IODP Proposal Cover Sheet

972 - APL 3

New England Slope Hydrogeology (APL)

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Title	Investigating groundwater flow, submarine groundwater discharge, and slope stability on the Atlantic continental slope offshore Massachusetts, New England, USA
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Keywords	submarine groundwater, slope stability
Area	New England Continental Slope

Proponent Information

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Abstract

Multiple studies have shown that passive margins are dynamic hydrologic systems. Examples of this are (1) documentation and interpretation that freshwater within continental shelf sediments is far out of equilibrium with modern sea level, (2) geophysical analyses confirming active seepage from the continental slope is common in many locations, and (3) extensive, large slope failures along passive margins. While these are global phenomena, one location where they are co-located and accessible for study is the Atlantic continental shelf and slope offshore Massachusetts, USA. IODP proposal 637: New England Continental Shelf Hydrogeology is a mission-specific proposal to drill, sample, and analyze the fluids on the continental shelf with aims to constrain the hydrogeologic system, origin and emplacement of the freshwaters in the continental shelf, and to understand the impacts of this dynamic flow system on microbiological abundance and productivity. The research proposed in this APL augments and advances IODP proposal 637 by extending characterization to the slope hydrogeologic and geomorphic system at two sites with active seepage but in different water depths and different geomorphic settings.

We hypothesize that glacial loading and sedimentation processes can create a freshwater source and generate fluid overpressures in shelf and slope sediments. Sub-ice-sheet recharge associated with glacial maxima provide a viable source for freshwater and a loading source that generates overpressure. High-sedimentation rates during glacial retreat also create overpressure. While these processes operate at different temporal and spatial time scales, they can be separated and quantified by dedicated expeditions that quantify hydrologic properties, fluid chemistry, and sedimentation history that are combined with detailed hydrogeological modeling of the system. Together IODP proposal 637 and this APL constrain the regional hydrogeological system from the shoreline to the ocean. Independently, this APL provides an efficient (~6 days) means to directly sample and understand seepage along the slope and its driving mechanisms and will provide insights of how the seepage on the slope is linked to fluid flow and slope failure processes within the shelf and slope.

This work will extend our understanding fluid flow along passive margins which impacts seepage and slope stability. This will also expand our characterization of chemical fluxes in this environment which will provide important constraints for understanding microbial abundance, diversity, and productivity and long-term fluxes of carbon, nitrogen, and other nutrients to the ocean. The results of this effort will provide validation and testing of process-based models that can be used to understand fluid fluxes in other margin settings worldwide.

Scientific Objectives

Targeted drilling and coring including hydrogeological, hydrogeochemical, microbiological, and sedimentological analyses and in situ pressure and temperature measurements on the continental slope offshore Massachusetts, USA will provide direct characterization of processes acting in the shallow subseafloor that drive seepage from the slope into the ocean. These data provide necessary inputs and calibration for process-based models that account for driving forces and temporal evolution of these dynamic, and at times ephemeral, flow systems. Additionally, the work provides data that will help us understand linkages between freshwater in the shelf, active seepage on the slope, and slope erosive processes.

We propose a two site drilling campaign on the Atlantic continental slope offshore Massachusetts, USA to assess hydrogeological, hydrochemical, microbiological and erosion systems of the slope. Each site will include two holes. The first hole will use APC/XCB to 400 mbsf and will use standard IODP analyses to describe physical properties, fluid and sediment chemistry, lithology, age, and microbial communities. The second hole will be dedicated to in situ pressure/termperature measurements and collection of cores for microbiological and geotechnical studies. In situ pressure measurements and spot core locations will be informed by data from Hole A at each site. The proposed drilling, sampling, and measurement campaign has applications for Challenges 5, 7, 10, 12, and 14 of the IODP 2013-2023 science plan and also for Strategic Objectives SO#1 and SO#7, Flagship Initiatives FI#3 and FI#5, and the Land to Sea Enabling Element proposed in the 2050 Science Framework document “Exploring Earth By Scientific Ocean Drilling”.

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

In situ formation pressure measurements with the temperature dual pressure (T2P) probe using the probe delivery tool (PDT – an update to the motion decoupled hydraulic delivery system, MDHDS).

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Proposal History

Submission Type: Resubmission from previously submitted proposal

Review Response

Site selection: We propose two new sites that are within 4km of active seepage so we can study the active processes (sedimentary, geomorphic, groundwater, chemistry, microbiology) on the mid-to-lower slope where canyons and mass wasting are prevalent and on the upper slope landward of the major canyons systems. Two sites are required to differentiate and address the importance of regional, lateral flow (from one site to the other) and local, vertical flow (at individual sites).

Hypotheses and data: We revamped our guiding questions into four testable hypotheses. We provide details of how specific data will provide tests to each hypotheses. We also provide more detailed assessment of what the data types will be.

Freshwater aquifer: We clarified that freshwater could be trapped or discharging at the sites based on previous modeling results. In addition we explain that this freshwater may be below the resolution of electromagnetic surveys and occurring in conduits that are below seismic resolution. Thus we emphasize drilling is the only way to test these model predictions and will help us understand the limitations for geophysics looking at large-scale freshwater deposits and the value of drilling for defining fine-scale details. The fine-scale and large-scale pictures will be integrated in post-drilling research.

Scientific objectives: We expanded our objectives to include a dedicated hypothesis related to the contribution that submarine groundwater flow and associated pressures have to erosion at the granular scale (groundwater sapping) and at the slope-sculpting scale (large submarine landslides). Our proximity to massive slope failures and active canyon excavation allows including this research with the data collection already proposed.

Proponents: We have expanded the proponent list to strengthen and broaden our expertise in sedimentology, slope stability, isotope geochemistry, clumped isotopes, electromagnetics, groundwater, geobiology, microbiology, and biogeochemical cycles. The proponents range from early career researchers to full professors, and provide representation from undergraduate colleges through research universities.

Data: Larger and higher-resolution images with more annotation will be uploaded to the SSDB. Bathymetric data will be uploaded in a grid format. Depth estimates have been revised based on an average velocity of 1700 m/s determined from ODP/IODP checkshots from offshore New Jersey (Leg 174a) and the Gulf of Mexico (Expedition 308). Processing streams have been located for the MCS data will be uploaded with the seismic data.

Proposed Sites (Total proposed sites: 2; pri: 2; alt: 0; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
MVS-03A (Primary)	39.8427 -69.6265	932	500	0	500	Document hydrogeological properties, geomechanical properties, sedimentology, fluid and sediment chemistry and age, fluid pressure/ temperature, microbial abundance and diversity in a region of active subseafloor fluid flow, active seepage, and recent slope failure on the mid-to-lower slope where canyons are prevalent.
MVS-04A (Primary)	40.0093 -69.2678	162	500	0	500	Document hydrogeological properties, geomechanical properties, sedimentology, fluid and sediment chemistry and age, fluid pressure/ temperature, microbial abundance and diversity in a region of active subseafloor fluid flow and active seepage on the upper slope and landward of major canyon systems.