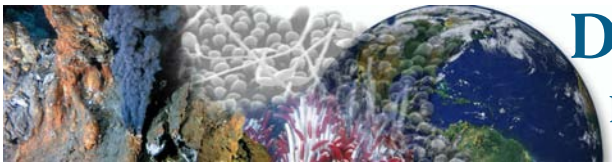


Deep Ocean Exploration Institute

Investigating Earth's Dynamic Processes

Winter 2006 Newsletter

Dan and his able assistant Riley

Director's Notes

In 2005, DOEI funded six new research projects, with investigators representing all WHOI departments and encompassing all of the Institute's research themes – Seafloor Observatory Science, Fluid Flow in Geologic Systems, and Earth's Deep Biosphere. Some of those projects are well underway in collecting data, while a few are still waiting for time to go to sea to deploy instruments. By this fall, most of the experiments will have results in hand.

In addition, DOEI currently supports two research fellows (Stan Hart and Greg Hirth, both of the Geology & Geophysics Department), one post-doctoral fellow and a graduate student, in its efforts to expand the research options available to scientists and engineers in all departments at WHOI. (See the DOEI Web site at http://www.whoi.edu/institutes/doei for more information). We expect to add a Claudia S. Heyman Institute Fellow in 2006 to those already in place.

DOEI-sponsored activities have also included outreach in various forms. For example, in September 2005 I met with delegations in the US Congress to discuss the importance of basic science and oceanographic research and to support increased funding for the National Science Foundation. In February 2006, I was asked to participate in a conference on the *Oceans in the Nuclear Age* at UC Berkeley, where there was considerable discussion about the policy and science of nuclear waste disposal in the oceans – past and future.

Public and educational outreach is also a focus of DOEI through the Dive and Discover™ Web site. Dive and Discover™ (http://www.divediscover.whoi.edu) provides a fun and interactive educational program for K-12 students and the general public. In 2005, Dive and Discover™ hosted Expedition 9, a revisit to the Galapagos Rift that included Alvin dives and deep-sea camera exploration for hydrothermal vents. Currently, Dive and Discover™ Expedition 10 is ongoing in the Antarctic's Southern Ocean.

DOEI is also looking to the future in terms of identifying important cross-disciplinary science topics with great promise for developing into national and international programs. NSF's recently approved Ocean Observatory Initiative ties into DOEI thematic research in many ways, and WHOI investigators will, no doubt, continue to think creatively about these and other opportunities. DOEI is committed to help with these endeavors and other science programs to ensure the viability of WHOI and its scientific, engineering and technical staff.

Research highlighted in this newsletter reflects the breadth and innovative nature of science being carried out by DOEI investigators at WHOI. First and foremost, WHOI and DOEI realize that investing in our students is key to the current and future health of the Institution and ocean sciences. Emily Van Ark's and Matt Jackson's research projects embody the range in geographic and disciplinary breadth of work being undertaken by our students. Matt's award by the AGU reflects the very high caliber of our students and acknowledges their achievements.

The seafloor geodetic experiment being carried out by Jeff McGuire and Mark Behn underscores how important technology development is to conducting world-class experiments on fundamental earth and ocean science problems. Their experiment is unique. It will provide not only crucial tests of hypotheses about how ocean island flanks deform, but their instrumentation will also play a major role in the understanding of oceanic transform behavior and, by analogy, how faults behave and how their movements may be better predicted.

As I write these notes, many investigators at WHOI will be pondering their upcoming proposal submissions to DOEI for consideration of funding in 2006. I look forward to reviewing what I am sure will be seminal ideas for innovative research that will continue to push at the boundaries of our knowledge about deep ocean and earth processes.

– Dan Fornari, March 3, 2006

Table of Contents

Deep Ocean Exploration Institute
www.whoi.edu/institutes/doei
Woods Hole Oceanographic Institution

Dan Fornari email: dfornari@whoi.edu
Andrew Daly email: adaly@whoi.edu
Audrey Rogerson email: arogerson@whoi.edu
Editor: Alison Kline email: akline@whoi.edu

Student Highlights

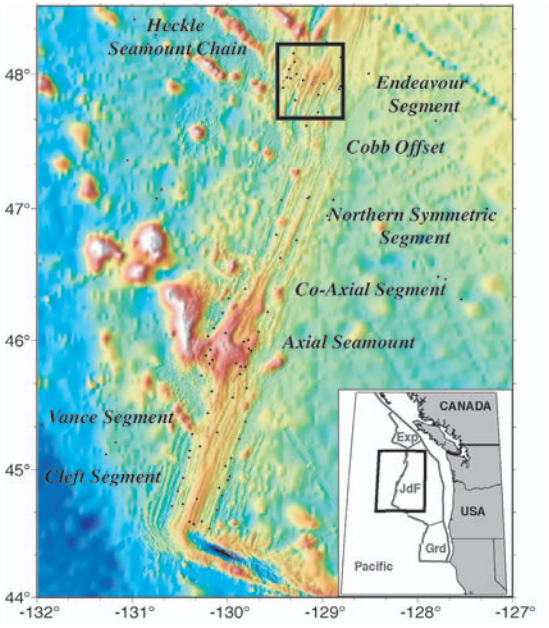
Research: Geology & Geophysics Graduate Student, Emily Van Ark

Emily Van Ark is interested in magma and volcanism in Earth's mantle and crust under the ocean. As a member of the MIT/WHOI Joint Program, she is working on three research projects. The first is focused on the volcanic production of the Hawaiian Islands and their undersea continuation, the Hawaiian and Emperor seamounts. The second involves the magma chambers at the Juan de Fuca Ridge off the coast of Oregon and Washington states (figure below). For the third project, Emily is working with models of partially molten mantle, deep in the earth near the core-mantle boundary.

Emily uses a variety of geophysical techniques to study these problems. For the Hawaiian islands seamount project, she worked with WHOI Senior Scientist Jian Lin using small variations in the strength of gravity measured by satellites to estimate how much the ocean crust has been thickened by volcanism. For the Juan de Fuca Ridge project, she spent a month at sea with WHOI Senior Scientist Bob Detrick and Associate Scientist Pablo Canales along with collaborators from other institutions, collecting marine seismic reflection data, which she later processed into images of the ocean crust. And, with MIT Professor Stephane Rondenay, she is using a seismic wave propagation model to find signatures of molten regions within the core-mantle boundary that might be targeted for identification in seismograms recorded at the surface of the earth.

Emily Van Ark on a May 2005 Field School trip (sponsored by the NSF's Ridge 2000 program) studying the Troodos Ophiolite in Cyprus. An ophiolite is a section of oceanic crust that has been deposited on dry land, allowing geologists to get "up close and personal" with the rocks.

Through all of her research, Emily hopes to gain a greater understanding of the dynamics of Earth's interior and the interactions that occur at the boundaries between the ocean and the crust, the crust and the mantle, and the mantle and the core. She wants to know why Hawaii is where it is, how new ocean crust forms at mid-ocean spreading centers, how that crustal formation interacts with the amazing hydrothermal chemical and biological systems on the ocean floor, and whether there is just as much fascinating variation at the core-mantle boundary as there is at the surface of the planet.



Map of the Juan de Fuca Ridge off the coast of Oregon and Washington states. The map shows the location of one of Emily's research areas, the Endeavour segment (upper black box). Inset: tectonic setting of the Juan de Fuca Ridge, where JdF = Juan de Fuca Plate, Exp = Explorer Plate, Grd = Gorda Plate, and Pacific = Pacific Plate. (Lower black box outlines location of main map). [Van Ark *et al.*, submitted.]

AGU Outstanding Student Paper Award

Please join us in congratulating MIT/WHOI Joint Program Student, Matt Jackson, for receiving an Outstanding Student Paper Award for his presentation at the American Geophysical Union (AGU) Fall meeting in October 2005. Matt's paper, "Implications of New High $^{3}He/^{4}He$ Values from the Samoan Hotspot," will be listed in an upcoming publication of ***Eos***, the weekly paper of AGU, and he will receive a certificate of achievement at the next AGU meeting in May 2006.

Matt Jackson, recipient of an Outstanding Student Paper Award at the American Geophysical Union. Matt explains about his research: "Helium isotopes (^{3}He and ^{4}He) are produced by fusion inside stars. Both were trapped inside Earth's mantle when it coalesced from the solar nebula 4.5 billion years ago. Therefore, when we find rare, high helium isotope ratios in volcanic rocks, we think we are looking at an ancient piece of Earth's mantle that has managed to remain isolated, preserving part of its early-Earth signature." Matt is working with WHOI Senior Scientist, Mark Kurz, of the Marine Chemistry and Geochemistry Department, on this project.

A Seafloor Geodetic Experiment to Monitor Deformation on the Slope of Kilauea Volcano, Hawaii

Co-PIs: Mark Behn and Jeff McGuire

Seafloor geodesy represents an exciting new field in marine geophysics. In geodesy, the size and shape of Earth's surface can be mapped through a network of accurately surveyed points of geographic position using longitude, latitude and elevation, while taking into account the curvature of the earth through precise mathematical calculations.

Developments over the last several decades in satellite-enabled GPS (Global Positioning Systems) and InSAR (Interferometric Synthetic Aperture Radar) systems have provided the ability to make geodetic measurements with sub-centimeter accuracy on the continents. These remote sensing techniques have led to unprecedented discoveries in fault behavior and earthquake mechanics on land.

In comparison, seafloor geodesy is in its infancy; and, to date, only a few scattered geodetic measurements have been made in the ocean basins.

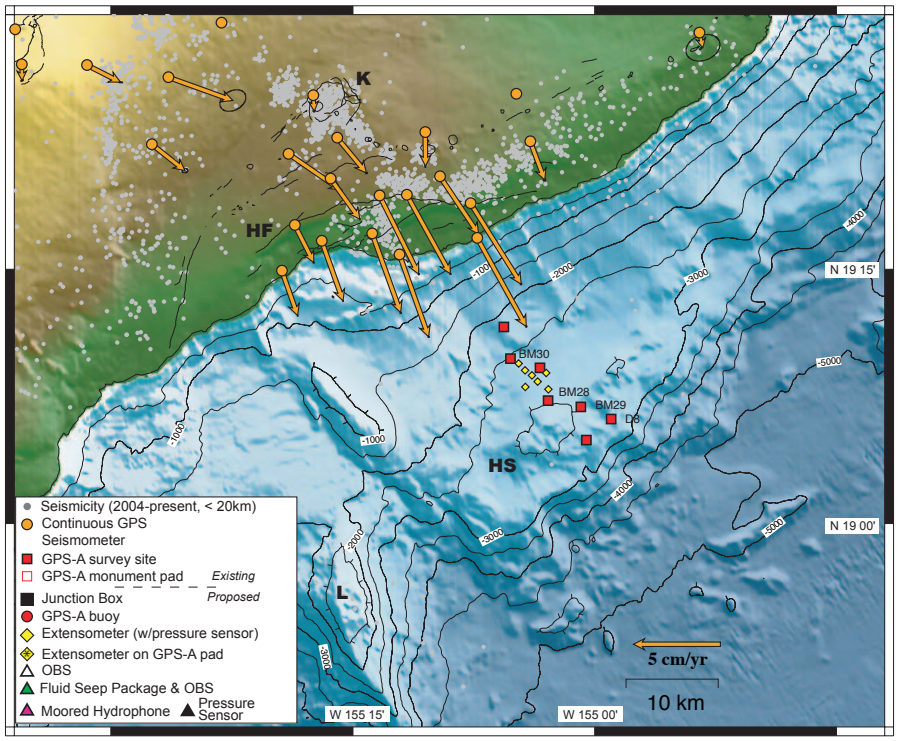
This DOEI-funded project, 'AHOLO, employs geodetic techniques to study undersea earthquakes and landslides in Hawaii. ('AHOLO stands for **A** **H**awaiian **O**cean **L**andslide **O**bservatory – *'Aholo* being the Hawaiian word for landslide.)

Massive slope failure and debris avalanches on the flanks of oceanic volcanoes have been linked to tsunami generation in the Pacific and Atlantic Oceans. However, the process by which the flanks of active volcanoes deform remains poorly understood. One of the best-studied active volcanic landslides is the Hilina slump on the southeast flank of Kilauea volcano, Hawaii. Geodetic measurements and field observations on land show that the Hilina slump breaks away along a system of seaward-dipping faults that transport material to the southeast at rates of approximately ten centimeters per year (see figure).

Two competing theories explain the movement of the Hilina slump. One posits that this extension may represent merely the upper-flank expression of a more massive slump sliding coherently seaward. Alternatively, several recent studies have proposed that volcanic spreading associated with magma injection at the summit of Kilauea causes the upper flanks to extend while simultaneously generating compression and thrust faulting in the lower submarine flanks. If correct, this second model implies a more stable flank configuration, with less potential for massive landslides and tsunami genesis. Distinguishing between these models for the Hilina slump has been difficult, because much of the deformation appears to be accommodated aseismically; and, prior to this project, no submarine geodetic measurements had resolved horizontal motions on the flank.

Project 'AHOLO involves an eight-month deployment of a new acoustic extensometer system developed at WHOI to monitor deformation in Kilauea's submarine flank. Extensometers measure small increments of deformation. When many are used in a network, a continuous time series can be obtained, showing incremental changes in land formation. The continuous time series obtained by the extensometer network can be compared to onshore continuous GPS data to look for correlations between transient periods of deformation.

In addition to explaining the movement of the Hilina slump, the



Map of the 'AHOLO project located offshore on the southern flank of Kilauea volcano, Hawaii, showing the location of WHOI's newly developed extensometer network (yellow diamonds). Extensometers are devices that measure small increments of movement or deformation in Earth's surface. K = Kilauea Caldera; HF = Hilina Faults; HS = Hilina Slump; L = Loihi Seamount.

data collected in this study will also be used to improve future seafloor geodetic studies, including those associated with NSF's ORION seafloor observatory initiative. (ORION stands for **O**cean **R**esearch **I**nteractive **O**bservatory **N**etworks.) New high-resolution multi-beam bathymetry and backscatter data were also collected during the deployment cruise, which was conducted aboard the University of Hawaii's R/V *Kilo Moana* between October 15-22, 2005. The bathymetric data will be analyzed and integrated with previous seismic reflection data to provide new insights into the tectonic setting of the Hilina slump.

Project 'AHOLO was funded through a combination of sources including WHOI's Deep Ocean Exploration Institute, the National Science Foundation, and a University of Hawaii grant for ship time. A cruise to recover the extensometer system is planned for June 2006.

Left to right: Mark Behn, Jeff McGuire and Matthew Gould (all at WHOI) with Ben Brooks (University of Hawaii). The four were co-PIs on a cruise aboard R/V *Kilo Moana* in October 2005 for the 'AHOLO project. Steam clouds from active Kilauea lava flows entering the sea are visible in the background, left.

One of our long-term goals is to establish a strong seafloor geodesy program at WHOI. To this end, McGuire will be using the WHOI extensometer system on another upcoming NSF-funded cruise to study fault behavior on oceanic transform faults on the East Pacific Rise in 2007. Furthermore, we are currently involved in ORION initiatives that, if selected, will place extensometer systems along the Blanco transform (part of the Juan de Fuca Ridge system) and off the Big Island of Hawaii.

DOEI Field Trip

In August 2005, WHOI Trustees and Members of the Corporation participated in an "AUV Adventure" aboard the R/V *Tioga*. The outing, sponsored by the DOEI, gave the group an opportunity to learn more about a new autonomous underwater vehicle (AUV) – the Puma/Jaguar system. Designed to operate under the ice, the Puma/Jaguar system is pushing the boundaries of technology in navigation, maneuverability, and sampling. During the field trip, the group was able to discuss the vehicle's capabilities with the project team, led by WHOI scientists Hanu Singh (AOP&E) and Rob Reves-Sohn (G&G), and to participate in the at-sea testing of its new instrument components.

Back row (left to right): Ken Woodcock, Sally Thibault, George Thibault, Frank Hoch, Lisina Hoch, Anne James, Bob James, Alix Laager, Ruedi Laager, Peter Aron, Ben Richards, Reuben Richards. Front row (left to right): Ballard Blair, Kathryn D'Epagnier, Chris Roman, Chris Murphy, Dan Fornari, Audrey Rogerson.

Associate Scientist, Hanu Singh (center) directing the retrieval of an autonomous underwater vehicle (AUV) aboard the R/V *Tioga*, after an at-sea test of the AUV's systems and capabilities.