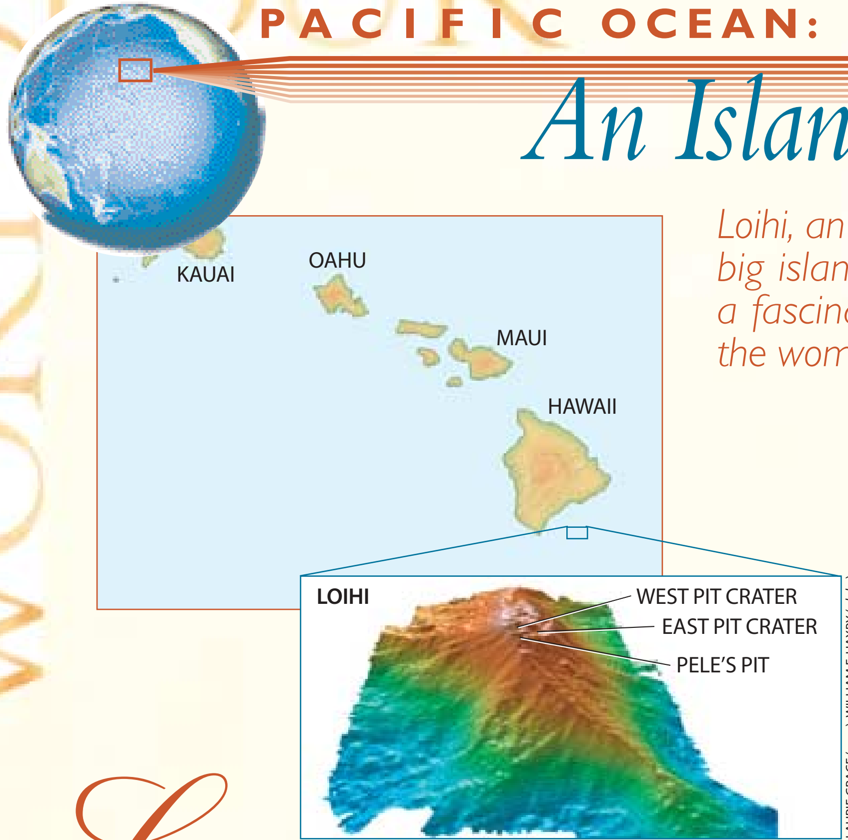
PACIFIC OCEAN:

An Island Is Born

Loihi, an undersea volcano south of the big island of Hawaii, offers geologists a fascinating glimpse of an "island in the womb"

by Alexander Malahoff



LAURIE GRACE (*map*); WILLIAM F. HAXBY (*globe*); J. R. SMITH (*contour map*)

Lying on my left side, peering through the small porthole, I gazed on a fantastic, jagged undersea landscape, just 47 days old. No human had seen it before. I was 1,328 meters (4,357 feet) below the sea, at the very bottom of a brand-new pit crater in Loihi, an undersea volcano 34 kilometers south of the big island of Hawaii.

Before July 16, 1996, the top of Loihi was marked by two pit craters, each about one kilometer in diameter and 300 meters deep, and a large hill, known as a cinder cone, underlain by magma (molten rock). Then, by August 10, and for largely unknown reasons, the magma inside the cone withdrew into the volcano's interior "plumbing," and Pele's Cone, as we called it, collapsed in a volcanic event as cataclysmic as the Mount St. Helens eruption in 1980. Some 300 million tons of rock fell into the volcano, creating a third pit crater, which my colleagues and I now call Pele's Pit.

We made our momentous first descent into Pele's Pit on September 15 on board the research submersible *Pisces V,* operated by my group at the University of Hawaii's Undersea Research Laboratory. Three of us—pilot Terry Kerby, co-pilot Allen Wright and I—were squeezed into the sub's tiny command sphere, which is just under two meters in diameter and crammed with electronic and mechanical equipment, gauges, dials, video monitors and levers. We wore thick layers of clothing and woolen caps in the unheated sphere to ward off the cold of the ocean depths. As I lay on my left side on a small bench on the port side of the sphere, Wright was across from me, on his right side. Between us, Kirby, kneeling, peered intently through the center porthole as he maneuvered the ship over the terra incognita.

The sights we saw were straight out of a science-fiction movie. As we drifted over the edge of the new crater, preparing to descend, we glimpsed the top of a rock pinnacle, one of a dozen or more left standing when the rock around them collapsed into the volcano. The pinnacle, the likes of which we had not seen in the other craters, was hundreds of meters tall. It loomed up in our lights like a skyscraper-size stalagmite.

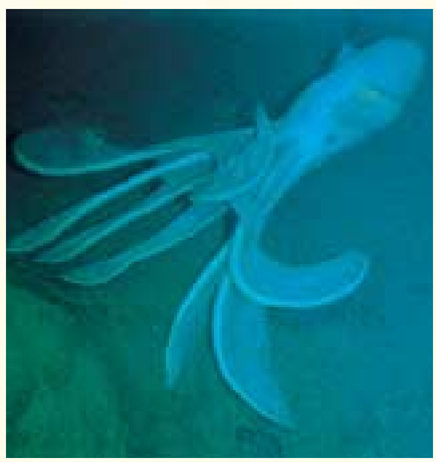
The water was still murky from the upheaval, so we relied primarily on sonar to guide our cautious descent. When we arrived at the bottom, I was amazed to see that in the five or so weeks since the collapse, large mats of hydrothermic bacteria had already formed near the vents where water, superheated and expanded by contact with the underlying magma, shot out.

At that moment we had no time for gawking, however. We found ourselves close enough to a vertical wall to be entombed if a landslide happened to come down it. And judging from the relatively fresh piles we had seen, there had been frequent landslides, prompted by the many seismic spasms that had followed the collapse. So we retreated to an area with a gentler slope, where we set the craft down at a depth of 1,297 meters. All around us, hot vents shimmered in our lights, which played over rocks covered with the huge, white mats of bacteria. We videotaped these mats and backed up to visit some other vent sites about 20 meters away.

But as we viewed some mats at a depth of 1,310 meters, we were snapped out of our engrossment by the unmistakable, high-frequency rattle over the hydrophone of rocks sliding down the inner walls of the crater. "Landslide," I said.

"Yeah, landslide," Wright agreed. "Coming toward us."

Kerby, a veteran of some 300 dives in the *Pisces V,* quickly steered us toward the cen-



HUGE OCTOPUS, over three meters (10 feet) long, was captured on the summit of the Loihi volcano using a submersible's manipulators, but it escaped in a cloud of ink as the craft ascended.

PHOTOGRAPHS BY ALEXANDER MALAHOFF

PISCES V SUBMERSIBLE (*above, left*) is lowered from its support vessel, the *Ka'imikai-o-Kanaloa*. Ocean-bottom observatory (*above*) has a time-lapse video camera on top, a seismometer to the right and temperature probes, which are inserted into hot-water vents.

ter of the pit crater and jettisoned our ballast weights, initiating a slow, buoyant ascent to the surface. By ascending from the center, not only would we be safely away from debris falling along the inner walls of the crater, but also we would eliminate the possibility of colliding with, and becoming trapped under, any rock ledges that may have formed on the inner walls.

Birth of an Island

Even before the cataclysmic formation of Pele's Pit, Loihi presented a unique opportunity for geologists: the chance to monitor closely an island in the making. The underwater volcano sits above a hot spot, the very same one that has been forming the Hawaiian island chain over the past 85 million years. (A hot spot is a local source of the heat embedded deep within the earth.) In dozens of places around the earth, the heat expands parts of the plastic, deformable rock deep down in the mantle. This expanded rock, now less dense than its surroundings, rises through the mantle toward the surface, much like a hot-air balloon in the atmosphere. Why this heat wells up in some places and not in others is not well understood at present.

The rising rock ultimately reaches and cracks the lithosphere, the relatively thin and brittle slab on top. The upwelling rock liquefies as it is released from the high-pressure mantle, and the resulting magma comes up through the cracks. An example of this magma is the lava flowing from a hot-spot volcano during eruption.

Because the earth's tectonic plates are in motion, the upwelling of rock can crack the lithosphere in a series of places as a plate moves relative to the hot spot over millions of years. In the case of the Hawaiian chain, the Pacific plate is moving to the northwest at 9.6 centimeters a year. This fact explains why the chain is oriented as it is.

Some five million years ago magma flowed up through underwater volcanoes and formed the chain's northwesternmost high islands, Niihau and Kauai. Then, as the plate moved northwest, it carried the newly formed islands off the hot spot. As they were moved off the underlying source of their heat, the volcanoes went dead, and new, active volcanoes formed underwater over the spot. The process repeated itself until a succession of volcanoes created, in order, Oahu, Molokai, Lanai, Maui, Kahoolawe and, finally, the big island of Hawaii. In fact, the big island is so young, at less than a million or so years old, that it is still partially over the hot spot. At present, the same upwelling of heat that feeds Loihi, just to the south, is also feeding the Kilauea and Mauna Loa volcanoes on the big island.

Percolating Magma

Our dives to Loihi on board the *Pisces V* and other research submersibles have added many fresh details to geologists' understanding of the long, convulsive process by which a volcanic island is born. We are using a variety of instruments to make sonar images of the volcano, to record its seismic spasms, to monitor the temperature and chemical composition of the emissions from the vents, and to record the salinity of the water at many different sites.

By analyzing and combining these data, we are slowly piecing together a picture of the volcano's interior, whose most important feature is a large chamber of magma. Driven by the heat from below, the percolations within this magma chamber are responsible for most of the key phenomena that interest us—for example, the volcano's growth, earthquakes and collapses, such as the one that formed Pele's Pit two years ago.

Changes in temperature at the many vents scattered all over the volcano, from the base to the summit, are an indication of how the hot magma is moving inside the chamber. Chemical analyses of the superheated water shooting out of the vents also reveals much about this magma.

We have also been studying the bizarre menagerie that congregates around the vents, living off the chemicals, such as hydrogen sulfide and methane, that come up with the hot water. The organisms include iron- and sulfur-oxidizing bacteria and hydrothermal worms (Vestimentifera). Up a link in the local food chain, a species of shrimp (*bresiliid*) feeds on the bacteria, and (continuing upward) a variety of larger creatures drop in opportunistically to feed on the shrimp or other organisms. We often see goosefish and various deepwater fin fish and were once treated to the sight of a 3.2-meter-long octopus (*Cirroteuthis, opposite page*), which we unsuccessfully attempted to capture. Over the years, we have seen perhaps 100 different species of animals, including 20 or 30 species of soft corals.

In all probability, scientists will be monitoring Loihi for the next 50,000 years, by which time it will have broken the surface and emerged as the next island in the Hawaiian chain. Hundreds of thousands of years after that event, another volcano will rise from the seafloor southeast of Loihi, and yet another Hawaiian island will start taking shape in this watery womb of the Pacific Ocean.

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