Investigating Earth's dynamic processes

This may sound like heresy, but for some of us at Woods Hole Oceanographic Institution, the ocean is a bit of a nuisance. All that lovely blue water can get in the way.

The ocean is a barrier that impedes our ability to understand how our planet works. It conceals powerful and fascinating forces that are constantly shaping and reshaping Earth's surface in ways that really make our planet unique.

Earth is not cold, dead, and static. Its surface is hot. It's moving. It's constantly changing. But just a half-century ago, we were largely unaware of our planet's extraordinary dynamism because it primarily occurred in a place where we couldn't easily observe it.

The ongoing, fundamental forces that forge our planet—that generate earthquakes and volcanoes; that perpetually create and destroy Earth's crust; that rip apart continents and smash them into one another; that create mountains like the Himalayas and island chains like Hawaii; that open and close ocean basins; that forge mineral deposits and generate oil and gas; and that brew chemical cauldrons that sustain rich communities of life in the sunless depths—most of this action occurs beneath the oceans.

Water is a blessing that supports life on Earth, but it is a dreadful medium for exploration. It is largely impenetrable to light, so we can't see through it. We can't view most of Earth's surface with a telescope, as we can with Mars. Flying vehicles through the viscous medium of water, under conditions of crushing pressure and complete darkness, poses daunting technical challenges.

Although we have fully mapped the waterless surfaces of Venus, Mars, and the moon in detail, we have mapped only *5 percent* of the entire seafloor at the same resolution. Just 50 years ago, we were as ignorant about our home planet as we were about our solar system nearly 500 years ago—before the astronomer Copernicus told us that the Earth revolved around the sun, rather than vice versa.

Since then we have learned that the seafloor is not some vast, placid beach. In the 1950s and 1960s, we discovered that the globe is encircled by an active volcanic mountain chain. It bisects the ocean floor and stretches continuously for more than 75,000 kilometers (45,000 miles)—more than five times the length of the Andes, Rocky, and Himalayan mountains combined. Over millions of years, this mid-ocean ridge system continually spews lava, creating new ocean crust that repaves most of the planet's surface.

The seafloor is also rife with deep trenches, where old, cold ocean crust sinks back into Earth's interior and is recycled. At both ridges and trenches, volcanism and earthquakes are rampant. Indeed, about 80 percent of volcanic and seismic activity on Earth occurs under the sea.

Fueled by heat emanating from Earth's core, the engine that drives much of this activity is the mantle—the layer of our

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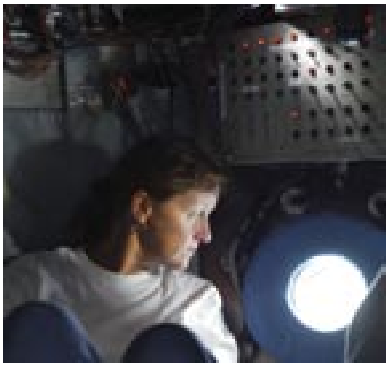
planet between the crust and core. At the high temperatures and pressures found within Earth's mantle, solid rocks can deform. (Think about how a blacksmith heats iron to a temperature just below its melting point to bend and shape a horseshoe.) Solid rocks within Earth's mantle can flow, with hot buoyant material rising and cold, dense material sinking.

This convection drives the motions of our planet's thin, rigid outer layer, which is broken into Earth's great tectonic plates. The plates move apart and together, continually (albeit slowly) changing the face of the planet. The continents atop the plates are carried along as passive riders.

In some cases, we are learning that the rending and collisions of continents have led to changes in the circulation of the oceans, or the atmosphere, or chemicals cycling among the earth, ocean, and atmosphere. All of these, in turn, can spawn changes in Earth's climate.

In the late 1970s, the surprising discovery of life thriving at deep-sea hydrothermal vents revolutionized our concepts of where and how life can exist. An abundance of life flourishes in conditions we had considered too extreme, supported by chemicals created by processes occurring within the planet itself. More recently, we have seen evidence that previously unimagined and potentially huge communities of microbial life reside deep *within* the Earth. These discoveries have fundamentally changed our perspective on the origins of life on Earth and redirected our approaches to searching for extraterrestrial life.



Craig N. McLean, NOAA

Susan Humphris, the first Director of the WHOI Deep Ocean Exploration Institute, peers through an Alvin *viewport before the sub descends to the seafloor.*

Unforeseen discoveries—such as plate tectonics and chemosynthetic deep-sea life—have transformed our understanding of Earth. But oceanography is a very young science. The oceans remain a frontier.

Dramatic advances in deep-submergence vehicles and technologies now provide the potential for unprecedented access to the oceans and seafloor—and unprecedented discovery. New robotic systems and oceanographic instruments are being developed to remain in the oceans for long periods—to go beyond learning what's down there and begin to make inroads into learning more about what's *going on* down there.

That is the mission of the Deep Ocean Exploration Institute at Woods Hole Oceanographic Institution: to investigate Earth's dynamic processes by exploring the frontier where they are occurring. We journey into uncharted waters—or more precisely, *under* them—to reveal the history and natural engineering of the planet we call home.

—Susan Humphris

Susan Humphris is Chair of the WHOI Geology and Geophysics Department. She was the first Director of the WHOI Deep Ocean Exploration Institute, serving from 2000 until June 2004, when she was succeeded by Dan Fornari.

Composite photo, above: IMAX film by William Reeve and Stephen Low, Stephen Low Productions