Developing Underwater Cosmic-Ray Muon Radiography —A Novel Application to Image the Inside of Active Submarine Volcanoes

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On Earth today, most volcanism by volume occurs underwater. Underwater volcanism is a major planetary activity of the Earth that drives heat exchange between the surface and interior of the planet, recycles geochemical materials, including CO_2 and water and was the likely host of early-Earth ecosystems. An accurate understanding of the magmatic processes that drive underwater volcanism is of fundamental importance to advance our knowledge on the geodynamics of Earth and to predict volcanic hazards world-wide. Capturing the magmatic processes in real time has not yet been accomplished due to limited conventional marine geophysical approaches in terms of data resolution in time and space and technological challenges. Even on land, this is not an easy task. Although many real-time volcano monitoring projects have been carried out, the characteristics of volcano-physics that constrain the eruption mechanism remain poorly known. For instance, conventional monitoring systems do not allow us to directly tie together the surface deformation and changes in the subsurface structure.

The application of muon radiography to active volcanoes has been proven on land over the last decade with real-time monitoring of volcanic activity in order to prevent volcanic disaster. We plan to expand the usage of this technique to image and monitor underwater magmatic processes that drive submarine volcanic activity. Our goals of this project are as follows: (1) to test a dual muon counter array on land to familiarize our team with the technical details of this device; (2) to modify the configuration of the telescope for underwater use; (3) to deploy the muon telescope in shallow water with water-tight housing, and assess the necessary time period over which to acquire sufficient counts of the particles; (4) to establish realistic expectations for long term data acquisition parameters – data variability, resolution, and noise.

We will construct a small array to collect and count muons that pass through the seawater at near horizontal angles. The shallow water test will be conducted at the WHOI dock. With this experiment, we will be able to acquire both scientific and technical information that will allow us to develop a larger multi-counter array for deployment at deeper water levels, i.e. the depth of submarine volcanoes (~ 3000 m).