IODP Proposal Cover Sheet

910 - Pre

Continental Margin Methane Cycling: Rio Grande

Received for: 2016-10-03

Title	Carbon cycling in methane-charged continental margin sediments: Rio Grande Cone (Brazil)
Proponents	Alberto Malinverno, Frederick S. Colwell, Gerald R. Dickens, Verena B. Heuer, Joao Marcelo Ketzer, John W. Pohlman, Marta E. Torres, Adriano R. Viana
Keywords	microbial methanogenesis, hydrates, carbon cycle
Area	Brazil Atlantic margin

Proponent Information

Proponent	Alberto Malinverno
Affiliation	Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York, USA
Country	United States

☑ Permission is granted to post the coversheet/site table on www.iodp.org

Abstract

Enormous quantities of microbial methane occur in continental margin sediments. This methane can exist as dissolved gas, free gas bubbles or gas hydrate. However, its abundance and importance remain poorly understood, because of major open issues regarding the formation and flow of methane. These include reaction pathways and rates of microbial methanogenesis; the influence of sediment lithology, temperature, and organic matter composition upon methanogenesis; the relative importance of shallow versus deep methanogenesis; and the cycling and fate of the associated carbon. The outstanding problems demand new drilling that enables linking microbiological experiments done at near in situ conditions, a vast array of geochemical analyses, and detailed physical property measurements within a framework of reaction-transport modeling. Such study would directly address Challenge 13 (What properties and processes govern the flow and storage of carbon in the subseafloor?) and Challenge 5 (What are the origin, composition, and global significance of subseafloor communities?) in the IODP 2013-2023 science plan.

Widespread microbial methane strongly suggests globally relevant processes. However, past drilling clearly demonstrates a high degree of heterogeneity in methane abundance and distribution at individual locations and between various regions. This reflects differences in key parameters that affect the formation and flow of methane. The Rio Grande Cone, offshore B Brazil, represents a spectacular natural laboratory for understanding how carbon cycles in methane-charged sediment. Seismic reflection profiles show a prominent bottom-simulating reflector spanning ~45,000 km2. Multibeam bathymetry and near-bottom surveys display areas with pockmarks near the upper limit of the methane hydrate stability zone. Shallow piston cores recovered samples of gas hydrate and authigenic carbonate. Analyses of pore water and gas from these cores have determined shallow (~2-8 mbsf) subbottom sulfate-methane transitions (SMTs) related to anaerobic oxidation of methane (AOM), as well as a microbial origin for the gas. All information indicates a large region of the seafloor with a dynamic microbial methane system.

We propose two transects of four sites each that sample the variation in methanogenesis and carbon cycling at different water depths (~500-3000 m) and different locations across the margin. The measurement plan consists of high-resolution sampling for microbiology and geochemistry, extensive pressure coring, APC-T temperature measurements, infrared core imaging, and downhole logging. Methanogenesis rates also will be measured in microbiological experiments where sediment samples are inoculated in biomass recycle reactors that reproduce the starved conditions experienced in situ and in separate incubation experiments done under in situ pressure.

Scientific Objectives

The overall scientific goal is to vastly improve our understanding of biogeochemical and physical processes that lead to widespread methane occurrence in continental margin sediments and that couple to the overlying ocean over time. We will determine the amount and distribution of methane across a region where basic observations suggest that key parameters differ in space and time. More crucially, we will focus on comparing methanogenesis rates derived from microbiological experiments with rates needed for reaction-transport modeling to match geochemical observations. The proposed study will address outstanding questions on carbon cycling in continental margin sediments: we will estimate in situ methanogenesis rates through experiments and modeling, test whether observations require a deep methane source, investigate how methanogenesis rates are related to sediment type, temperature, age and composition of organic matter, and clarify the role of methane in the complex set of near-seafloor biogeochemical reactions relevant to the global carbon cycle. The planned measurements of in situ methane concentration will provide key constraints to the modeling and the estimated methanogenesis rates will inform the quantification of methane amounts in continental margin sediments. Additional benefits will include a comparison of in situ methane estimates based on N_2 and Ar with PCS data, a set of combined incubation and extraction-based measurements of H_2, and constraints on how methane and carbon escape the seafloor near the feather edge of hydrate stability conditions.

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

Proposed Sites (Total proposed sites: 8; pri: 8; alt: 0; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
RGC-01A (Primary)	-32.7915 -49.8764	1200	200	0	200	Sample sediments around pockmarks on the upper slope.
RGC-02A (Primary)	-33.0568 -49.7431	1300	500	0	500	Sample a "stratigraphic" methane hydrate setting in the extensional domain of the Rio Grande Cone.
RGC-03A (Primary)	-33.1839 -49.5389	1600	550	0	550	Sample a "stratigraphic" methane hydrate setting in the extensional domain of the Rio Grande Cone.
RGC-04A (Primary)	-33.3073 -49.3315	2400	600	0	600	Sample a methane hydrate setting with upward pore water advection in the compressional domain of the Rio Grande Cone.
RGC-05A (Primary)	-33.4108 -50.4081	650	150	0	150	Sample sediments around pockmarks on the upper slope.
RGC-06A (Primary)	-33.5487 -50.2564	1150	500	0	500	Sample a "stratigraphic" methane hydrate setting in the extensional domain of the Rio Grande Cone.
RGC-07A (Primary)	-33.6596 -50.0817	1650	550	0	550	Sample a "stratigraphic" methane hydrate setting in the extensional domain of the Rio Grande Cone.
RGC-08A (Primary)	-33.7718 -49.9032	2500	600	0	600	Sample a methane hydrate setting with upward pore water advection in the compressional domain of the Rio Grande Cone.