IODP Proposal Cover Sheet

Brothers Arc Flux

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Title	Gateway to the Sub-Arc Mantle: Volatile Flux, Metal Transport, and Conditions for Early Life
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Area	Kermadec Arc

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Abstract

Hydrothermal systems hosted in submarine arc volcanoes differ substantially from those in spreading environments in commonly containing a large component of magmatic fluid. Our primary scientific goal is to discover the fundamental, underlying processes that drive these differences. This magmatic hydrothermal signature, coupled with the shallow depths of these volcanoes and high volatile contents, strongly influences the chemistry of the fluids and the resulting mineralization, and likely has important consequences for the biota associated with these systems. Given the high metal contents and very acidic fluids, these hydrothermal systems are also thought to be important analogs of many porphyry copper and epithermal gold deposits mined on land.

Drilling Brothers Volcano on the Kermadec arc provides the missing link (i.e., the 3rd dimension) in our understanding of mineral deposit formation along arcs, the sub-seafloor architecture of these volcanoes and their related permeability, and the relationship between the discharge of magmatic fluids and the deep biosphere. The proposed drilling has four main objectives:

(i) Characterizing the sub-volcano, magma chamber-derived volatile phase to test model-based predictions that this is either a single-phase gas, or two-phase brine-vapor;
(ii) Exploring the sub-seafloor distribution of base and precious metals and metalloids, and the reactions that have taken place along pathways to the seafloor;
(iii) Quantifying the mechanisms and extent of fluid-rock interaction, the consequences for mass transfer of metals and metalloids into the ocean, and the role of magmatically-derived carbon and sulfur species in mediating those fluxes; and
(iv) Assessing the diversity, extent and metabolic pathways of microbial life in an extreme, metal-toxic and acidic volcanic environment.

We propose a JOIDES Resolution expedition to drill and log a series of sites at Brothers Volcano that will provide access to critical zones dominated by magma degassing and high-temperature hydrothermal circulation, over depth ranges regarded as crucial not only in the development of multiphase mineralizing systems, but also in identifying subsurface microbially habitable environments. We have identified and prioritized seven potential drill sites based on topographic slope, magnetic delineation of upflow' zones, and the location of hydrothermal vents that target all four hydrothermal fields that range from gas- to seawater-dominated systems.

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Scientific Objectives

Our primary scientific goal is to discover the fundamental, underlying processes that distinguish hydrothermal systems in arc volcanoes from those in spreading environments, such as backarc basins and mid-ocean ridges. Through the recovery of cores and logging drill holes at Brothers Volcano, we plan to pursue this goal by addressing the following four objectives:
(i)Characterizing the sub-volcano, magma chamber-derived volatile phase to test model-based predictions that this is either a single-phase gas, or two-phase brine-vapor. This will be achieved through the study of mineralogical, chemical, and isotopic analysis of trapped volatiles and precipitates in veins and wall-rock reaction products;
(ii)Exploring the sub-seafloor distribution of base and precious metals and metalloids, and the reactions that have taken place along pathways to the seafloor;
(iii) Quantifying the mechanisms and extent of fluid-rock interaction, and consequences for mass transfer of metals and metalloids into the ocean and the role of magmatically-derived carbon and sulfur species in mediating these fluxes; and
(iv) Assessing the diversity, extent and metabolic pathways of microbial life in an extreme, metal-toxic and acidic volcanic environment.
The drill sites represent discharge zones of geochemically distinct fluids that are variably affected by magmatic volatile input, allowing us to directly address the consequences of magma degassing for metal transport to the seafloor and its effect on the functioning of microbial communities.

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

Proposed Sites

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SEC-1A	-34.876105, 179.081069	1676	0	200	200	This site on the eastern side of the caldera floor targets the largely extinct SE Caldera upflow zone, as demarcated by a magnetic 'low' in the area. The upflow zone in the subseafloor at the site is likely less affected by magmatic vapors than the cone sites.
NWC-2A	-34.866529, 179.060990	1892	5	500	505	Site is within an area of active hydrothermal high temperature vent field atop of a distinct magnetic-low anomaly. It is expected to represent the margin of an active upwelling zone of black-smoker type fluids exiting at the caldera wall vent field. Site is downslope and south of these high-temperature vents. Coring there will provide samples of a hydrothermal upflow zone. These objectives are similar to those of Site NWC-1A, where drilling will be more challenging.

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-	-	-	-	-	-	NWC-2A is an alternate site.
WC-1A	-34.87527, 179.058567	1765	5	560	565	The Site is in the centre of an area of extremely low magnetic intensity on the floor of the western Caldera. It provides a good opportunity for sampling a hydrothermal upflow zone and provide core material complementary to that from the deep NWC-1A site. The WC-1A site is expected to be less affected by faulting and perhaps features less seawater entrainment.
LC-1A	-34.879597, 179.07031	1359	0	300	300	Site is a saddle between the Upper and Lower Cones and marking the boundary between the two. Venting in this area is the most Fe-rich sampled in the volcano. Coring will sample the transition between the two cones and the upflow zone of metal-rich fluids. Both cone sites are important targets for deep drilling and intersection of single-phase magmatic gas.
UC-1A	-34.882137, 179.068339	1232	0	800	800	The target area corresponds to a maximum surface expression of advanced argillic alteration in a ~40 m diameter pit crater atop the Upper Cone. High potential for successful penetration and sampling deep rocks influenced mainly by magma degassing.
UC-2A	-34.887636, 179.072414	1476	0	530	530	High potential for successful penetration and sampling deep rocks influenced mainly by magma degassing. Alternate site for upper cone drilling in periphery of a diffuse vent field and above a magnetic low.
NWC-1A	-34.86086, 179.054017	1464	0	405	405	This high-priority site is atop the caldera rim, in the NW sector, with flat ground and evidence for hydrothermal activity. Based on an expected outward dip of the caldera-bounding faults and known younging mineralization ages from caldera rim to base, drilling here would target an older hydrothermal upflow zone of Type I, dominated by hot seawater-derived solutions. Drill core will provide samples of a heavily mineralised fault-bound upflow zone.

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