IODP Proposal Cover Sheet

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Continental Margin Methane Cycling: Rio Grande

Received for: 2018-10-01

Title	Carbon cycling in methane-charged continental margin sediments: Rio Grande Cone (Brazil)
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Keywords	microbial methanogenesis, hydrates, carbon cycle
Area	Brazil Atlantic margin

Proponent Information

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Abstract

Enormous quantities of microbial methane occur in continental margin sediments. This methane exists as dissolved gas, free gas, 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; the cycling of carbon and its sequestration as carbonate in the sediment; and carbon release from the sediment column back to the ocean. These 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 implies globally relevant processes. However, past drilling clearly demonstrates a high degree of heterogeneity in methane abundance and distribution at individual locations and between regions. This reflects differences in key parameters that affect the formation and flow of methane. The Rio Grande Cone, offshore 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. Piston cores recovered samples of gas hydrate and authigenic carbonate. Analyses of pore water and gas from these cores have determined shallow (~3-10 mbsf) subbottom sulfate-methane transitions related to anaerobic oxidation of methane, 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 five sites that sample the variation in methanogenesis and carbon cycling at different water depths (~600-3000 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 will also 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.

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Scientific Objectives

The overall scientific goal is to substantially 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. The proposed study will address outstanding questions on carbon cycling in continental margin sediments: we will estimate in situ methanogenesis rates by comparing the results of microbiological experiments and reaction-transport 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, characterize the time-dependent organic matter input driven by paleoceanographic changes, clarify the role of methane in the complex set of near-seafloor biogeochemical reactions relevant to the global carbon cycle, and constrain the flux of carbon from the sediment back to the ocean. The planned measurements of in situ methane concentration from pressure core sampling 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 N2 and Ar with PCS data, a set of combined incubation and extraction-based measurements of H2, 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

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Proposed Sites (Total proposed sites: 16; pri: 5; alt: 11; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
RGC-01C (Primary)	-32.94865 -49.88057	1159	500	0	500	Sample a "stratigraphic" methane hydrate setting in the extensional domain of the Rio Grande Cone. This site will allow for investigating microbial methanogenesis where fluid flow is likely not to be significant and address our scientific objectives on constraining the of microbial methanogenesis pathway, vertical distribution, and rate, and on characterizing reactions at the SMTZ. This site is located on the axis of the cone where sedimentation rates are expected to be the highest and will be triple-cored for a paleoceanographic reconstruction.
RGC-09B (Alternate)	-33.01200 -49.80825	1219	500	0	500	Alternate site with same site-specific objectves as RGC-01C.
RGC-02C (Alternate)	-33.21597 -49.66411	1368	500	0	500	Alternate site with same site-specific objectves as RGC-01C.
RGC-03C (Primary)	-33.65803 -50.15192	1505	500	0	500	Sample a "stratigraphic" methane hydrate setting in the extensional domain of the Rio Grande Cone. This site will allow for investigating microbial methanogenesis where fluid flow is likely not to be significant and address our scientific objectives on constraining the of microbial methanogenesis pathway, vertical distribution, and rate, and on characterizing reactions at the SMTZ. This site is located on the southern flank of the RGC where sediments are thinner and sedimentation rates are likely lower than at the location of primary Site RGC-01C.
RGC-04C (Alternate)	-33.5006 -50.34727	914	500	0	500	Alternate site with same site-specific objectves as RGC-03C.
RGC-11A (Alternate)	-33.66913 -50.16478	1484	500	0	500	Alternate site with same site-specific objectves as RGC-03C.
RGC-07C (Primary)	-33.58388 -49.22675	2972	800	0	800	Sample a "stratigraphic" methane hydrate setting in the deepwater contourite SE of the Rio Grande Cone. This site will allow for investigating microbial methanogenesis where fluid flow is likely not to be significant and address our scientific objectives on constraining the of microbial methanogenesis pathway, vertical distribution, and rate, and on characterizing reactions at the SMTZ. This site will be also triple-cored for a paleoceanographic reconstruction.
RGC-08C (Alternate)	-33.92741 -49.81531	2664	800	0	800	Alternate site with same site-specific objectves as RGC-07C.
RGC-12A (Alternate)	-33.46151 -49.09352	2993	800	0	800	Alternate site with same site-specific objectves as RGC-07C.
RGC-16A (Alternate)	-33.15918 -48.9736	2938	800	0	800	Alternate site with same site-specific objectves as RGC-07C.
RGC-10B (Primary)	-32.77458 -49.85012	1299	500	0	500	Sample a location near pockmarks on the middle slope of the Rio Grande Cone. This site will allow for determining the variation in methanogenesis in a location where fluid advection may be important for a comparison to "stratigraphic" settings.
RGC-06C (Alternate)	-32.79565 -49.87302	1257	500	0	500	Alternate site with same site-specific objectives as RGC-10B.
RGC-15A (Alternate)	-32.74982 -49.92467	1219	500	0	500	Alternate site with same site-specific objectives as RGC-10B.
RGC-05C (Primary)	-33.43466 -50.45741	607	200	0	200	Sample a location near pockmarks on the upper slope of the Rio Grande Cone at the feather edge of the MHSZ. This site will allow for determining the variation in methanogenesis in a location where fluid advection may be important and where hydrates may be actively dissociating, providing key observations on the portion of the marine hydrate reservoir that is most sensitive to climatic change.
RGC-13A (Alternate)	-33.42207 -50.44317	608	200	0	200	Alternate site with same site-specific objectves as RGC-05C.
RGC-14A (Alternate)	-33.44959 -50.47509	607	200	0	200	Alternate site with same site-specific objectves as RGC-05C.