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2008 Annual Report: Geology & Geophysics

Research in the Department of Geology and Geophysics encompasses earth and ocean processes: from the formation of ocean crust and ocean basins, to the underlying dynamics of plate tectonics and deep earth mantle geochemistry, to climate change and its relation to present and past ocean circulation and coastal environments.

In the last quarter of 2008, Susan Humphris stepped down as Chair of the Geology and Geophysics Department and was succeeded by Maurice Tivey. Former G&G Department Chair Susan Humphris agreed to be interim Vice-President of Marine Operations replacing Bob Detrick, who was appointed Division Director of Earth Sciences (EAR) at the National Science Foundation (NSF). Department member and Senior Scientist Debbie Smith is also currently at NSF, as a Program Director in the Ocean Drilling Program section of Ocean Sciences.

The total Department staff numbered 92, with 39 postdoctoral investigators and Joint Program (JP) graduate students. Our scientific staff decreased by four this year, including Brian Tucholke, who retired after ~30 years at the Institution and was appointed Scientist Emeritus. Promotions included Mark Behn to Associate Scientist and Maurice Tivey to Senior Scientist. There were no new additions to the scientific staff in 2008.

Three Department members received notable awards and recognition in 2008: Scientist Emeritus Stan Hart received the Arthur L. Day award for his lasting contributions to the study of the physics of the Earth; Ralph Stephen was awarded the Edward W. and Betty J. Scripps Chair for Excellence in Oceanography; and Dan Fornari was appointed Chair of the NSF-sponsored RIDGE2000 program with the RIDGE2000 Office moving to WHOI in November 2008 for a 4-year term.

As always, Geology and Geophysics Department members traveled to all corners of the world this year to carry out their research. Staff participated in research cruises to the Pacific, Atlantic, Indian, and Arctic Oceans as well as the Red Sea, aboard vessels from the US, United Kingdom, Japan, China and Saudi Arabia. They conducted land-based fieldwork in Greenland, Romania, Bermuda, Costa Rica, Iceland, Samoa, Australia, Florida, Hawaii, and North Carolina.

A significant area of research in the G&G Department is seismology – the study of earthquakes and the propagation of waves through the Earth – and our scientists use tools that range from seafloor instruments to ships to obtain seismic information. Several important seismology cruises took place this year using the newly commissioned *R/V Marcus Langseth*, an NSF-owned vessel specially equipped for seismology. Dan Lizarralde, Chief Scientist and Co-Chief for the first two such cruises, studied the region beneath the coast of Costa Rica where the Cocos tectonic plate subducts beneath (slides under) the Caribbean plate. The work was part of an NSF-funded research program called the “MARGINS Subduction Factory” initiative. This large project aims to quantify chemical exchanges between Earth’s mantle and crust, changes in mantle and crust physical properties, and the role of water and rock alteration in the subduction process.

Enlarge Image

Postdoctoral researcher Justin Ries, working with Anne Cohen and Dan McCorkle in the WHOI Geology and Geophysics Department, grew this tropical pencil urchin (*Eucidaris tribuloides*) and other marine shell-building animals for months in tanks under atmospheres containing high carbon dioxide levels. More carbon dioxide generates greater acidity in the water, which can corrode calcium carbonate, the material many marine animals use for their shells. Ries (now at the University of North Carolina) wanted to test the animals' ability to build their shells under the increasingly high levels of carbon dioxide predicted for the future, if fossil fuel reserves continue to be burned and the resulting CO_2 released. (Photo by Tom Kleindinst, Woods Hole Oceanographic Institution)

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Another major topic of G&G scientists is the crustal structure of the mid-ocean ridge system, where tectonic plates spread apart. Pablo Canales took part in the first academic “3D seismic reflection” experiment (sending sound through the water to the crust and analyzing the return echoes) aboard the *Langseth.* The objective was to create an accurate 3D image of the oceanic crust at the East Pacific Rise (EPR) at $9^{o}\,50^{'}$ N, and the magma chamber that lies underneath it.

One note about the magnitude of this work: The cruise collected about 3.7 Terabytes (thousands of gigabytes) of data! – the equivalent of 30,256 km of seismic tracklines with 99,888 seismic “shots,” or sound bursts, and 186,998,336 seismic traces, which is nearly a trillion data samples.

Pablo and JP student Min Xu will process part of this mass of data, to investigate the structure of the crust and the axial magma chamber at the EPR. In a separate seismic experiment, also on the *Langseth*, Chief Scientist Jeff McGuire and John Collins placed an array of ocean bottom seismometers (OBSs), instruments designed to measure seafloor earthquakes, on three faults along the EPR where

tectonic plates slide past each other, called Quebrada, Discovery, and Gofar (also known as the “QDG transform faults.”) The QDG transforms, although similar in appearance, have very different levels of seismic activity, with the Quebrada being almost completely quiet, with very few earthquakes. Based on his previous work on earthquake cycles, Jeff predicted that a large quake of magnitude 6.0 should occur on the Gofar or Discovery transforms during the period the OBSs remained on site, and indeed such a quake did occur on Sept. 18 th, 2008—a successful result. The OBSs were recovered at the beginning of 2009. These data will be used to help us define the faulting and triggering processes for earthquakes that occur on oceanic transforms.

The year also marked the first field work in the Red Sea as part of a collaborative research program with King Abdullah University of Science and Technology (KAUST), a new world-class, graduate-level scientific research university under development in Saudi Arabia. WHOI research vessel *Oceanus* carried out oceanographic surveys in the Red Sea and geological and geophysical surveys of the very unusual hot brine deeps, including deep-towed camera surveys. Steve Swift led the geological program at sea with WHOI colleagues Dan Fornari, Adam Soule, Mark Behn and Maurice Tivey.

Another aspect of our collaborative work with KAUST was studying the Red Sea’s diverse coral reefs. Anne Cohen led a science team with Pat Lohmann, Postdoc Neal Cantin, and JP student Casey Saenger to collect coral samples to investigate the relationships between natural and human-driven environmental changes in coral growth and reef health. The researchers will measure changes in the skeletal and tissue growth of the corals on seasonal through centennial timescales, with longer timescales providing an assessment of the pre-industrial reef, and seasonal timescales allowing correlations between ocean conditions and coral growth. In related work, Dan McCorkle collected water samples from Red Sea reefs and offshore waters to document the balance of carbon compounds and nutrients. This will help to define current environmental conditions on the reefs and improve our ability to anticipate impacts of rising atmospheric CO_2 concentrations on the Red Sea coral reef ecosystems.

—*Maurice Tivey, Department Chair*

Will Climate Change Affect the Greenland Ice Sheet?

In July 2008 researchers from Woods Hole Oceanographic Institution and the University of Washington spent nearly 3 weeks camping and working on Greenland's ice sheet.

Greenland—the worlds largest island—is also home to one of the worlds largest ice sheets (after Antarctica). If Greenland's two-mile-thick ice sheet melts completely, it would ultimately raise global sea level by 23 feet, drowning significant portions of coastal regions under water.

» Learn more about this expedition on the *Polar Discovery* Web site.

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