Volcanoes reveal Earth's hidden currents

Massive currents of semisolid stone flow just a few hundred kilometers below Earth's surface, yet geophysicists find them maddeningly out of reach. Hidden beneath thin surface plates, these rock rivers in the planet's mantle are less accessible than the moon.

Geochemist Phillip D. Ihinger of Yale University now proposes that volcanic island chains, such as the Hawaiian Islands, provide a means of tracking the mantle's elusive flow. Ihinger calculates that the mantle beneath Hawaii is traveling southeast, even as the surface plate creeps northwest.

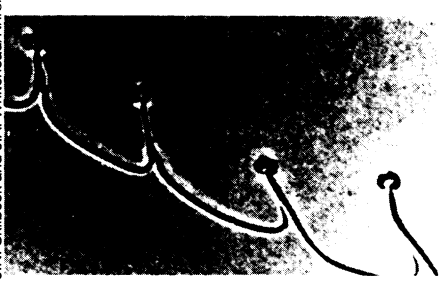
"The mantle is moving very fast in the opposite direction of what I was taught as an undergraduate," says Ihinger, who discusses his concept in the November AMERICAN JOURNAL OF SCIENCE.

The new hypothesis raises questions about the traditional explanation for the Hawaiian volcanic chain, which continues for thousands of kilometers as a line of submerged seamounts. For 25 years, geophysicists have pinned the chain's origin on a so-called hot spot—a place in the mantle where a plume of molten rock rises from deep in the planet's interior. When the plume hits the surface plate, it burns its way through the crust and erupts to form a volcano. As the surface plate moves, it carries the first volcano away from the stationary plume, and a new volcano arises over the hot spot.

This simple model cannot explain many important features of the Hawaiian chain, claims Ihinger. Researchers in the past have noted that the volcanoes do not line up exactly. They are divided into dozens of short, overlapping segments that consist of three to seven volcanoes each. Although the volcanoes Mauna Loa and Mauna Kea are only 40 km apart, they lie on different segments and spew remarkably dissimilar lava.

To explain the Hawaiian puzzle, the Yale scientist proposes that a strong mantle current runs beneath the islands and disrupts the plume of ascending hot rock. Instead of rising vertically, the plume is sheared into discrete blobs of molten rock that climb like balloons in a wind. Each of these so-called plumelets creates a short line of volcanoes pointing in a direction that reflects the movement of the underlying mantle.

J.N. Skilbeck and J.A. Whitehead/NATURE



A tank experiment supports the plumelet concept by showing how a horizontal current might shear a rising plume.

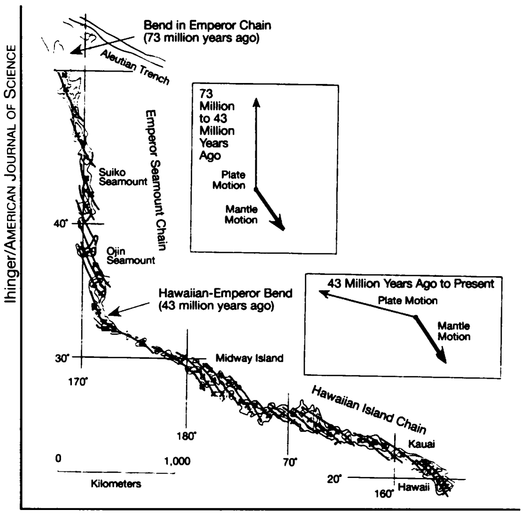
From the orientation of the Hawaiian Islands, Ihinger calculated that the mantle beneath them flows southeast at 4.3 centimeters per year—almost completely opposite the movement of the Pacific Plate, which travels northwest at 8.6 cm per year. Scientists had once thought that shallow mantle streams flow in the same direction as the surface plates.

The current identified by Ihinger runs toward the East Pacific Rise, a line of volcanoes marking the edge of the Pacific Plate. He theorizes that the flow forms part of a conveyor belt system: Mantle rock streams toward the rise, erupts, and bonds to the Pacific Plate, then moves with the plate away from the rise.

David A. Clague of the Hawaiian Volcano Observatory lauds Ihinger for trying to explain the problem of overlapping volcanic segments. "It's an admirable thing to go after. Whether he's got it or not remains to be seen," says Clague.

Other researchers criticize Ihinger's theory. Norman H. Sleep of Stanford University contends that strong mantle flow should disrupt the seafloor around Hawaii. But the ocean bottom shows no evidence of such disturbance, says Sleep.

Ihinger/AMERICAN JOURNAL OF SCIENCE



Map of the Hawaiian Island–Emperor Seamount chain. Individual volcanoes (shown as X's) line up on short segments that reflect mantle flow.

Peter L. Olson of Johns Hopkins University in Baltimore says that part of Ihinger's theory is well-founded. A plume rising through a horizontal stream would indeed get broken into discrete blobs.

But Olson questions evidence that the mantle flows at shallow depths beneath the Pacific. "People have looked for a surface manifestation of mantle flow, and they have not seen it," he says.

— *R. Monastersky*

Bacteria take new role as cancer vaccine

Oral vaccines are becoming commonplace: Immunity to typhoid and cholera, for example, now comes without a needle prick, and other such vaccines await testing. But vaccines for cancer, let alone oral ones, seem years distant.

Recent work with mice, however, makes the idea of such vaccines a little less fantastic. In the Nov. 1 CANCER RESEARCH, scientists at the University of Pennsylvania in Philadelphia and the Johns Hopkins Medical Institutions in Baltimore report success with an oral vaccine against two types of specially tagged tumors.

The vaccine itself, as novel as that result, consisted of a live, genetically engineered version of a bacterium, *Listeria monocytogenes*, usually found as a food contaminant. Fed to mice, these modified bacteria induced a powerful immune reaction.

"We've based our vaccine on its ability to induce immune cells to destroy tumors, just as they'd kill viruses, for example," says Pennsylvania's Yvonne Paterson. The immune cells in question—cytotoxic T lymphocytes, or CTLs—recognize foreign proteins on diseased or infected cells. Engineering that recognition became the idea behind the vaccine development.

The researchers first transferred a nonmouse gene called *NP* into laboratory-grown cells from renal or colon cancers in mice. The gene directed the cancer cells to make a protein, also called NP. These NP-marked cells readily grew into tumors when the scientists implanted them in the mice.

Meanwhile, the researchers inserted the *NP* gene into *Listeria* and fed the bacteria to tumor-carrying mice. The *Listeria* churned out NP protein, and the mice responded by producing CTLs that homed in on NP.

Attacked by the CTLs, the bacteria lasted less than 6 days—a typical fate when immune response is strong. But the tumors also had a bad time: Because the cancer cells carried the NP protein, the CTLs recognized and attacked them too. The vaccine cleared all tumors from 60 percent of the mice with renal cancer and 50 percent of those with colon cancer.

"It's kind of wild to think you could make cancer go away with something you swallow," says Paterson, "but a benefit could come not only from treating the cancer, but from being far less invasive."

Now the researchers plan to move on to human cancers. The team has inserted into mouse tumors a gene taken from the human papilloma virus (hpv), which causes 90 percent of human cervical cancers. The group hopes to attack these mouse tumors by stimulating CTLs that recognize the hpv protein. — *M. Centofanti*