IODP Proposal Cover Sheet

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Chatham Rise Geologic CO2 Release

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Title	Accumulation and release of Carbon Dioxide from geologic sources in the South Pacific contributed to Glacial/ Interglacial pCO2 variability and caused the formation of Seafloor Pockmarks on the Chatham Rise, New Zealand
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Area	Chatham RIse

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Abstract

One of the Grand Challenges in Ocean and Climate Science is to learn what mechanisms operating within the Earth System regulated the concentration of atmospheric CO2 systematically between ~280ppm and 190ppm during each glacial cycle of the late Pleistocene. Recent discoveries have identified accumulations of both liquid and hydrate (~solid) CO2 in the oceans at a variety of tectonic settings. Liquid and hydrate phases of CO2 are stable and accumulate in marine sediments below ~400m water depth where temperatures are below ~9°C. This represents a significant fraction of the sea floor where hydrothermal fluids circulate and communicate with the ocean. Changes in temperature and pressure that accompanied glacial cycles would have affected the stability and hence, the flux of this carbon to the ocean. In this way, geologic reservoirs can act as 'capacitors', accumulating carbon during glaciations and then leaking carbon during glacial terminations.

New radiocarbon data from sediments deposited on the Chatham Rise document release of geologic CO2 to the ocean during the last glacial cycle. The large magnitude of these D14C excursions requires there to have been significant flux of 14C-dead carbon from the Chatham Rise at the last glacial termination. Importantly, the D14C excursions coincided with the formation of large pockmarks distributed across the southern margin of the Chatham Rise. Seismic profiles document earlier episodes of pockmark formation, each coinciding with a glacial termination during the late Pleistocene. We hypothesize that the close temporal relationship between the late glacial D14C excursions and the formation of pockmarks points to a causal relationship where carbon-rich fluids released from geologic reservoirs during glacial-interglacial transitions caused the sediment disturbances that formed pockmarks (Davy et al., 2010) . The carbon released from these episodes entered the overlying ocean where it then contributed to the deglacial rise in atmospheric pCO2 (Stott and Timmermann, 2011).

We propose a coring expedition to recover the Pleistocene sediments on the Chatham Rise and its margins to test the hypothesis that geologic carbon was released from the Chatham Rise at each glacial termination and the release of carbon contributed to the formation of pockmarks. Verification that geologic carbon was released from the Chatham Rise (and other geologic settings throughout the oceans) during each glacial cycle would constitute a transformative discovery that would potentially solve one of the Grand Scientific Challenges in Climate Science, a regulatory mechanism for the systematic variations in atmospheric pCO2.

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Scientific Objectives

Drilling, sampling (sediments and pore fluids), and geochemical measurements to test for the presence of geologic carbon-rich fluids in the subsurface and for evidence that carbon-rich fluids were released to the ocean at glacial terminations during the Pleistocene in association with the formation of pockmarks.

Major questions that will be addressed are: 1) Are there carbon-rich fluids (CO2 and/or CH4) at relatively shallow subsurface depths on the Chatham Rise? This requires the deep core capabilities of IODP. 2) Are pockmarks at each glacial termination associated with geochemical and sedimentological anomalies (pH and [CO3=] sensitive proxies including, d11B, B/Ca; carbon isotope anomalies, d13C and D14C; carbonate dissolution). This two will require multiple deep cores from the Rise and along its margins. 3) Was the timing of pockmark formation associated with each glacial termination over the past 1.8 Myr as suggested by seismic reflection data?

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

n/a

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Proposed Sites (Total proposed sites: 9; pri: 9; alt: 0; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
COSP-01A (Primary)	-44.0003 174.4760	569	30	0	30	Investigate whether pockmarks are linked to glacial terminations. Target high-amplitude reflection that corresponds to base of seafloor depression. (Key questions 1,2)
COSP-02A (Primary)	-43.9977 174.4738	563	70	0	70	Investigate a link between pockmark formation and CO2. High-amplitude reflections in pockmarks, located outside of pockmark and having continuous sedimentation to document sea water anomalies at time of pockmark formation. (Key questions 1,3)
COSP-03A (Primary)	-43.9921 174.4693	563	70	0	70	Investigate whether pockmarks are linked to glacial terminations. Target high-amplitude reflection that corresponds to base of seafloor depression. (Key questions 1,2)
COSP-04A (Primary)	-44.3250 177.0472	1017	350	0	350	Investigate a link between pockmark formation and CO2. High-amplitude reflections in pockmarks, located outside of pockmark and having continuous sedimentation to document sea water anomalies at time of pockmark formation. Determine timing of mounded contourite deposition and investigate the potential role of currents in pockmark modification. Investigate potential hypothesis of pockmark formation being linked to overpressured dewatering of sediments. (Key questions 1,3,4,5,6)
COSP-05A (Primary)	-44.3031 177.0401	983	500	0	500	Investigate a potential connection between silica diagenesis dewatering and pockmark formation. Determine timing of mounded contourite deposition and investigate the potential role of currents in pockmark modification. (Key questions 1,4,5,6)
COSP-06A (Primary)	-44.0983 178.5927	860	300	0	300	Investigate potential connection between vent structure imaged in seismic data and formation of large pockmark. (Key question 1)
COSP-07A (Primary)	-43.9815 178.7928	790	30	0	30	Investigate whether the timing of pockmark formation supports the hypothesis that original structures have been enlarged and elongated by currents related to Subtropical Front. (Key questions 1,6)
COSP-08A (Primary)	-43.9839 178.7647	750	30	0	30	Investigate whether pockmarks are linked to glacial terminations. Target high-amplitude reflection that corresponds to base of seafloor depression. Investigate a potential connection between silica diagenesis dewatering and pockmark formation. (Key questions 1,2,4,5,6)
COSP-09A (Primary)	-45.7576 178.1489	2502	200	0	200	Investigate a link between pockmark formation and CO2. High-amplitude reflections in pockmarks, located outside of pockmark and having continuous sedimentation to document sea water anomalies at time of pockmark formation. (Key questions 1,3)