressed the need for downhole hydrologic testing (pump tests). The overall consensus was that pump tests are important for constraining the hydrologic properties, especially in the sand-rich intervals where core recovery is expected to be low which precludes shore-based hydrogeological testing on cores. The conclusion was that pump tests can be completed but a detailed scoping on casing and screening is needed. The overall consensus is that a casing-screening-testing plan can be designed to keep all operations in a single hole at each site.

Water Dating

One important aspect to characterizing the origin of offshore freshwater is obtaining age data on the water. At the simplest level, these data provide the temporal constraints on the origin of the freshwater which then can be used to refine groundwater flow models to test emplacement mechanisms, to evaluate flow pathways, and then to predict the modern dynamics of the flow system. We concluded that to accomplish this we should date the freshwater and the saltwater endmembers as well as the mixed waters to help understand the age of the freshwater and the seawater and to help understand the mixing of the waters.

The primary approaches for age dating are krypton (^{81}Kr), helium (^4He), carbon (^{14}C), tritium (^3H), oxygen ($\delta^{18}\text{O}$), and a full suite of noble gases from the porewater samples from traditional IODP porewater samples (core squeezing of intact intervals with good recovery – most likely confining units) and from pumping tests (intervals of poor recovery – most likely aquifer units). In addition, strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) analyses are desired as they can provide constraints on the origin of the freshwater and on flow pathways. To get the best constraints on water ages, multiple age-dating approaches should be employed. Most of the dating techniques can be done with porewater samples from core squeezing, allowing us to bracket the age and origin of fluids in the confining units where core recovery should be good. The exception to this is krypton work which requires larger water volumes, which will have to be collected from pumping tests. Pumping tests, however, also provide fluids from intervals of poor recovery facilitating analyses of all the isotopes and of the formation hydrologic properties. Thus a combined approach of core squeezing and pumping tests in a single hole allows collection of all the data needed for age and origin assessment. It also

provides enough fluids for rare earth elemental (REE) analyses allowing improved constraints on global geochemical cycles and on the contribution of REEs to the ocean via submarine groundwater discharge (SGD). This in turn allows a better understanding of SGD volumes, which are not well constrained.

Onshore Drilling

Another objective of the workshop was to determine the value added from an onshore component to the drilling. Initial thoughts were that an onshore site would provide direct access to modern recharge, could isolate then transition from modern water to paleo-freshwater, and might facilitate the removal of some offshore sites to reduce overall costs. After evaluating the numerical flow models and the electromagnetic and magnetotelluric data, it was determined that three offshore sites were sufficient to characterize the entire offshore system from freshwater to seawater and would keep the project in the estimated budget. This limited the amount of discussion for onshore sites, but it was concluded that a separate proposal would be developed for ICDP as a stand-alone, but complementary, onshore drilling project. The onshore proposal will focus on three discrete issues: (1) characterizing the hydrogeological properties of the sediments to better understand the nearshore permeability architecture; (2) evaluating the spatial variability of freshwater on Martha's Vineyard and/or Nantucket including any potential transitions from modern freshwater to paleo-freshwater; and (3) collecting basement material to contribute to our overall understanding the central Atlantic magmatic province.

References

- Austin, J.A., Jr., Christie-Blick, N., Malone, M.J., et al., 1998, Proc. ODP, Init. Repts., 174A: College Station, TX (Ocean Drilling Program), doi:10.2973/odp.proc.ir.174a.1998.
- Mountain, G., Proust, J.-N., McInroy, D., Cotterill, C., and the Expedition 313 Scientists, 2010, Proc. IODP, 313: Tokyo (Integrated Ocean Drilling Program Management International, Inc.). doi:10.2204/iodp.proc.313.2010.
- Siegel, J., Dugan, B., Lizarralde, D., Person, M., DeFoor, W., Miller, N., 2012, Geophysical evidence of a late Pleistocene glaciation and paleo-ice stream on the Atlantic Continental Shelf offshore Massachusetts, USA, *Mar Geol*, 303-306, 63-74.
- Siegel, J., Person, M., Dugan, B., Cohen, D., Lizarralde, D., Gable, C., 2014, Influence of late Pleistocene glaciations on the hydrogeology of the continental shelf offshore Massachusetts, USA, *Geochem Geophys Geosys*, 15, doi:10.1002/2014GC005569.

IODP Site Forms

Form 1 – General Site Information

637 - Add 7

Section A: Proposal Information

Proposal Title	A Shallow Drilling Campaign to Assess the Pleistocene Hydrogeology, Geomicrobiology, Nutrient Fluxes, and Fresh Water Resources of the Atlantic Continental Shelf, New England		
Date Form Submitted	2017-11-23 05:44:34		
Site-Specific Objectives with Priority (Must include general objectives in proposal)	MV-8A will characterize the freshwater endmember.		
List Previous Drilling in Area	AMCOR wells 6001, 6009, 6020, 6021; COST wells B-2, G-1, G-2, ODP Leg 174A, IODP Exp. 313		

Section B: General Site Information

Site Name:	MV-08A		Area or Location:	New England continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#				
Latitude:	Deg:	40.9976	Jurisdiction:	USA
Longitude:	Deg:	-70.3334	Distance to Land: (km)	44
Coordinate System:	WGS 84			
Priority of Site:	Primary: <input checked="" type="checkbox"/>	Alternate: <input type="checkbox"/>	Water Depth (m):	41

Section C: Operational Information

	Sediments		Basement	
Proposed Penetration (m):	550		0	
	Total Sediment Thickness (m) 550			
	Total Penetration (m):			550
General Lithologies:	Silt, sand, clay		Not applicable, no basement penetration	
Coring Plan: (Specify or check)				
	APC <input checked="" type="checkbox"/>	XCB <input checked="" type="checkbox"/>	RCB <input type="checkbox"/>	Re-entry <input type="checkbox"/> PCS <input type="checkbox"/>
Wireline Logging Plan:	Standard Measurements		Special Tools	
	WL <input checked="" type="checkbox"/> Porosity <input checked="" type="checkbox"/> Density <input checked="" type="checkbox"/> Gamma Ray <input checked="" type="checkbox"/> Resistivity <input checked="" type="checkbox"/> Sonic (Δt) <input checked="" type="checkbox"/> Formation Image (Res) <input checked="" type="checkbox"/> VSP (zero offset) <input type="checkbox"/> Formation Temperature & Pressure <input checked="" type="checkbox"/>	Magnetic Susceptibility <input type="checkbox"/> Borehole Temperature <input type="checkbox"/> Formation Image (Acoustic) <input type="checkbox"/> VSP (walkaway) <input type="checkbox"/> LWD <input type="checkbox"/>	Other tools:	
	Other Measurements: Pump tests			
Estimated Days:	Drilling/Coring: 19	Logging: 4	Total On-site: 23	
Observatory Plan:	Longterm Borehole Observation Plan/Re-entry Plan			
Potential Hazards/Weather:	Shallow Gas <input type="checkbox"/> Hydrocarbon <input type="checkbox"/> Shallow Water Flow <input type="checkbox"/> Abnormal Pressure <input type="checkbox"/> Man-made Objects (e.g., sea-floor cables, dump sites) <input type="checkbox"/> H ₂ S <input type="checkbox"/> CO ₂ <input type="checkbox"/> Sensitive marine habitat (e.g., reefs, vents)	Complicated Seabed Condition <input type="checkbox"/> Soft Seabed <input type="checkbox"/> Currents <input type="checkbox"/> Fracture Zone <input type="checkbox"/> Fault <input type="checkbox"/> High Dip Angle <input type="checkbox"/>	Hydrothermal Activity <input type="checkbox"/> Landslide and Turbidity Current <input type="checkbox"/> Gas Hydrate <input type="checkbox"/> Diapir and Mud Volcano <input type="checkbox"/> High Temperature <input type="checkbox"/> Ice Conditions <input type="checkbox"/>	Preferred weather window Summer
	Other:			

IODP Site Forms

Form 2 - Site Survey Detail

Proposal #:	637 - Add 7	Site #:	MV-08A	Date Form Submitted:	2017-11-23 05:44:34
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Data Type	In SSDB	Details of available data and data that are still to be collected
1a High resolution seismic reflection (primary)	yes	Line: Line 1 Position: CDP 14100 Data already approved by site characterization panel. Depth approved to 350 mbsf by EPSP so will request depth extension approval.
1b High resolution seismic seismic reflection (crossing)	yes	Line: Line 13 Position: CDP 1700 Data already approved by site characterization panel. Depth approved to 350 mbsf by EPSP so will request depth extension approval.
2a Deep penetration seismic reflection (primary)		
2b Deep penetration seismic reflection (crossing)		
3 Seismic Velocity	yes	
4 Seismic Grid		
5a Refraction (surface)		
5b Refraction (bottom)		
6 3.5 kHz		
7 Swath bathymetry		
8a Side looking sonar (surface)		
8b Side looking sonar (bottom)		
9 Photography or video		
10 Heat Flow		
11a Magnetism		
11b Gravity		
12 Sediment cores	yes	
13 Rock sampling		
14a Water current data		
14b Ice Conditions		
15 OBS microseismicity		
16 Navigation	yes	
17 Other		

IODP Site Forms

Form 4 - Environmental Protection

Proposal #:	637 - Add 7	Site #:	MV-08A	Date Form Submitted:	2017-11-23 05:44:34
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Pollution & Safety Hazard	Comment
1. Summary of operations at site	APC to refusal followed by XCB to TD. Will core/case/log/sample following strategy employed on Exp 313.
2. All hydrocarbon occurrences based on previous DSDP/ODP/IODP drilling	None
3. All commercial drilling in this area that produced or yielded significant hydrocarbon shows	None
4. Indications of gas hydrates at this location	None
5. Are there reasons to expect hydrocarbon accumulations at this site?	None
6. What "special" precautions will be taken during drilling?	Maybe some low overpressures; have been evaluated by EPSP and approved to 350 mbsf; depth extension to be requested.
7. What abandonment procedures need to be followed?	Standard IODP procedures
8. Natural or manmade hazards which may affect ship's operations	Fishing
9. Summary: What do you consider the major risks in drilling at this site?	Shallow water, unlithified sediments

Proposal #:	637 - Add 7	Site #:	MV-08A	Date Form Submitted:	2017-11-23 05:44:34
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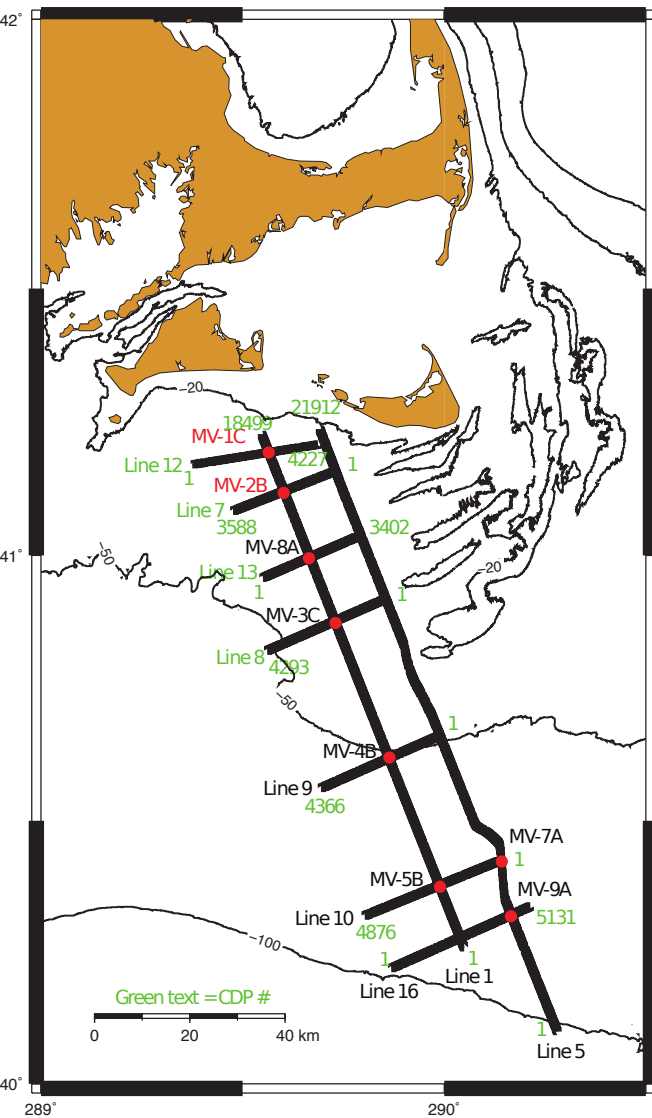
Subbottom depth (m)	Key reflectors, unconformities, faults, etc	Age (My)	Assumed velocity (km/s)	Lithology	Paleo-environment	Avg. accum. rate (m/My)	Comments
0 - 550		< Cretaceous	1.75	silt, sand, clay			

Site Summary Form

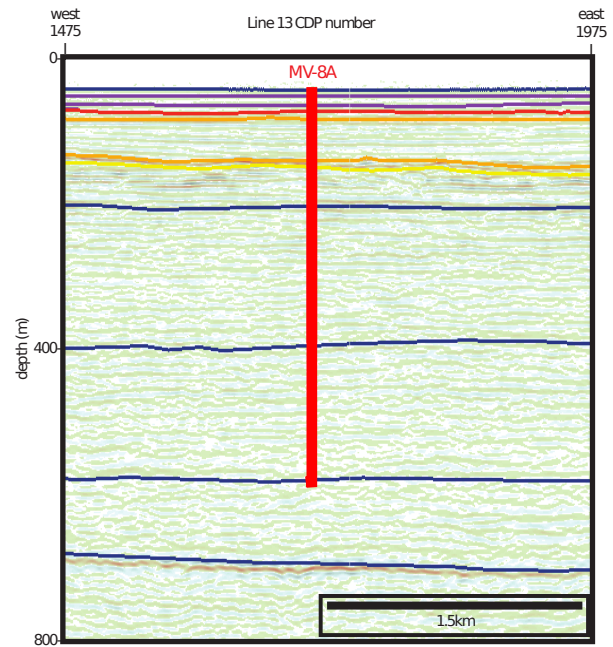
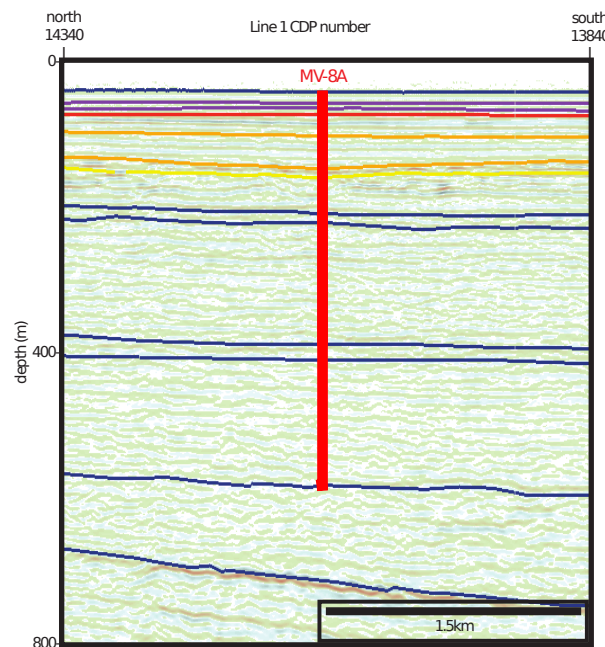
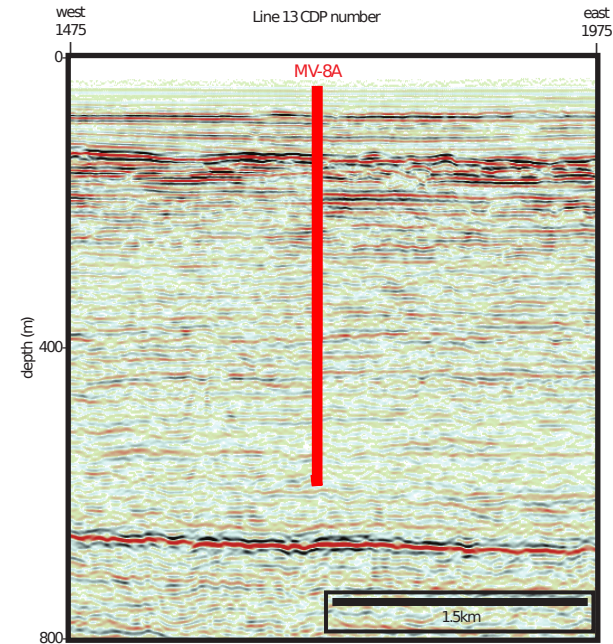
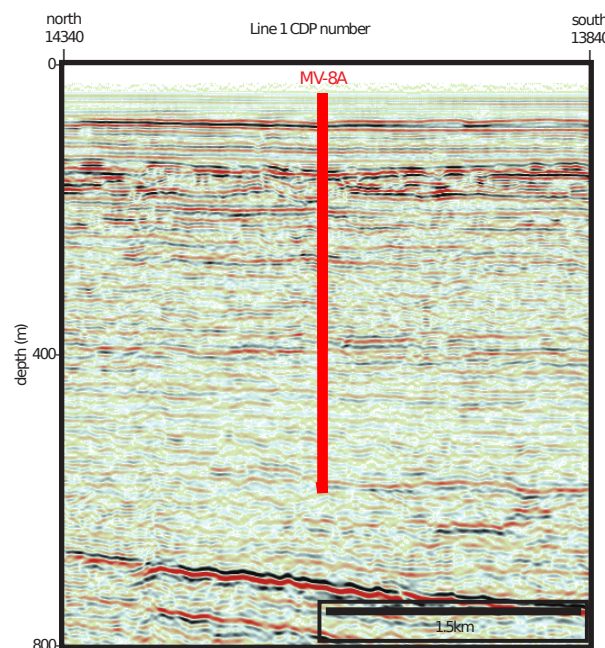
Proposal 637

Site MV-8A

Line 1 CDP 14100, Line 13 CDP 1700



SSDB Data Files: CDP Trackline Map;
Raw and Interpreted Seismic Figures;
SEG-Y Data; Navigation Data



IODP Site Forms

Form 1 – General Site Information

637 - Add 7

Section A: Proposal Information

Proposal Title	A Shallow Drilling Campaign to Assess the Pleistocene Hydrogeology, Geomicrobiology, Nutrient Fluxes, and Fresh Water Resources of the Atlantic Continental Shelf, New England		
Date Form Submitted	2017-11-23 05:44:34		
Site-Specific Objectives with Priority (Must include general objectives in proposal)	MV-4C will characterize the freshwater-to-seawater transition zone or the seawater endmember of the transect.		
List Previous Drilling in Area	AMCOR wells 6001, 6009, 6020, 6021; COST wells B-2, G-1, G-2, ODP Leg 174A, IODP Exp. 313		

Section B: General Site Information

Site Name:	MV-04C		Area or Location:	New England continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#				
Latitude:	Deg:	40.6185	Jurisdiction:	USA
Longitude:	Deg:	-70.1370	Distance to Land: (km)	87
Coordinate System:	WGS 84			
Priority of Site:	Primary: <input checked="" type="checkbox"/>	Alternate: <input type="checkbox"/>	Water Depth (m):	52

Section C: Operational Information

	Sediments		Basement	
Proposed Penetration (m):	650		0	
	Total Sediment Thickness (m) 650			
	Total Penetration (m):			650
General Lithologies:	Silt, sand, clay		Not applicable, no basement penetration	
Coring Plan: (Specify or check)				
	APC <input checked="" type="checkbox"/>	XCB <input checked="" type="checkbox"/>	RCB <input type="checkbox"/>	Re-entry <input type="checkbox"/> PCS <input type="checkbox"/>
Wireline Logging Plan:	Standard Measurements		Special Tools	
	WL <input checked="" type="checkbox"/> Porosity <input checked="" type="checkbox"/> Density <input checked="" type="checkbox"/> Gamma Ray <input checked="" type="checkbox"/> Resistivity <input checked="" type="checkbox"/> Sonic (Δt) <input checked="" type="checkbox"/> Formation Image (Res) <input checked="" type="checkbox"/> VSP (zero offset) <input type="checkbox"/> Formation Temperature & Pressure <input checked="" type="checkbox"/>	Magnetic Susceptibility <input type="checkbox"/> Borehole Temperature <input type="checkbox"/> Formation Image (Acoustic) <input type="checkbox"/> VSP (walkaway) <input type="checkbox"/> LWD <input type="checkbox"/>	Other tools:	
	Other Measurements: Pump tests			
Estimated Days:	Drilling/Coring: 19	Logging: 4	Total On-site: 23	
Observatory Plan:	Longterm Borehole Observation Plan/Re-entry Plan			
Potential Hazards/Weather:	Shallow Gas <input type="checkbox"/> Hydrocarbon <input type="checkbox"/> Shallow Water Flow <input type="checkbox"/> Abnormal Pressure <input type="checkbox"/> Man-made Objects (e.g., sea-floor cables, dump sites) <input type="checkbox"/> H ₂ S <input type="checkbox"/> CO ₂ <input type="checkbox"/> Sensitive marine habitat (e.g., reefs, vents)	Complicated Seabed Condition <input type="checkbox"/> Soft Seabed <input type="checkbox"/> Currents <input type="checkbox"/> Fracture Zone <input type="checkbox"/> Fault <input type="checkbox"/> High Dip Angle <input type="checkbox"/>	Hydrothermal Activity <input type="checkbox"/> Landslide and Turbidity Current <input type="checkbox"/> Gas Hydrate <input type="checkbox"/> Diapir and Mud Volcano <input type="checkbox"/> High Temperature <input type="checkbox"/> Ice Conditions <input type="checkbox"/>	Preferred weather window Summer
	Other:			

IODP Site Forms

Form 2 - Site Survey Detail

Proposal #:	637 - Add 7	Site #:	MV-04C	Date Form Submitted:	2017-11-23 05:44:34
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Data Type	In SSDB	Details of available data and data that are still to be collected
1a High resolution seismic reflection (primary)	yes	Line: Line 1 Position: CDP 6861 Located 250 m from intersection with Line 9. Approved by site characterization panel and EPSP to 650 mbsf; plan to drill to 550 mbsf.
1b High resolution seismic seismic reflection (crossing)	yes	Line: Line 9 Position: CDP 1821
2a Deep penetration seismic reflection (primary)		
2b Deep penetration seismic reflection (crossing)		
3 Seismic Velocity	yes	
4 Seismic Grid		
5a Refraction (surface)		
5b Refraction (bottom)		
6 3.5 kHz		
7 Swath bathymetry		
8a Side looking sonar (surface)		
8b Side looking sonar (bottom)		
9 Photography or video		
10 Heat Flow		
11a Magnetism		
11b Gravity		
12 Sediment cores	yes	
13 Rock sampling		
14a Water current data		
14b Ice Conditions		
15 OBS microseismicity		
16 Navigation		
17 Other		

IODP Site Forms

Form 4 - Environmental Protection

Proposal #:	637 - Add 7	Site #:	MV-04C	Date Form Submitted:	2017-11-23 05:44:34
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Pollution & Safety Hazard	Comment
1. Summary of operations at site	APC to refusal followed by XCB to TD. Will core/case/log/sample following strategy employed on Exp 313.
2. All hydrocarbon occurrences based on previous DSDP/ODP/IODP drilling	None
3. All commercial drilling in this area that produced or yielded significant hydrocarbon shows	None
4. Indications of gas hydrates at this location	None
5. Are there reasons to expect hydrocarbon accumulations at this site?	None
6. What "special" precautions will be taken during drilling?	Maybe some low overpressures; have been evaluated by EPSP and approved
7. What abandonment procedures need to be followed?	Standard IODP procedures
8. Natural or manmade hazards which may affect ship's operations	Fishing
9. Summary: What do you consider the major risks in drilling at this site?	Shallow water, unlithified sediments

Proposal #:	637 - Add 7	Site #:	MV-04C	Date Form Submitted:	2017-11-23 05:44:34
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Subbottom depth (m)	Key reflectors, unconformities, faults, etc	Age (My)	Assumed velocity (km/s)	Lithology	Paleo-environment	Avg. accum. rate (m/My)	Comments
0 - 650		< Cretaceous	1.75	silt, sand, clay			

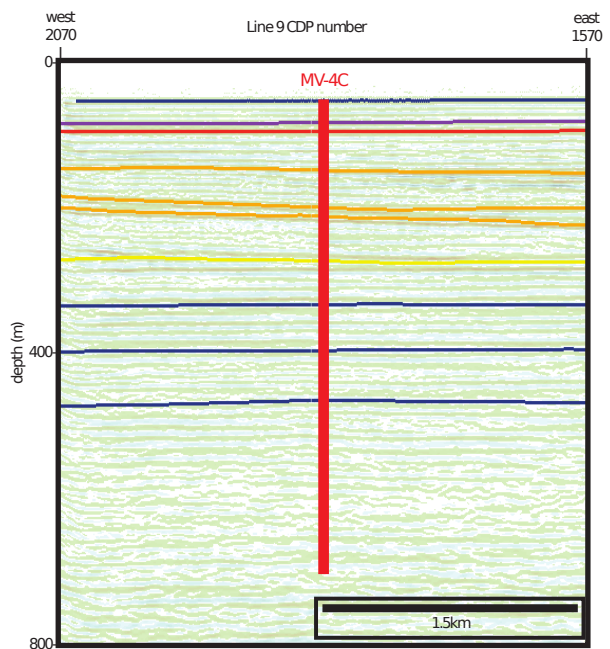
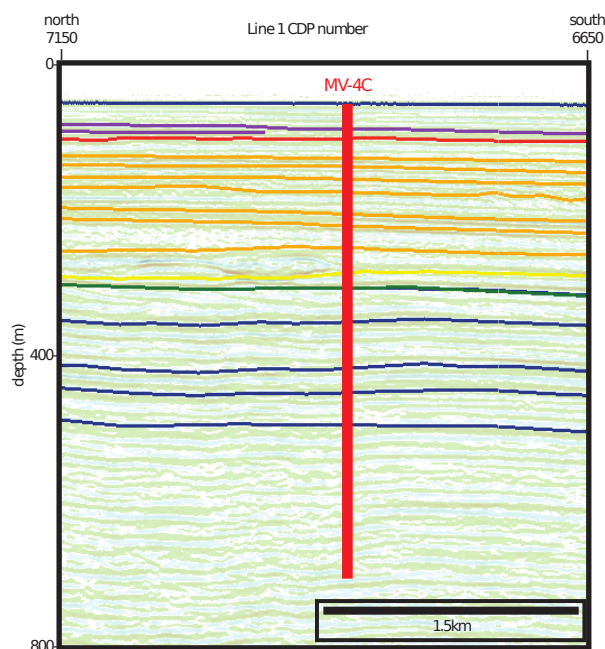
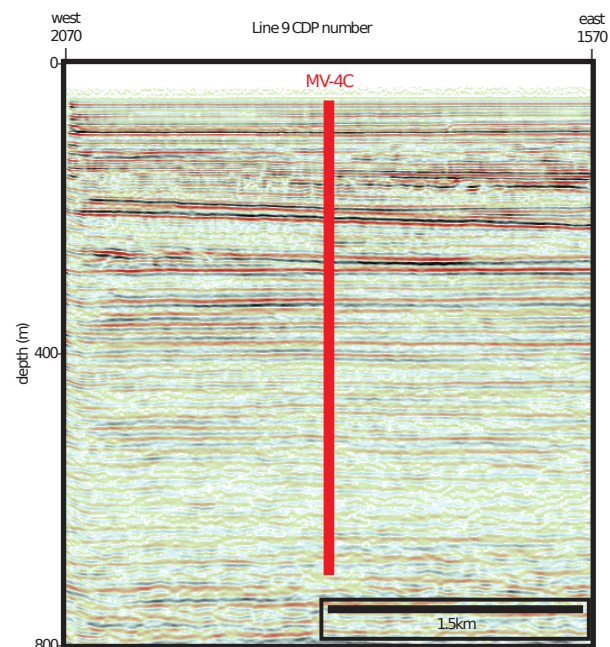
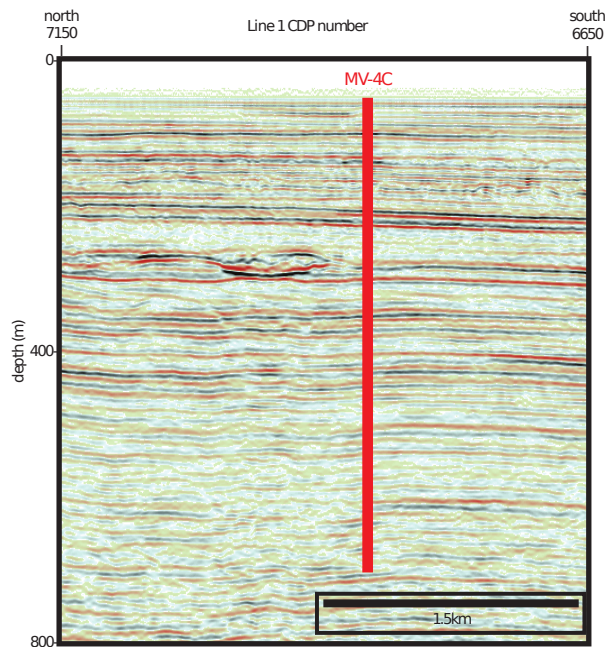
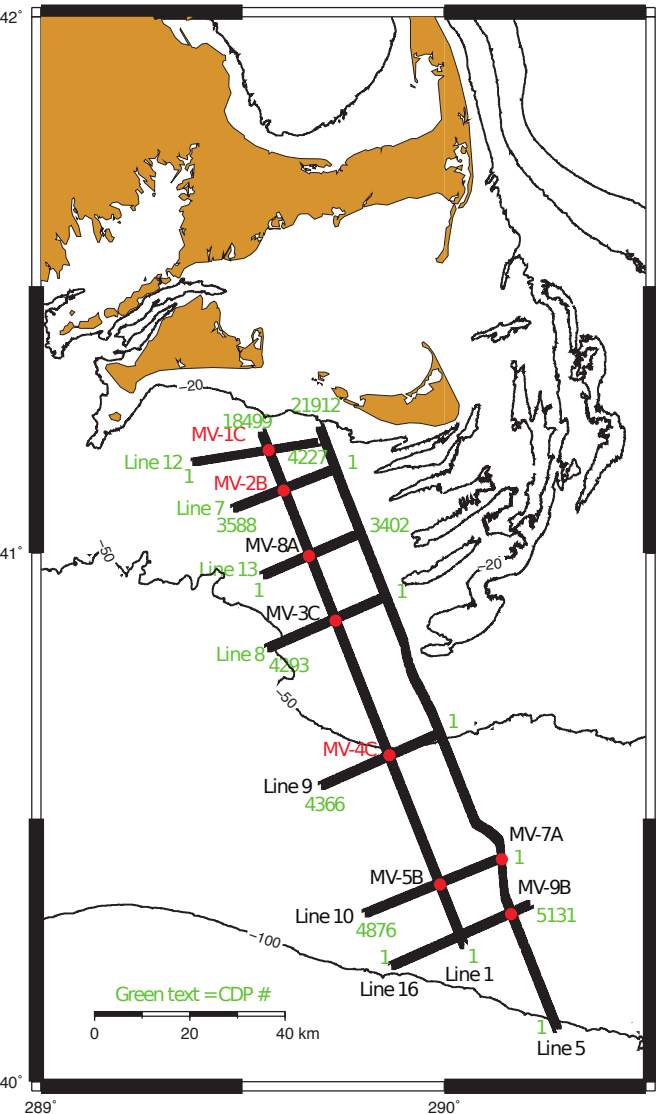
Site Summary Form

Proposal 637

Site MV-4C

Line 1 CDP 6861*, Line 9 CDP 1821

(*located 250 m from intersection with Line 9)



SSDB Data Files: CDP Trackline Map;
Raw and Interpreted Seismic Figures;
SEG-Y Data; Navigation Data

IODP Site Forms

Form 1 – General Site Information

637 - Add 7

Section A: Proposal Information

Proposal Title	A Shallow Drilling Campaign to Assess the Pleistocene Hydrogeology, Geomicrobiology, Nutrient Fluxes, and Fresh Water Resources of the Atlantic Continental Shelf, New England		
Date Form Submitted	2017-11-23 05:44:34		
Site-Specific Objectives with Priority (Must include general objectives in proposal)	MV-3C will characterize the freshwater-to-seawater transition zone of the transect.		
List Previous Drilling in Area	AMCOR wells 6001, 6009, 6020, 6021; COST wells B-2, G-1, G-2, ODP Leg 174A, IODP Exp. 313		

Section B: General Site Information

Site Name:	MV-03C		Area or Location:	New England continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#				
Latitude:	Deg:	40.8746	Jurisdiction:	USA
Longitude:	Deg:	-70.2697	Distance to Land: (km)	56
Coordinate System:	WGS 84			
Priority of Site:	Primary: <input checked="" type="checkbox"/>	Alternate: <input type="checkbox"/>	Water Depth (m):	42

Section C: Operational Information

	Sediments		Basement	
Proposed Penetration (m):	550		0	
	Total Sediment Thickness (m) 550			
	Total Penetration (m):			550
General Lithologies:	Silt, sand, clay		Not applicable, no basement penetration	
Coring Plan: (Specify or check)				
	APC <input checked="" type="checkbox"/>	XCB <input checked="" type="checkbox"/>	RCB <input type="checkbox"/>	Re-entry <input type="checkbox"/> PCS <input type="checkbox"/>
Wireline Logging Plan:				
	Standard Measurements		Special Tools	
WL <input checked="" type="checkbox"/>	Magnetic Susceptibility <input type="checkbox"/>		Other tools:	
Porosity <input checked="" type="checkbox"/>	Borehole Temperature <input type="checkbox"/>			
Density <input checked="" type="checkbox"/>	Formation Image (Acoustic) <input type="checkbox"/>			
Gamma Ray <input checked="" type="checkbox"/>	VSP (walkaway) <input type="checkbox"/>			
Resistivity <input checked="" type="checkbox"/>	LWD <input type="checkbox"/>			
Sonic (Δt) <input checked="" type="checkbox"/>				
Formation Image (Res) <input checked="" type="checkbox"/>				
VSP (zero offset) <input type="checkbox"/>				
Formation Temperature & Pressure <input checked="" type="checkbox"/>				
Other Measurements:	Pump tests.			
Estimated Days:	Drilling/Coring: 19	Logging: 4	Total On-site: 23	
Observatory Plan:	Longterm Borehole Observation Plan/Re-entry Plan			
Potential Hazards/Weather:	Shallow Gas <input type="checkbox"/>	Complicated Seabed Condition <input type="checkbox"/>	Hydrothermal Activity <input type="checkbox"/>	Preferred weather window Summer
	Hydrocarbon <input type="checkbox"/>	Soft Seabed <input type="checkbox"/>	Landslide and Turbidity Current <input type="checkbox"/>	
	Shallow Water Flow <input type="checkbox"/>	Currents <input type="checkbox"/>	Gas Hydrate <input type="checkbox"/>	
	Abnormal Pressure <input type="checkbox"/>	Fracture Zone <input type="checkbox"/>	Diapir and Mud Volcano <input type="checkbox"/>	
	Man-made Objects (e.g., sea-floor cables, dump sites) <input type="checkbox"/>	Fault <input type="checkbox"/>	High Temperature <input type="checkbox"/>	
	H ₂ S <input type="checkbox"/>	High Dip Angle <input type="checkbox"/>	Ice Conditions <input type="checkbox"/>	
	CO ₂ <input type="checkbox"/>			
	Sensitive marine habitat (e.g., reefs, vents)			
Other:				

IODP Site Forms

Form 2 - Site Survey Detail

Proposal #:	637 - Add 7	Site #:	MV-03C	Date Form Submitted:	2017-11-23 05:44:34
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Data Type	In SSDB	Details of available data and data that are still to be collected
1a High resolution seismic reflection (primary)	yes	Line: Line 1 Position: CDP 11751 Site approved by site characterization panel and EPSP to 550 mbsf.
1b High resolution seismic seismic reflection (crossing)	yes	Line: Line 8 Position: CDP 1785
2a Deep penetration seismic reflection (primary)		
2b Deep penetration seismic reflection (crossing)		
3 Seismic Velocity	yes	
4 Seismic Grid		
5a Refraction (surface)		
5b Refraction (bottom)		
6 3.5 kHz		
7 Swath bathymetry		
8a Side looking sonar (surface)		
8b Side looking sonar (bottom)		
9 Photography or video		
10 Heat Flow		
11a Magnetism		
11b Gravity		
12 Sediment cores	yes	
13 Rock sampling		
14a Water current data		
14b Ice Conditions		
15 OBS microseismicity		
16 Navigation		
17 Other		

IODP Site Forms

Form 4 - Environmental Protection

Proposal #:	637 - Add 7	Site #:	MV-03C	Date Form Submitted:	2017-11-23 05:44:34
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Pollution & Safety Hazard	Comment
1. Summary of operations at site	APC to refusal followed by XCB to TD. Will core/case/log/sample following strategy employed on Exp 313.
2. All hydrocarbon occurrences based on previous DSDP/ODP/IODP drilling	None
3. All commercial drilling in this area that produced or yielded significant hydrocarbon shows	None
4. Indications of gas hydrates at this location	None
5. Are there reasons to expect hydrocarbon accumulations at this site?	None
6. What "special" precautions will be taken during drilling?	Maybe some low overpressures; have been evaluated by EPSP and approved
7. What abandonment procedures need to be followed?	Standard IODP procedures
8. Natural or manmade hazards which may affect ship's operations	Fishing
9. Summary: What do you consider the major risks in drilling at this site?	Shallow water, unlithified sediments

Proposal #:	637 - Add 7	Site #:	MV-03C	Date Form Submitted:	2017-11-23 05:44:34
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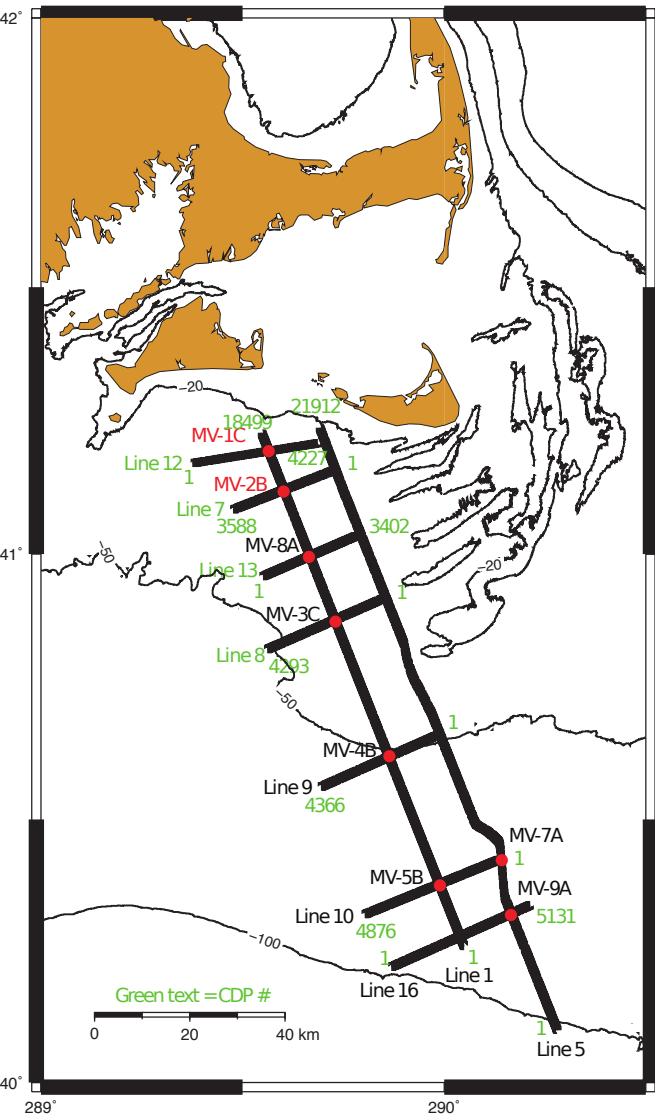
Subbottom depth (m)	Key reflectors, unconformities, faults, etc	Age (My)	Assumed velocity (km/s)	Lithology	Paleo-environment	Avg. accum. rate (m/My)	Comments
0 - 550		< Cretaceous	1.75	silt, sand, clay			

Site Summary Form

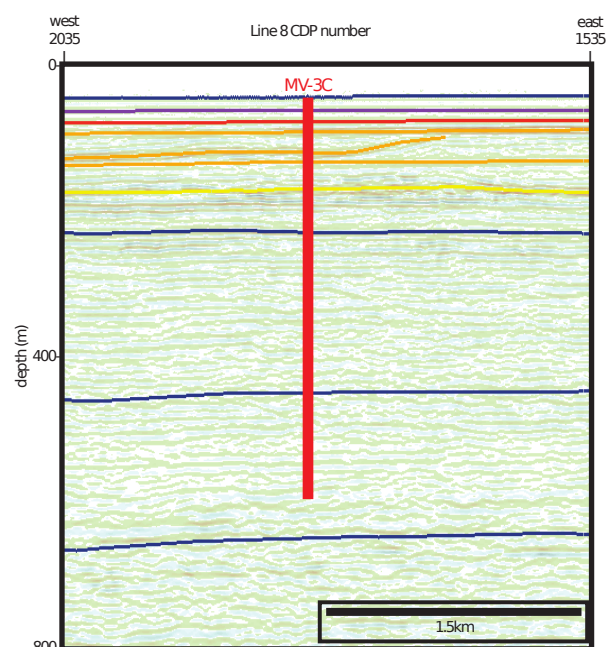
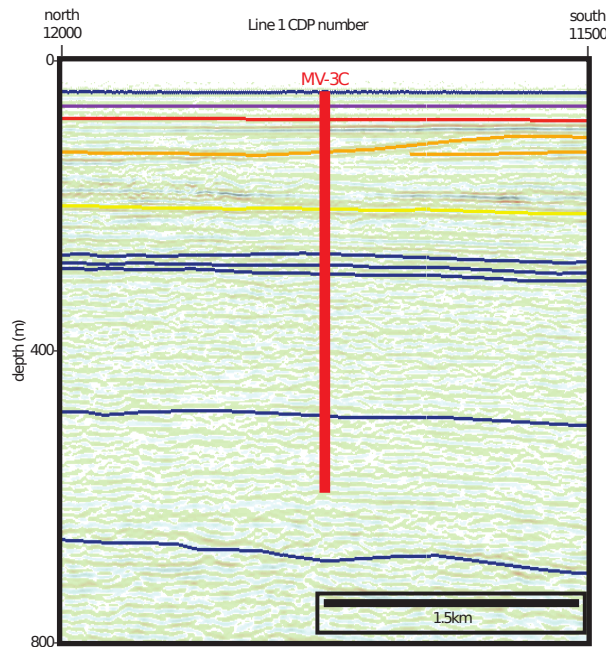
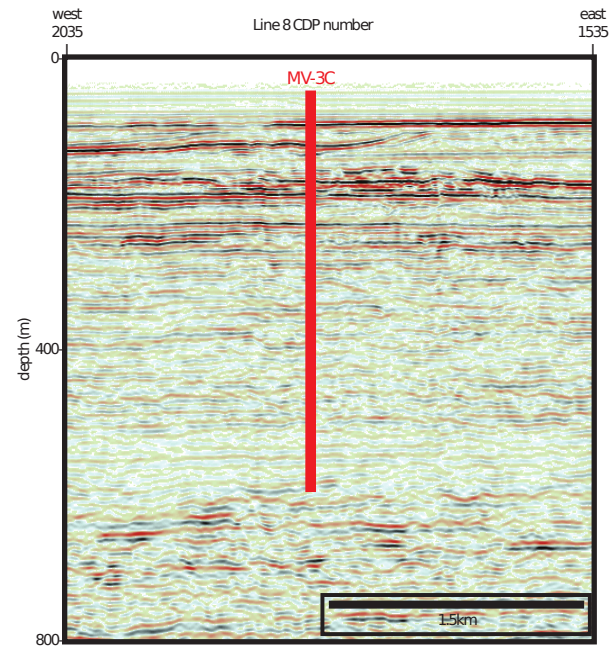
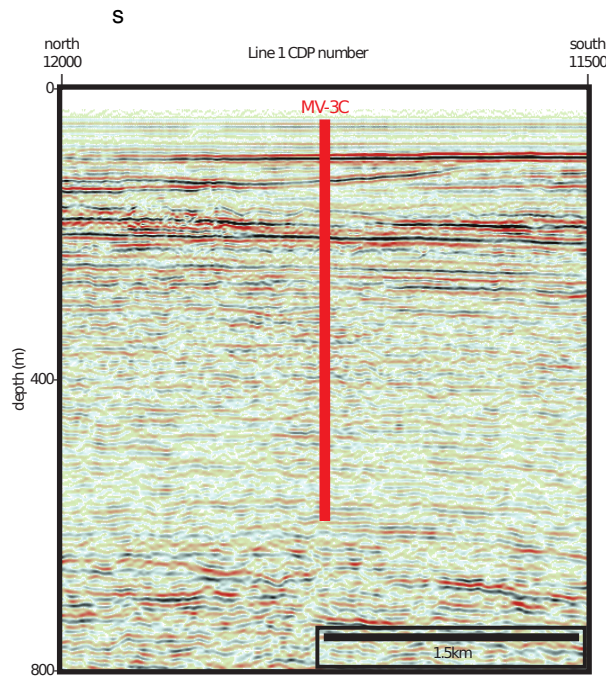
Proposal 637

Site MV-3C

Line 1 CDP 11751, Line 8 CDP 1785



SSDB Data Files: CDP Trackline Map;
Raw and Interpreted Seismic Figures;
SEG-Y Data; Navigation Data



IODP Site Forms

Form 1 – General Site Information

637 - Add 7

Section A: Proposal Information

Proposal Title	A Shallow Drilling Campaign to Assess the Pleistocene Hydrogeology, Geomicrobiology, Nutrient Fluxes, and Fresh Water Resources of the Atlantic Continental Shelf, New England		
Date Form Submitted	2017-11-23 05:44:34		
Site-Specific Objectives with Priority (Must include general objectives in proposal)	MV-5B will characterize the seawater endmember of the transect.		
List Previous Drilling in Area	AMCOR wells 6001, 6009, 6020, 6021; COST wells B-2, G-1, G-2, ODP Leg 174A, IODP Exp. 313		

Section B: General Site Information

Site Name:	MV-05B		Area or Location:	New England continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#				
Latitude:	Deg:	40.3771	Jurisdiction:	USA
Longitude:	Deg:	-70.0119	Distance to Land: (km)	116
Coordinate System:	WGS 84			
Priority of Site:	Primary: <input checked="" type="checkbox"/>	Alternate: <input type="checkbox"/>	Water Depth (m):	79

Section C: Operational Information

	Sediments		Basement	
Proposed Penetration (m):	650		0	
Total Sediment Thickness (m)	650			
			Total Penetration (m):	650
General Lithologies:	Silt, sand, clay		Not applicable, no basement penetration	
Coring Plan: (Specify or check)				
	APC <input checked="" type="checkbox"/>	XCB <input checked="" type="checkbox"/>	RCB <input type="checkbox"/>	Re-entry <input type="checkbox"/> PCS <input type="checkbox"/>
Wireline Logging Plan:				
	Standard Measurements		Special Tools	
WL	<input checked="" type="checkbox"/>	Magnetic Susceptibility	<input type="checkbox"/>	Other tools:
Porosity	<input checked="" type="checkbox"/>	Borehole Temperature	<input type="checkbox"/>	
Density	<input checked="" type="checkbox"/>	Formation Image (Acoustic)	<input type="checkbox"/>	
Gamma Ray	<input checked="" type="checkbox"/>	VSP (walkaway)	<input type="checkbox"/>	
Resistivity	<input checked="" type="checkbox"/>	LWD	<input type="checkbox"/>	
Sonic (Δt)	<input checked="" type="checkbox"/>			
Formation Image (Res)	<input checked="" type="checkbox"/>			
VSP (zero offset)	<input type="checkbox"/>			
Formation Temperature & Pressure	<input checked="" type="checkbox"/>			
Other Measurements:				
Estimated Days:	Drilling/Coring: 19	Logging: 4	Total On-site: 23	
Observatory Plan:	Longterm Borehole Observation Plan/Re-entry Plan			
Potential Hazards/Weather:	Shallow Gas <input type="checkbox"/>	Complicated Seabed Condition <input type="checkbox"/>	Hydrothermal Activity <input type="checkbox"/>	Preferred weather window Summer
	Hydrocarbon <input type="checkbox"/>	Soft Seabed <input type="checkbox"/>	Landslide and Turbidity Current <input type="checkbox"/>	
	Shallow Water Flow <input type="checkbox"/>	Currents <input type="checkbox"/>	Gas Hydrate <input type="checkbox"/>	
	Abnormal Pressure <input type="checkbox"/>	Fracture Zone <input type="checkbox"/>	Diapir and Mud Volcano <input type="checkbox"/>	
	Man-made Objects (e.g., sea-floor cables, dump sites) <input type="checkbox"/>	Fault <input type="checkbox"/>	High Temperature <input type="checkbox"/>	
	H ₂ S <input type="checkbox"/>	High Dip Angle <input type="checkbox"/>	Ice Conditions <input type="checkbox"/>	
	CO ₂ <input type="checkbox"/>			
	Sensitive marine habitat (e.g., reefs, vents)			
Other:				

IODP Site Forms

Form 2 - Site Survey Detail

Proposal #:	637 - Add 7	Site #:	MV-05B	Date Form Submitted:	2017-11-23 05:44:34
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Data Type	In SSDB	Details of available data and data that are still to be collected
1a High resolution seismic reflection (primary)	yes	Line: Line 1 Position: CDP 2250 Approved by site characterization panel and EPSP to 650 mbsf; plan to drill to 550 mbsf
1b High resolution seismic seismic reflection (crossing)	yes	Line: Line 10 Position: CDP 2115
2a Deep penetration seismic reflection (primary)		
2b Deep penetration seismic reflection (crossing)		
3 Seismic Velocity	yes	
4 Seismic Grid		
5a Refraction (surface)		
5b Refraction (bottom)		
6 3.5 kHz		
7 Swath bathymetry		
8a Side looking sonar (surface)		
8b Side looking sonar (bottom)		
9 Photography or video		
10 Heat Flow		
11a Magnetism		
11b Gravity		
12 Sediment cores	yes	
13 Rock sampling		
14a Water current data		
14b Ice Conditions		
15 OBS microseismicity		
16 Navigation		
17 Other		

IODP Site Forms

Form 4 - Environmental Protection

Proposal #:	637 - Add 7	Site #:	MV-05B	Date Form Submitted:	2017-11-23 05:44:34
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Pollution & Safety Hazard	Comment
1. Summary of operations at site	APC to refusal followed by XCB to TD. Will core/case/log/sample following strategy employed on Exp 313.
2. All hydrocarbon occurrences based on previous DSDP/ODP/IODP drilling	None
3. All commercial drilling in this area that produced or yielded significant hydrocarbon shows	None
4. Indications of gas hydrates at this location	None
5. Are there reasons to expect hydrocarbon accumulations at this site?	None
6. What "special" precautions will be taken during drilling?	Maybe some low overpressures; have been evaluated by EPSP and approved
7. What abandonment procedures need to be followed?	Standard IODP procedures
8. Natural or manmade hazards which may affect ship's operations	Fishing
9. Summary: What do you consider the major risks in drilling at this site?	Shallow water, unlithified sediments

IODP Site Forms

Form 5 - Lithologies

Proposal #:	637 - Add 7	Site #:	MV-05B	Date Form Submitted:	2017-11-23 05:44:34
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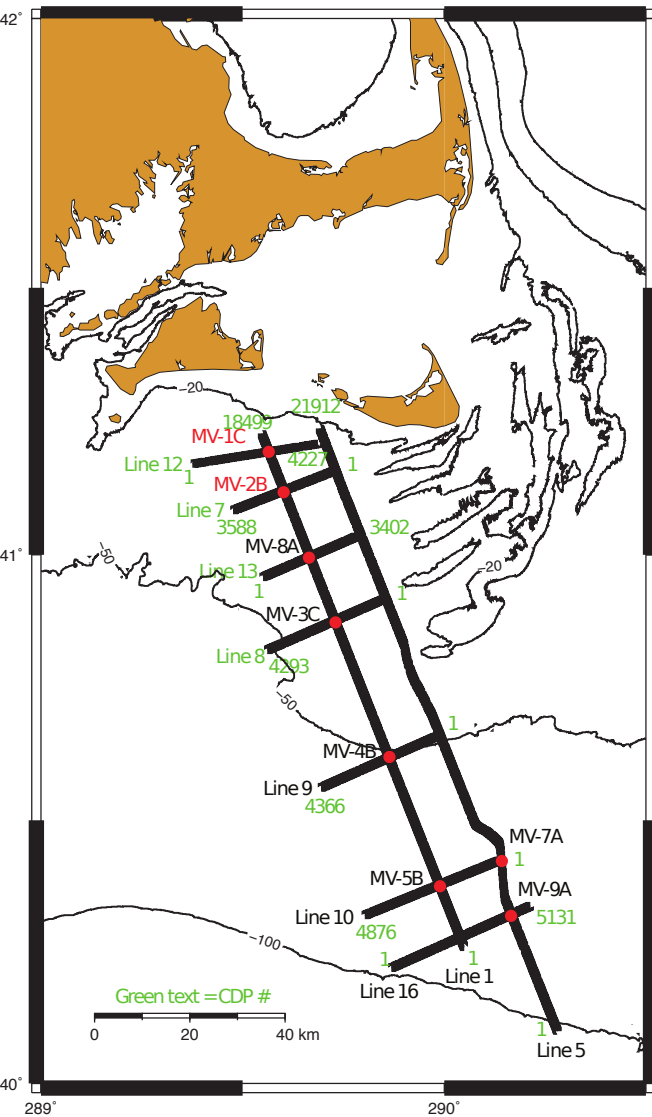
Subbottom depth (m)	Key reflectors, unconformities, faults, etc	Age (My)	Assumed velocity (km/s)	Lithology	Paleo-environment	Avg. accum. rate (m/My)	Comments
0 - 650		< Cretaceous	1.75	silt, sand, clay			

Site Summary Form 6

Proposal 637

Site MV-5B

Line 1 CDP 2250, Line 10 CDP 2115



SSDB Data Files: CDP Trackline Map;
Raw and Interpreted Seismic Figures;
SEG-Y Data; Navigation Data

