Volcanic Eruptions at East Pacific Rise Near 9°50′N

Evidence for recent volcanic eruptions along the fast spreading East Pacific Rise (EPR) crest near 9°50′N spanning about four to five months of activity was discovered in April–May 2006 as a result of studies related to five months of activity was discovered at the EPR (EPR) crest near 9°50′N, eight of 12 OBSs could not be recovered [Tolstoy et al., 2006]. Anomalous turbidity and temperature structure in the water column along the ridge axis confirmed scientists’ suspicions that the OBSs were triggered by a new lava flow.

A resurgence in magmatism recently had been postulated, based on temporal changes observed over the past few years in hydrothermal vent fluid chemistry and temperatures [Von Damm et al., 2003] and increasing microseismicity [Tolstoy et al., 2006]. Within a week of the initial bottom-water surveys in late April, a rapid-event response expedition onboard the research vessel (R/V) New Horizon was mobilized. Conductivity-temperature-depth (CTD) and optical tow-yo (tows during which a pack-age is alternately lowered and raised) surveys, hydrocasts, and towed digital imaging surveys at the EPR axis between 9°50′N and 9°57′N unequivocally confirmed the occurrence of recent extensive seafloor eruptions along >35 kilometers of the ridge axis and up to approximately one kilometers off axis, and they documented widespread vigorous hydrothermal venting and a notable absence of typical seamounts (Figure 1).

Many of the hydrothermal vents studied over the past 15 years were disrupted. This is the first repeat eruption documented at the same location along the mid-ocean ridge (MOR) crest; a prior eruption occurred in 1991–1992 [e.g., Haymon et al., 1993].

Response Survey Strategy and Methods

The primary objective of the rapid-response cruise was to determine whether or not a volcanic eruption recently had taken place, and if so, to assess its extent and its hydrothermal and biological impact. Shipboard equipment included a CTD with optical and electrochemical sensors and Niskin® water sampling bottles [e.g., Baker et al., 1984], and a digital deep-sea camera with rock and water sampling capabilities (Woods Hole Oceanographic Institution TowCam [Fornari et al., 2003]). These instruments were easily mobilized and efficient tools to examine eruption effects on the water column, hydrothermal venting, and existing biologi-cal communities along the EPR axial summit trough (AST).

Coordinating Earth Observing System Land Validation

The National Aeronautics and Space Administration’s (NASA) moderate resolution imaging spectroradiometer (MODIS) land product validation project, initiated prior to the launch of the NASA Earth Observing System (EOS) Terra platform in late 1999, provides data, instrument, and information resources for the validation of products that quantify land surface characteristics from MODIS and other satellite sensors. Land products derived from MODIS and other moderate-resolution sensors include, among others, land cover, snow cover extent, surface temperature, land area index, fire occurrence, and vegetation productivity.

The land validation project infrastructure, developed at NASA’s Goddard Space Flight Center (GSFC), involves an integration of NASA-funded researchers, international collaborators, and science data networks. These resources facilitate determination of product uncertainty, which is the definition of validation, through best practice methods.

Key to the project is the set of EOS Land Validation Core Sites, a global network of 33 sites (including six added in 2006), which serve as a focus for validation activities. The initial infrastructure and activities were described in Morissette et al. [1999], Justice et al. [2005] and Morissette et al. [2002]. The present article provides an update on two components of the project: delivering validation status information on MODIS land products and providing Core Site data and information (Figure 1).

MOIDS Land Team Validation Information and Core Site Infrastructure

The primary objective of the MODIS Land Team validation activities is to provide quantitative assessment of land product accuracy.

On the Land Validation Web site (http://landval.gsfc.nasa.gov), summarized product uncertainty information is given in a validation status page for each product. Each product status page provides a brief validation statement and a list of reference mate-rials, each element of which is linked to its own subsequent page with a full reference, an abstract, and sample results (usually fig-ures or tables). Much of the supporting mate-rial for the product accuracy statements has been generated from data and feedback collected at Core Sites.

Though designed to support MODIS land product validation, the Core Site data and infrastructure provide a valuable resource that has been useful to researchers through-

Fig. 1. (left) Location map of TowCam surveys over the new eruptions. Red circles indicate positions of old high-temperature hydrothermal vents. (top right) Near-bottom seafloor profile compiled from depth and altitude data from TowCam 1 is shown with geological and biological observations keyed to colored symbols. Potential temperature from TowCam is shown in red. (middle right) New pillow to lobate lava flow overlying older sediment covered pillows and (bottom right) diffuse hydrothermal venting through recently erupted lava covered with potential microbial material.

Fig. 2. Contour plots of light attenuation (μL per meter) versus (a) depth and longitude for a cross-axis (CTD Box 5) tow-yo and (b) depth and latitude for an along-axis tow-yo (ridge summit). Density (isopycnic) surfaces (solid white curves) are superimposed over Δc; the deep-red dense line indicates localized areas of instability in the floor part of the water column. The dotted grey curve indicates the unwashed data points of the instrument package (SeaBird SBE37plus CTD configured with SeaTech 347 light backscatter sensor, WetLab CSS39IDSR transmis-sion sensor, LMETDeep laser in situ scanning and transmission sensor, and Koden size distributor), ISER electrochemical analyzer, and a rosette of 21 ten-liter SIO-built, Niskin-style sampling bottles.)
Eruptions

Hydrothermal Plume Observations

During seven days on station, three towys were performed in the region of 9°46.3'N and 9°54.2'N as well as three cross-toways and two vertical columns (Figure 1). Along-axis towys revealed particle plumes from 9°46.6'N to approximately 9°54.6'N (Figure 2a). The most intense particle plumes were centered near 9°46.6'N and 9°53.0'N, while the highest Δθ (0.6°) background was observed near 9°53.0'N area, site of the most intense particle plume observed in late April. Cross-axis towys revealed that deep camera images of the plumes primarily to the east during the cruise (Figure 2b).

Pronounced density inversion layers were found throughout the deepest 250 meters of water between 9°45.9'N and 9°55.0'N (Figure 2c). These results demonstrate that rapid eruption response to MOR eruptions can be quickly and efficiently monitored (i.e., in <1 week) in areas outside the rate of the Pacific, and that these surveys can effectively document recent seafloor eruptions, document pristine post-eruption processes, and initiate longer-term studies. The data presented here provide conclusive proof that new volcanic plumes have been erupted at the EPR, and that the near-bottom hydrographic and hydrothermal systems are dominated by new and young organisms. While the hydrothermal venting apparently influenced community diversity within the resulting hydrothermal plume, further work is needed to identify the origin and geochemical impact of this change.

Geological and Biological Observations From TowCam Surveys

Along-axis TowCam surveys (Figure 1a) acquired nearly continuous image coverage over the EPR summit, and sometimes just outside the AST. Hydrothermally active regions were identified by an apparent 0.5–2.0°C temperature anomaly in potent temperature that frequently coincided with images of Roccus-like mats in the water column or apparent microbial coatings on fresh lava surfaces (Figure 1a). Recent eruptive lava was devoid of sediment but typically was dusted with to white-brown material (Figure 1b), similar to that observed following the June 1991 eruption [e.g., Mottl et al., 1995].

Before sampling, the first CTD cast (070°C) for replicate gas samples collected in May 2006 averaged ~30.34±0.37°C in the CTD-bottom water column samples, but were lower (averaging ~29.65±0.14°C) in near-bottom TowCam profiles near crater (050°C; Figures 1c and 1d). We hypothesize that different methods for measuring temperature in the CTD and TowCam data sets may explain this difference. The water temperature in the bottom water column as well as in situ geochemical analyzer (200 of 4059 scans, between 9°46.8'N and 9°54.7'N). The distribution of detectable (<0.1 mg/l) in situ hydrogeochemical (H2S) concentrations is consistent with that for the particle plumes and regions of vertical instability (Figure 2a).

Hydrothermal Plume Microbial Diversity

Extensive exploitation of microbial biomass and products, including microorganisms apparently uniquely adapted to deep, hydrothermally active submarine environments [e.g., Summit and Barnes, 1998], have been documented in the recent volcanic eruptions and magmatic plume.

Terrestrial terminal length polyacrylamide gel analysis of 16S rDNA genes amplified from biomass samples recovered with an in situ large-volume pump revealed differences in microbial diversity between the hydrothermal plume and ambient background. In situ microbial community analyses were confirmed by restriction analysis of full-length 16S rDNA clones where one dominant phenotype was present (38%–56% of clones) while being nearly absent in the background (4%). Analysis of second- and third-generation clones with this pattern were divided into 15 different subpopulations. Further analysis is needed, but it is expected that the microbial community present in these hydrothermal plumes is distinct from the ambient background. While the hydrothermal venting apparently influenced community diversity within the resulting hydrothermal plume, further work is needed to identify the origin and geochemical impact of this change.

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Applications Due: March 20, 2007

A workshop on Central America subduction studies will be held in Heredia, Costa Rica, June 18-22, 2007. This workshop, co-sponsored by MARGINS and the German SFB574-DFG, will integrate offshore and onshore studies carried out in Central America over the past 5 years. A wide array of topics will be covered, including plate motion (upplid, geotectonic vs. seismological observations, slab silt events, fault zone permeability, imaging, and hydrothermal plating) and the Subduction Factory (tectonics, age, structure, climatene, petrologic and metamorphic reactions within the subduction input and processes occurring within, structure of- and output from the forearc, volcanic arc, backarc and mantle wedge).

Participants chosen from applicants to this announcement will be provided with full or partial funding of their costs of travel, accommodation and meals. We encourage applications from those interested in this scientific endeavor, including those from outside the USA, and especially encourage applications from Ph.D. and M.S. graduate students. Present or previous MARGINS or SFB574 funding is not a prerequisite for attendance.

Applications should prepare a brief (no more than two pages) resume, and a brief (half-page) statement of why they are interested in participating in the meeting, and an abstract of what they hope to contribute to it. Detailed instructions are available at the web site indicated below. The abstracts will be submitted online at http://www.margins.org/CostaRica2007.

Applications close on March 20, 2007 - Invitations should be directed to the conveners (e-mail above).

References


