SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAIʻI AT MĀNOA

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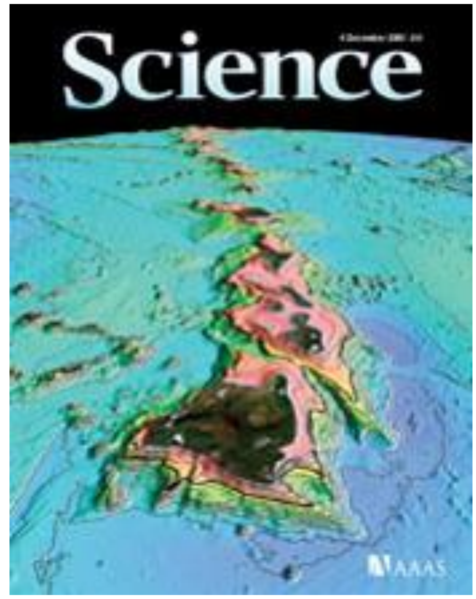
Scientists map deep origins of the 'Hawaiian Hotspot'



The researchers' findings appear in the December 4, 2009, issue of the journal Science.
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The Hawaiian Islands are one of the outstanding volcanic features on Earth, but their origins have been shrouded in mystery. Still in debate is a theory that was proposed forty years ago, which states that mid-plate hotspots such as Hawaii are generated by upwelling mantle plumes from the base of the lower mantle.

Cecily Wolfe, a professor from the University of Hawaiʻi at Mānoa School of Ocean and Earth Science and Technology, and a multi-institutional team of scientists have put the theory to test. Their research findings, titled "Mantle Shear-wave Velocity Structure beneath the Hawaiian Hotspot," will be published in the December 4 edition of *Science* magazine.

A deployment of a large network of sea-floor seismometers in Hawaiʻi, called the Plume-Lithosphere Undersea Melt Experiment (PLUME), opened up a window into the Earth, obtaining the best picture yet of a mantle plume originating from the lower mantle and finally revealing Hawaiʻi's deep roots.

The project involved four research cruises over a more than two-year period to deploy and recover ocean bottom seismometers at 73 sites, led by Gabi Laske (Scripps Institution of Oceanography (SIO)) and John Collins (Woods Hole Oceanographic Institution (WHOI)). Sean Solomon (Carnegie Institution of Washington) provided a concurrent deployment of land seismometers on the main Hawaiian Islands.

The seismometers were used to record the timing of seismic shear waves from large earthquakes (magnitudes greater than 5.5) around the world. This information can be used to determine whether seismic waves travel more slowly through hot rock as they pass beneath Hawaiʻi. Combining the timing measurements from many earthquakes recorded on many seismometers allowed Wolfe to construct a sophisticated 3-dimensional image of the Hawaiian mantle. The large, 1,000-km wide aperture of the seafloor network yielded unprecedented deep resolving power in a remote oceanic region, and inclusion of SKS waves (a type of wave that travels through the Earth's core) was critical for extending the imaging down to 1,500 kilometers depth.

The images from the PLUME experiment provide strong support for the existence of a mantle plume beneath Hawaiʻi. In the upper mantle, the Hawaiian Islands are underlain by low shear-wave velocities, consistent with hotter-than-average material from an upwelling plume. Low velocities continue down into the Earth's transition zone, at 410 to 660 km depth, and extend even deeper into the Earth's lower mantle down to at least 1,500 km depth. Strikingly, the plume tilts toward the southeast of Hawaiʻi as it extends downward. Such southeast tilting is consistent with prior dynamic predictions that the background circulation of the Earth's mantle associated with plate tectonics will deflect the upwelling Hawaiian plume. Or, in other words, like rising smoke on a windy day, the Hawaiian plume conduit is blown in the background mantle wind.

SIO (yellow) and WHOI OBS (orange) data acquisition systems stored for transit on the launch deck of the R/V Kilo Moana.
Photo credit: Gabi Laske, SIO/UCSD

The location of the Hawaiian Islands in the middle of the Pacific Ocean had hampered past seismological efforts to resolve its deep structure. Seismometer deployments limited to just land sites on the islands did not provide sufficient coverage for high-resolution imaging, and Hawaii is also far from the most active circum-Pacific zones of earthquakes. As a result, scientists had to turn to a more technologically challenging, marine seismology approach by placing temporary instrumentation on the seafloor to record seismic waves for two one-year deployments. Results of the project indicate a strong case for the existence of a deep mantle plume, which has fundamental implications—not just for Hawaii, but more generally for the form of convection in the solid Earth, the Earth's composition with depth, and its evolution over geologic time.

"This experiment was first conceived by our team a decade ago. Fortunately, the results have been worth the wait and exceeded all expectations," says Professor Wolfe. "The success of such an ambitious seafloor experiment is a technological feat in itself and signals a new era in the field of marine seismology."

The study is published in the December 4, 2009 issue of *Science*. Authors are C.J. Wolfe, University of Hawai'i at Mānoa; S.C. Solomon and E.H. Hauri, Carnegie Institution for Science; G. Laske and J.A. Orcutt, Scripps Institution of Oceanography; J. A. Collins and R.S. Detrick, Woods Hole Oceanographic Institution; and D. Bercovici, Yale University.

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To view a copy of the abstract, see http://www.sciencemag.org/magazine.dtl (Article Information: December 4, 2009, manuscript number science.1180165).

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