

IODP Proposal Cover Sheet

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Canterbury Bight Offshore Freshened Groundwater

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Title	Hydrogeology, biogeochemistry and microbiology of an offshore freshened groundwater system in the Canterbury Bight, New Zealand		
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Keywords	offshore groundwater, hydrogeology, biogeochemistry, microbiology	Area	Canterbury Bight

Proponent Information

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Abstract

Offshore freshened groundwater (OFG) is groundwater with a dissolved solid concentration lower than seawater that is stored in sediments/rocks below the seafloor. The large majority of OFG has been emplaced by meteoric recharge and is located in siliciclastic, rifted, non-glaciated margins, within 50 km of the coast and down to a water depth of 75 m. The OFG system hosted in the Canterbury Bight, located offshore of the South Island of New Zealand, shares these characteristics. This OFG system is well constrained by a dense geophysical database, and is located at drillable depths and in a safe drilling environment.

We are proposing a hydrogeology-focused drilling campaign that targets three primary sites along a 40 km shore-normal transect in the Canterbury Bight. We plan in-situ measurements and long-term pumping to: (i) determine hydrogeological and petrophysical properties of the aquifer, physical and chemical characteristics of the OFG, as well as the variation of boundary conditions over geological time-scales; (ii) sample groundwater for geochemical (e.g. geochemical tracers, environmental isotopes, gas and nutrient analyses) and microbiological (e.g. gene-based analyses, microbial rate experiments, cell enumeration, radiocarbon analysis of RNA and DNA) analyses. We also plan to complete the casing and screening operations in a manner that allows for long-term monitoring of pressure, chemistry, temperature and microbiology.

The collected data will allow us to address fundamental knowledge gaps related to OFG characteristics, controls and emplacement dynamics, and the role that it plays in global biogeochemical cycles, by: (i) reducing uncertainty in estimations of OFG distribution and dimensions from geophysical data, (ii) improving hydrological models and developing reactive transport models, (iii) estimating the residence times of OFG, (iv) reconstructing the environmental conditions prevailing during recharge, (v) constraining rates and mechanisms of freshening/salinisation, (v) quantifying current concentrations and production/consumption rates of methane and nutrients in shelf sediments, and their long-term fluxes in response to flushing during the Pleistocene, and (vi) characterising the abundance, activity, distribution and controls of microbial communities.

The project outcomes will improve the: (i) mapping and volumetric estimations of OFG systems, and assessment of their residence time distribution, with direct implications for global water budgets; (ii) understanding of biogeochemical cycling in shelf environments and development of biogeochemical models; (iii) global models of total cellular life and their response to environmental change. The outcomes relate to challenges 5-7, 13 and 14 of the IODP Science Plan.

Scientific Objectives

The proposed drilling campaign will address the following scientific questions:

Q1. What is the distribution of OFG characteristics (salinity, flow velocity and direction, pressure, temperature) across the shelf? How are these controlled by sub-seafloor stratigraphy and margin evolution?

Q2. How and when was the OFG emplaced? How does the OFG system function? Is it actively recharging and discharging, or is it slowly recovering from past hydrological conditions?

Q3. What are the current concentrations and production/consumption rates of methane and nutrients in shelf sediments? What is the magnitude of their long-term fluxes in response to periodic flushing of the shelf during the Pleistocene?

Q4. What microbial communities are involved? What is their abundance, activity and distribution, and what factors control these?

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

rotosonic method; cased/screened wells, packer and pumping tests; dipole aquifer testing; borehole dilution tests; probe penetration tool (temperature, pressure); wireline temperature tool or distributed temperature sensing system; microbiological sampling and contamination tracer use; gas analysers; FID/TCD gas chromatography; infrastructure for long-term monitoring

Proposed Sites (Total proposed sites: 6; pri: 3; alt: 3; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CB-01A (Alternate)	-44.3397 171.6545	41	600	0	600	Characterise the main groundwater body (freshest end member and shallowest seawater-freshwater interface)
CB-02A (Primary)	-44.4594 171.8155	63	600	0	600	Characterise the main groundwater body
CB-03A (Primary)	-44.5656 171.9639	89	600	0	600	Characterise shallow groundwater body and main groundwater body
CB-04A (Primary)	-44.7039 172.1383	130	600	0	600	Characterise main groundwater body (most saline end member)
CB-05A (Alternate)	-44.4436 171.7954	59	600	0	600	Characterise main groundwater body
CB-06A (Alternate)	-44.5659 171.9641	89	600	0	600	Characterise shallow groundwater body and main groundwater body