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IODP Proposal Cover Sheet

791-APL2

☐ **New** ☒ **Revised** ☐ **Addendum**

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Title:	**Constraining methane cycling in continental margins: a combined microbiological, geochemical, and modeling approach**		
Proponent(s):	Alberto Malinverno, Frederick S. Colwell, Marta E. Torres, John W. Pohlman, and Verena B. Heuer		
Keywords: *(5 or less)*	Microbial methanogenesis, gas hydrates, methane cycle, early diagenesis	Area:	Northern Cascadia continental margin

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Permission to post abstract on IODP Web site: X Yes ☐ No

Abstract: (*400 words or less)*

Microbial methanogenesis in continental margin sediments, where most marine organic carbon is deposited, is not well understood. Methanogenesis is a key process in the diagenesis of organic matter, and an improved understanding will advance our knowledge of fundamental carbon cycle processes. Open questions include the pathways and rates of microbial methanogenesis; the influence of sediment temperature and organic matter characteristics; and the relative importance of shallow versus deep methanogenesis. We propose to address these outstanding questions by linking (1) microbiological experiments done at conditions comparable to those in situ, (2) geochemical measurements, and (3) reaction-transport modeling. The proposed study directly addresses 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. The necessary fresh samples and measurements can be collected at Site U1325 on the northern Cascadia margin (IODP Expedition 311) and this study can build on the extensive data set already acquired. Site U1325 has broad significance as a model site because most of the methane gas and hydrate in continental margins is in similar "stratigraphic" settings. We propose to core by APC two additional holes at Site U1325: one going to ~300 mbsf or to APC refusal, and one reaching just below the sulfate-methane transition (4.5 mbsf at Site U1325). The measurement plan consists of high-resolution sampling for microbiology and geochemistry (0.5-5 m sampling interval), ~10 pressure cores with the PCS tool, and APC-T temperature measurements. Methanogenesis rates 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. We will also conduct an extensive geochemical program for interstitial waters (including organic matter metabolites, pH, Ca, Mg, Cl, volatile fatty acids, DOC), headspace gas (including N_2 and Ar to estimate in situ methane concentration and H_2), in situ methane from degassing of PCS cores, and organic matter characterization. Based on experience at Site U1325, the proposed drilling can take place in ~3 days. Site U1325 is logistically attractive because it is only 150 nautical miles from the port of Victoria, and APL operations can be carried out during a transit. A companion proposal will be submitted to support the science proposed herein.

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Scientific Objectives: (*250 words or less*)

The overall scientific goal is to improve our understanding of biogeochemical processes fueled by organic matter degradation in continental margin sediments. We will focus on comparing methanogenesis rates derived from microbiological experiments with the rates needed for reaction-transport modeling to match the geochemical observations. If experimental rates match the modeling rates, the observations can be explained by in situ methanogenesis only; if instead the experimental rates are insufficient to generate the observed amounts of methane, the existence of an alternate, possibly deeper source is supported. The proposed study will address outstanding questions on methane cycling in continental margin sediments: we will estimate in situ methanogenesis rates by experiments and modeling, test whether the observations require a deep methane source, investigate how methanogenesis rates are related to 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 C cycle. The planned measurements of in situ methane concentration will provide key constraints to the modeling and the estimated methanogenesis rates will inform models that quantify methane amounts in continental margin sediments. Additional benefits include a comparison of in situ methane estimates based on N_2 and Ar with PCS data, combined incubation and extraction-based measurements of H_2, the determination of the advective regime at Site U1325, and a comparison with the 2005 Exp. 311 results to test local steady-state conditions.

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
U1325	48° 38.7’ N 126° 59.0’ W	2195	300	0	300	See above