CHEMISTRY OF LAVA-SEAWATER INTERACTIONS

Yuan-hui Li
University of Hawaii
Department of Oceanography
1000 Pope Rd.
Honolulu, Hawaii 96822
yhli@uhunix.uhcc.hawaii.edu
808-956-6297
fax: 808-956-7112

Award # N000149610352

LONG TERM RESEARCH GOALS

The long term goals of this research are to better understand and identify the chemical and physical effects of submarine volcanic events. This information will be used as a means to identify ongoing submarine eruptions using surface-ocean based water sampling. This information will allow us to constrain the duration, frequency, and the flux of heat and chemicals to the ocean from submarine volcanic eruptions. In addition, this technology will help us understand submarine hydrothermal systems from the nascent point in their evolution.

OBJECTIVES

In general, the majority of the field-based scientific objectives of this research have been concluded. The remainder of this research will focus on the continued development and refinement of analytical methodology. The techniques being pursued are those that will allow detection of the salient tracers of neo-submarine volcanic activity. These include the detection of H_2S at nM levels in discrete samples as well as the *in situ* determination of pH at a precision of 0.002 pH units.

APPROACH

To achieve our previously reported objectives, we have collected water samples in areas where submarine eruptions are known or suspected to have occurred. These include on the Island of Hawaii where lava enters the ocean along the shoreline of Kilauea Volcano (Sansone and Resing, 1995), at the Submarine Volcano of Loihi (Duennebier et al., 1997) where an eruption occurred in July or August of 1996 , and at Gorda Ridge where an eruption occurred in early 1996.

In addition, we continue to look for and develop chemical analytical methods that are rapid, have low limits of detection, and require as little sample as possible. The advantage of small samples is that they require less processing time in the field, and thus require fewer individuals to collect the samples. Methods of rapid analysis inherently allow for a

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comprehensive data set to be gathered more quickly, requiring fewer person hours for sample and data processing (Resing, 1997).

WORK COMPLETED

During fiscal year 1997, we continued analyses of samples collected previously as well as participated in a follow up cruise in September 1997 to Loihi Volcano, a Seamount off the coast of the Island of Hawaii. In late July 1996, Loihi experienced the most intense seismic swarm ever recorded in Hawaii's seismic history. An immediate response was mounted in August 1996 by researchers at UH. We participated in that expedition and collected and analyzed water samples for a great variety of chemical tracers including Al, pH, Total CO_2, Fe, Mn, Co, Cu, Ni, Zn, Pb and the Rare Earth Elements. During the follow up cruise this September, CO_2-rich water continued to effuse from the summit of Loihi but the water temperatures surrounding the summit were much lower. Analyses of these water samples are continuing.

We have completed our collaboration with Dr. A. Harris at UH and have used satellite data to quantify the effusion of lava both from Kilauea as a whole as well as that entering the ocean (Harris et al., 1997). We have completed development of an FIA preconcentration technique for the Inductively Coupled Plasma Mass Spectrometer (ICP-MS). This technique allows for pM detection limits for many elements and takes less than 5 minutes per sample (Resing, 1997; DeCarlo and Resing, 1997). Finally, we have completed our model for elemental degassing for lavas and have continued to model elemental volatility and its effect in other settings (Li and Resing, 1997).

RESULTS

Our analyses of the samples from Loihi show a trace-element chemical signature that follows the same pattern as that observed where the lava enters the ocean on the Island of Hawaii. In both settings elemental enrichments arose from two processes, through congruent dissolution of the basalt and transport of elements to the water as their volatile phases. Our sampling around the summit of Loihi at 1000m indicated that the volcano was actively issuing very hot gassy water. Additionally, at a site 50 km east of Loihi we found a plume of water at 1800m which was greatly enriched in Al, Fe, Mn, CO_2, and ^3He. The enrichment in these elements is unequivocally hydrothermal in origin, while the great enrichment in Al suggests that this plume represents water associated with an eruption that took place at this site. In prior research under ONR funding on lava-seawater interactions we identified Al as being an indicator of lava-seawater contact (Resing et al., 1992).

The more classic magmatic volatiles (C, H, S) are greatly enriched at submarine volcanoes (versus the degassed lava entering the ocean at Kilauea), making them good target for the chemical detection of submarine eruptive event, and as a result, our participation in the eruptive responses has included the detection of these volatiles.

IMPACT

Over 80% of the volcanism that takes place on the face of the earth does so underwater. Despite the frequency and magnitude of this interaction, the work that we have completed to date is the most comprehensive study of this type ever undertaken. These data will be useful in identifying areas of recent submarine volcanism. In addition, the results that we obtain will aid us in understanding the nature and magnitude of the fluxes associated with submarine volcanism.

The methods that we have developed for trace element analysis are extremely rapid, they allow for the generation of a comprehensive geochemical data set in a short time. The speed with which this work can be completed makes data acquisition less expensive in both time and money.

TRANSITIONS

The method that we have developed using online preconcentration-matrix-elimination for trace determination by ICP-MS can be used to analyze samples with complex matrices. Trace analysis of fluids with complex matrices come from a cross section of industry, including mining, water treatment, medical, and others.

RELATED PROJECTS.

We continue to work with other researchers at UH to fully understand the data that we have gathered on the eruption of Loihi Volcano.

We continue to co-develop a technique to measure Co with a graduate student at UH.

Finally, we continue to work with Gary Massoth at NOAA-PMEL to allow his *in situ* analyzer to measure high precision pH.

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