Search for hydrothermal fluids on the northwest Fernandina rift

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Summary

A hydrologic survey will be conducted aboard the R/V Thomas G. Thompson along the NW Fernandina Rift to determine if this rift zone is hydrothermally active. A Vertically Oscillating CTD Tow (e.g. a Tow-Yo but herein referred to as a VOT) will be conducted along an 8.4 km transect that follows the rift. During the transect, real-time data will be logged and visually analyzed for density differences, transmissivity spikes and potential temperature spikes. VOT data will subsequently be used for more detailed analysis of possible potential temperature anomalies. If one is detected, discreet water samples will be collected from the center of the anomaly and analyzed shipboard for enhanced silica and decreased phosphate concentrations, characteristics commonly considered geochemical tracers for hydrothermally altered fluids.

Introduction

The global heat budget remains a poorly defined quantity. Hydrothermal systems on mid-ocean ridges make up a large percentage of the global heat flux (Wheat et al. 2003) but other locations such as hotspots contribute to the heat flux as well. In order to make our models of global heat flux as complete as possible it is necessary to take into account all sources. The well known "black smoker" hydrothermal vents are point sources of intense heat and fluid flow, on the order of 350 °C (Von Damm 1995) and 10 cm s^{-1} (R. McDuff, pers. comm.) respectively. This represents a global heat flux from high temperature vents of order 1.8 ± 0.3 TW (Wheat et al. 2003). Black smokers have been intensively studied because of the diverse array of unique macro and micro fauna that thrives in these environments. Some studies have also been directed towards areas of warm, diffuse venting on the flanks of mid-ocean ridges. It has been estimated that the heat flux through diffuse vent sites is 8.1 ± 2 TW and comprises 82% of the global heat flux (Wheat et al. 2003). Diffuse venting is obviously a very important quantity in the global heat flux equations. All attempts should be made to identify all areas of diffuse venting so as to allow for accurate heat flux estimates to be determined.

Not all hydrothermal systems are located on mid-ocean ridges. Intraplate (hotspot) volcanoes also produce hydrothermal systems. Faults and fissures in the base rock allow seawater to percolate down into the mantle where it becomes altered hydrothermally. These systems generally produce diffuse venting off the sides of the volcanoes. The Hawaiian and Canary Islands are prime examples of this type of system.

The Galápagos Islands are also produced by hotspot volcanism, in this case passing over the focus of the hotspot as the Nazca plate spreads away from the Pacific and Cocos plates (Figure 1). Because the Galápagos are magmatically active (as of this writing the latest eruption was one month ago) the possibility of finding hydrothermal fluids on the flanks of these volcanoes is high. The smallest and youngest island, Roca Redonda, is reported to have warm water venting in less than 30 m of water (Standish et al. 1998).

Fernandina is another young island of the archipelago and is on the westernmost edge of the island plateau. Bathymetric maps produced during the DRIFT Leg-4 (Kurz et al. 2001) cruise aboard the R/V Roger Revelle show that Fernandina has two rift zones; one to the northwest and one to the southwest (Figure 2). A hydrographic survey may further delineate whether these rift zones host areas of hydrothermal activity. Due to time constraints only the NW rift zone will be surveyed. If the conductivity, temperature and depth (CTD) data show a potential temperature anomaly along the rift, this could be evidence of hydrothermal activity. Discreet fluid samples will be collected in the area of highest anomaly. Analysis of these fluids for silica and phosphate concentrations may also provide evidence of alteration by hydrothermal processes. Fluids that have been altered by hydrothermal processes tend to have higher silica and lower phosphate concentrations then the surrounding fluid (Wheat and Mottl 2000). These analyses will show if the NW Fernandina Rift has hydrothermal venting and will provide an estimate as to the location of these vents.

Proposed Research

Due to its location on the edge of a hotspot and the flanks of an active volcano, and the concomitant likelihood of fluid circulation near the magma chamber, the NW rift of Fernandina Island in the Galápagos archipelago may be hydrothermally active. I propose to conduct a hydrologic survey along the rift to search for possible, diffuse hydrothermal vents, using temperature, silica and phosphate anomalies as detection criteria for hydrothermally-altered fluids.

In order to determine if the NW Fernandina Rift is venting hydrothermal fluids, a detailed hydrographic survey must be completed along the rift. The survey will take place the 12-20 January 2006 aboard the R/V Thomas G. Thompson. The ship track will follow the rift from 0° 15.42’ S and 91° 43.68’ W to 0° 18.21’ S and 91° 40.068’ W (Figure 3). Precise in situ CTD measurements will be collected during a VOT between 200 meters above bottom (mab) and 10 mab between these two points. These depths were chosen to encompass any rising and neutrally buoyant plumes and to collect data near bottom in case the venting is not very rigorous.

The speed of this transect will be 0.3 knots, chosen to reduce the amount of interpolation between casts during analysis and to diminish the strain on the hydro-wire winch. The data collected will show temperature changes in the water column along the rift. A CTD cast to collect background information will be completed before the survey and far away from the NW rift (at 1° N and 92° W). The coldest, most dense fluids should be concentrated near bottom except in areas where hydrothermal activity creates a density inversion due to the heat input into the water column; this rising fluid is the hydrothermal plume.

During the survey, every time the CTD is raised to 200 mab, the file containing that cast’s data will be saved. By saving the data file at the top of each cast, the file size will be small thereby facilitating processing of the data with the SeaBird software. The data files will be analyzed using The MathWorks MATLAB® program. This analysis should produce figures that show the location along the transect of the highest potential temperature anomaly.

Based on analysis of the transect data, the ship will return to the location that shows the highest anomaly and collect discreet water samples within the anomalous water using the standard CTD rosette water sampling methods. From the shallowest depth of the potential temperature anomaly to the seafloor, five samples will be taken at equal intervals. For each depth, two Niskin bottles will be tripped to allow for duplicate sampling. For both silica and phosphate samples the collected water is used to rinse the nutrient sample bottles (acid-washed, 125 ml polyethylene bottles) three times. The bottles are then filled 2/3 of the way, labeled and frozen for later analysis shipboard. The chemical analysis for silica and phosphate will follow standard procedures set forth by the Hawaii Ocean Time-series (HOT) guidelines (HOT website 2005). To determine the background concentrations of these chemicals, water will be sampled using CTD rosette standard techniques during the background CTD cast. The entire background cast should be split into five even sections and sampled in duplicate as described above. Forty total samples will be needed for chemical analysis ([5 depths x 2 samples x 2 chemicals] x 2 locations).

Galápagos 2006 Budget

Project: **Search for hydrothermal fluids on the northwest Fernandina Rift**
Investigator: **Wesley J. Thompson**

Item	Cost / unit	per unit	# of units	Projected cost	Actual Cost	Supplier	Notes
R/V Thomas G. Thompson	$18,000.00	per day	0.71	$12,750.00	$0.00	UW Ocean	17 hours of ship-time requested
4x4 ft overview map of Galapagos Islands	$65.00	per map	1	$65.00	$65.00	UW Pub. Serv.	Overview/planning map
Arc GIS License Dongle	$50.00	per dongle	1	$50.00	$50.00	UW GIS Serv.	$90 for 3 keys if others are interested
Equipment for Analysis							
Technical Analyzer II Continous Flow System				$0.00	$0.00	UW Ocean	
125 ml Sample Bottles		per bottle	40	$0.00	$0.00	UW Ocean	
Si Analysis	$5.00	per sample	20	$100.00	$100.00	UW Ocean	
ACS Amonium paramolybdate							
Oxalic Acid							
ACS Ascorbic Acid							
PO4 Analysis	$5.00	per sample	20	$100.00	$100.00	UW Ocean	
1 Molar HCl for Cleaning							
Concentrated H_2SO_4							
Ultrapure NaOH							
Ultrapure HCl							
ACS Amonium paramolybdate							
ACS Ascorbic Acid							
ACS Antimony Potassium Tartrate							
Potassium Phosphate Monobasic							
Chloroform							
Totals:				**$13,065.00**	**$315.00**		

References

HOT website. 2005. HOT: Analytical Methods & Results. http://hahana.soest.hawaii.edu/hot/methods/results.html. Accessed 21 Nov 2005.

Kurz, M., D. Fornari, D. Geist, et al.. 2001. Cruise Report DRIFT Leg-4 R/V Roger Revelle.

Standish, J., D. Geist and K. Harpp. 1998. The emergence of a Galápagos shield volcano, Roca Redonda. Contrib Mineral Petrol. **133**: 136-148.

Von Damm, K. L. 1995. Controls on the chemistry and temporal variability of seafloor hydrothermal fluids, p. 222-247. *In* S. Humphris et. al. [eds.], Seafloor Hydrothermal Systems: Physical, Chemical, Biological, and Geological Interactions. Amer. Geophys. Union, Washington, DC.

Wheat, C. G. and M. J. Mottl. 2000. Composition of pore and spring waters from Baby Bare: Global implications of geochemical fluxes from a ridge flank hydrothermal system. Geochim Cosmochim Ac. **64**: 629-642.

Figure Captions

Figure 1. The location of the Galápagos archipelago in relation to the triple junction between the Pacific, Nazca and Cocos plates. The motion of the Nazca plate is to the southwest. The age of the islands increases to the East with the youngest islands, Roca Redonda and Fernandina on the West. Reproduced from a lecture given by D. Geist at the University of Oregon, 10 November 2005.

Figure 2. A bathymetric contour map around Fernandina Island showing the locations of the NW and SW rifts. From Kurz et al. (2001).

Figure 3. A bathymetric map showing the proposed transect along the NW rift of Fernandina.

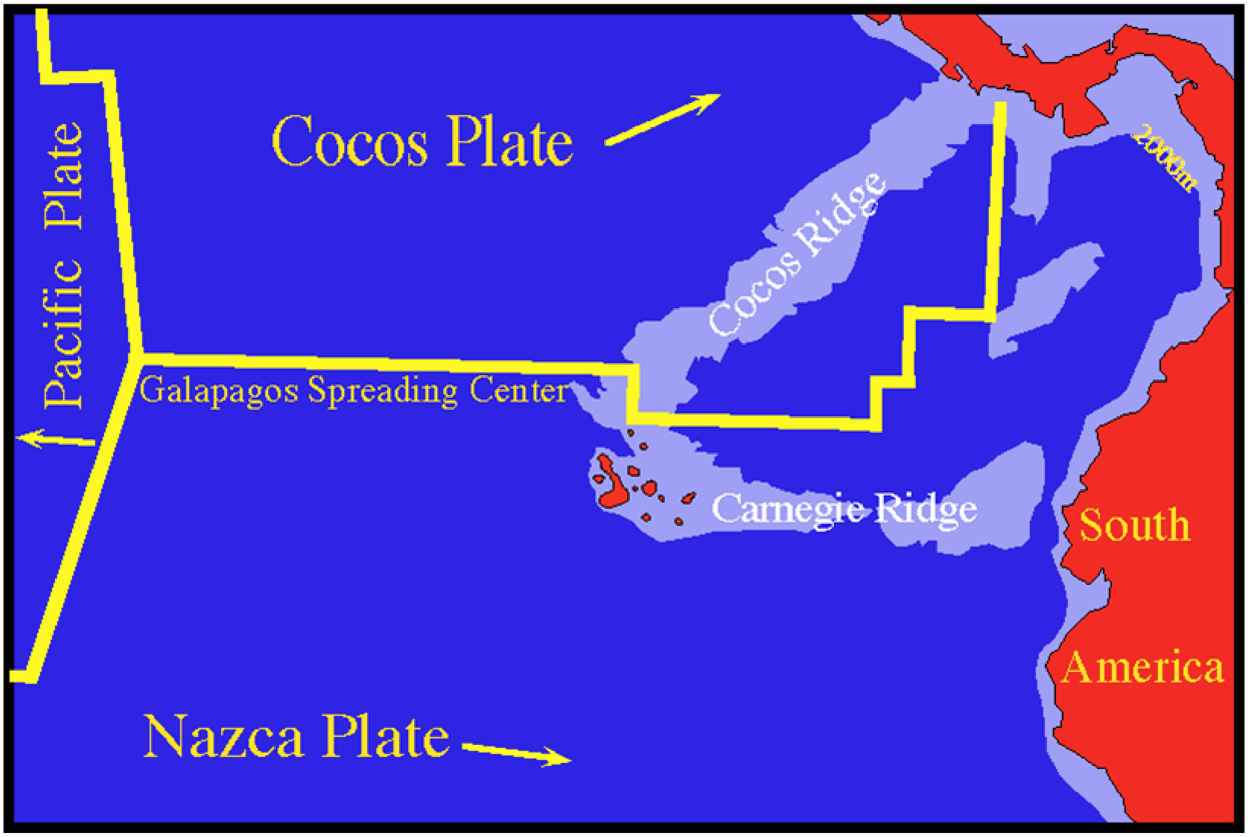

Figure 1.

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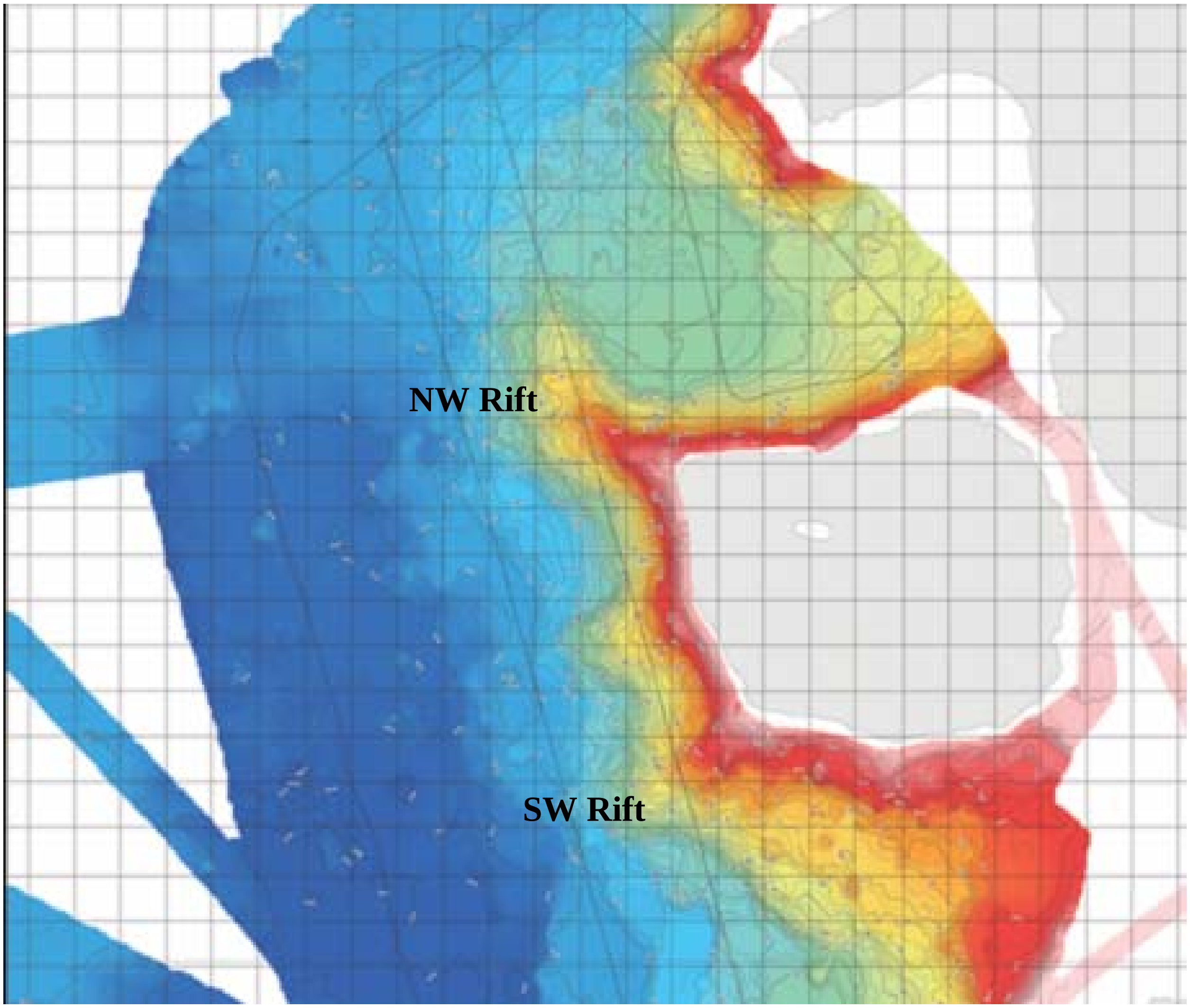

Figure 2.

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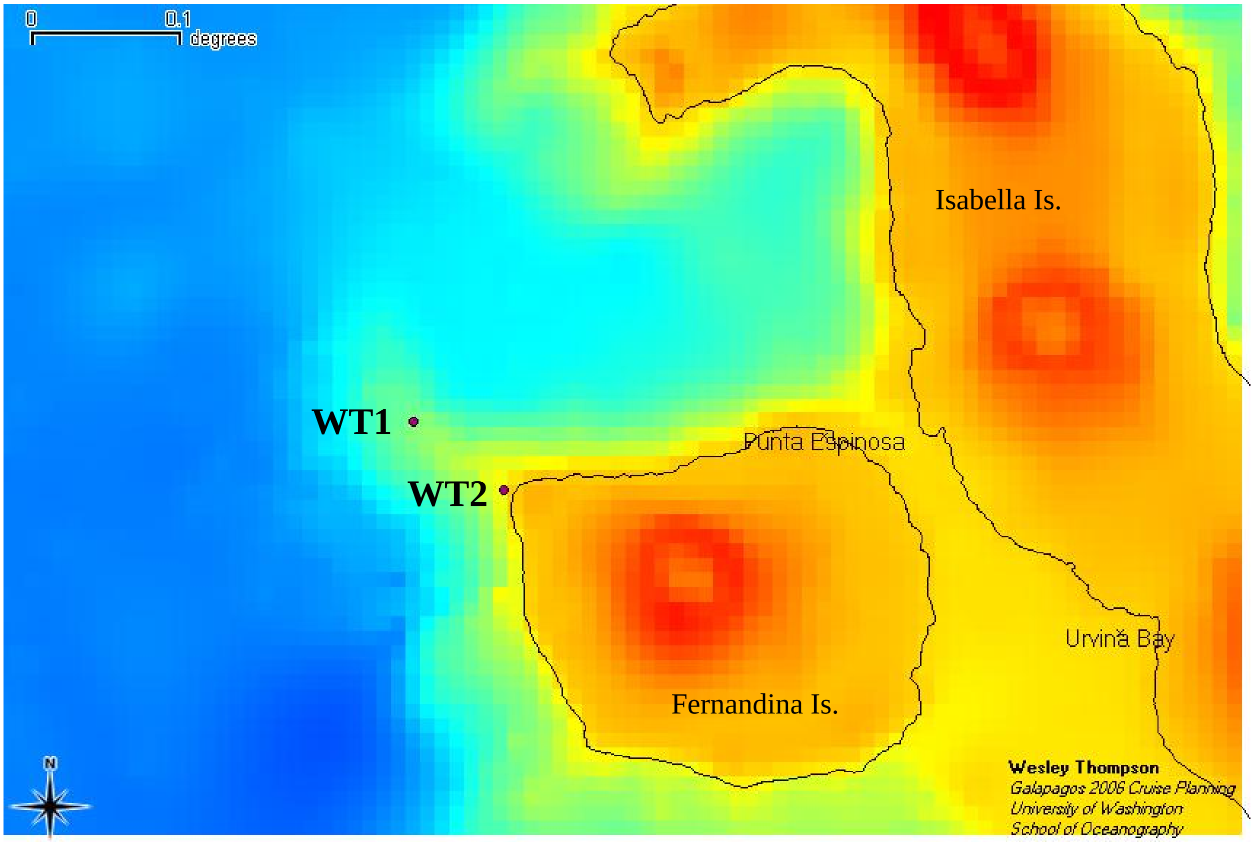

Figure 3.

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