The Discovery of Hydrothermal Vents

25th Anniversary CD-ROM

Deep Questions From the Sea

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by

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Aboard the R/V Knorr
Above the Galapagos Rift Zone

It's time to turn imaginations loose and speculate a bit about the unique and unexpected discoveries this expedition's scientists have been making on the bottom of the Pacific ocean, where the sea floor is splitting apart in a turmoil of volcanism and earth movement.

"If you were sitting on the moon with a telescope aimed at our planet," says Bob Ballard, the expedition's chief scientist from Woods Hole Oceanographic Institution in Massachusetts, "and you blinked your eyes every million years while you watched this part of the globe, in 200 blinks you'd see a whole new ocean evolve and a whole continent shape itself."

"Just look at the flow of hot water we're seeing in these volcanic vents," says red-bearded John Edmond of Massachusetts Institute of Technology in his broad Scots accent. "Why, vents like those must be pushing the whole ocean through them every four or five million years. If we study the chemistry hard enough, it may even tell us why the sea is salty."

And what of the strange and spectacular abundance of vibrantly colored life this expedition has discovered around geysers of warm water in the tumbled lava fields of the sea floor along the Galapagos rift zone?

A few of the animals seem truly weird, unlike anything familiar to anyone but marine biologists. But many resemble surprisingly the living creatures that inhabit tidepools and reefs of ocean shores, particularly tropic ones.

Tanya Atwater, an MIT geophysicist, strays far from her own field to enjoy speculating about the masses of organisms: "Maybe they all started out life as free-swimming larvae, and swam down and down until they were lost in the pitch dark of the ocean bottom. Then they found the plumes of hot water, and snuggled in next to the warmth to grow up and reproduce and start colonies."

Jack Corliss of Oregon State University, a geochemist and leader of the diving scientists, adds his own admittedly non-expert thought about biology:

Perhaps, he wonders, one species of organism may begin a colony around a warm water vent on the floor of the rift, and dominate it for a while. Then the water temperature changes, growing cooler or warmer, and another species moves in and take over. Then another, and another, each forming a dominant population in its turn.

This picture would certainly help account for the curiously unique pattern of life around each of the oases that the expedition's submarine Alvin and the research vessel Knorr have seen and photographed and sampled over the past weeks.

The ocean-bottom oases known as "clambakes" — so-called because the first one we discovered contained hundreds of clam shells and a single empty beer can — are dominated by huge white clams nearly a foot long. The "oyster bed" is marked by thriving colonies of brown mussels. The "Garden of Eden" is populated heavily by tubeworms two feet long, while in still another clambake region limpets crowd the pillow-shaped basalt rocks and turn them white. Crabs and fish, octopods and shrimp move through all the colonies.

"But all those little colonies are doomed," Corliss says, "because their life cycle can last only as long as the warm water circulates. And we can be sure that hot plumes last only briefly, before fresh volcanic action closes old vents and opens new ones."

The earth scientists on this expedition — geophysicists, geochemists, geologists and oceanographers — are aware they have stumbled on a treasure of new biological information. They have collected samples of all the life forms — the crabs, the shrimp, molluscs and the fish — and have preserved them carefully.

Some they have frozen, some they have pickled in formalin. They've even frozen samples of the slime on lava rocks where deep-sea snails graze, and they have cultured bacteria from the warm water amid the life. Perhaps the dark-adapted bacteria provide an important food supply for some of the other organisms.

But the scientists here are basically more interested in the original purpose of their venture — to study the physical and chemical phenomena of the Galapagos rift zone's rocks and sediments amd deep waters.

Analyzing water samples, measuring heat flow, scooping up specimens of lava and mineral crusts and muddy sediments, thrusting into soft bottom layers for countless core samples, the explorers have reaped a rich harvest.

Jack Dymond of Oregon State, for example, described one dive with Ballard inside the six-foot titanium sphere that forms the submarine Alvin's passenger compartment. They reached a floor of lava nearly 8000 feet down, and found it studded with tiny black crystalline spires, gleaming in the submarine's floodlights like stalagmites in a cave.

The crystals of manganese in those spires were unlike any of the common manganese nodules that lie profusely on most ocean bottoms, Dymond said.

For ordinary nodules are loosely clumped and poorly crystalline, indicating that they formed at low temperatures. The smooth, shiny faces of these spire crystals are perfectly formed and more than a millimeter across, Dymond said — an indication they were created at very high temperatures, perhaps many hundreds of degrees.

This expedition has certainly found many signs of intense heat below the surface of the ocean floor. The lava is obviously newly formed from molten matter. And the scientists have measured water temperatures up to 61 degrees in the lava vents of the central rift and the sediment mounds nearly ten miles away — "phenomenal heat values," as Corliss says. Normal bottom water hereabouts is a cold 35.6 degrees.

The rift zone's heat is one of its most important properties, for it is a major method of carrying heat away from the molten material of the earth's deep interior. The great mid-ocean gashes that cleave the crust for 40,000 twisting miles around the globe are believed to carry into the oceans nearly

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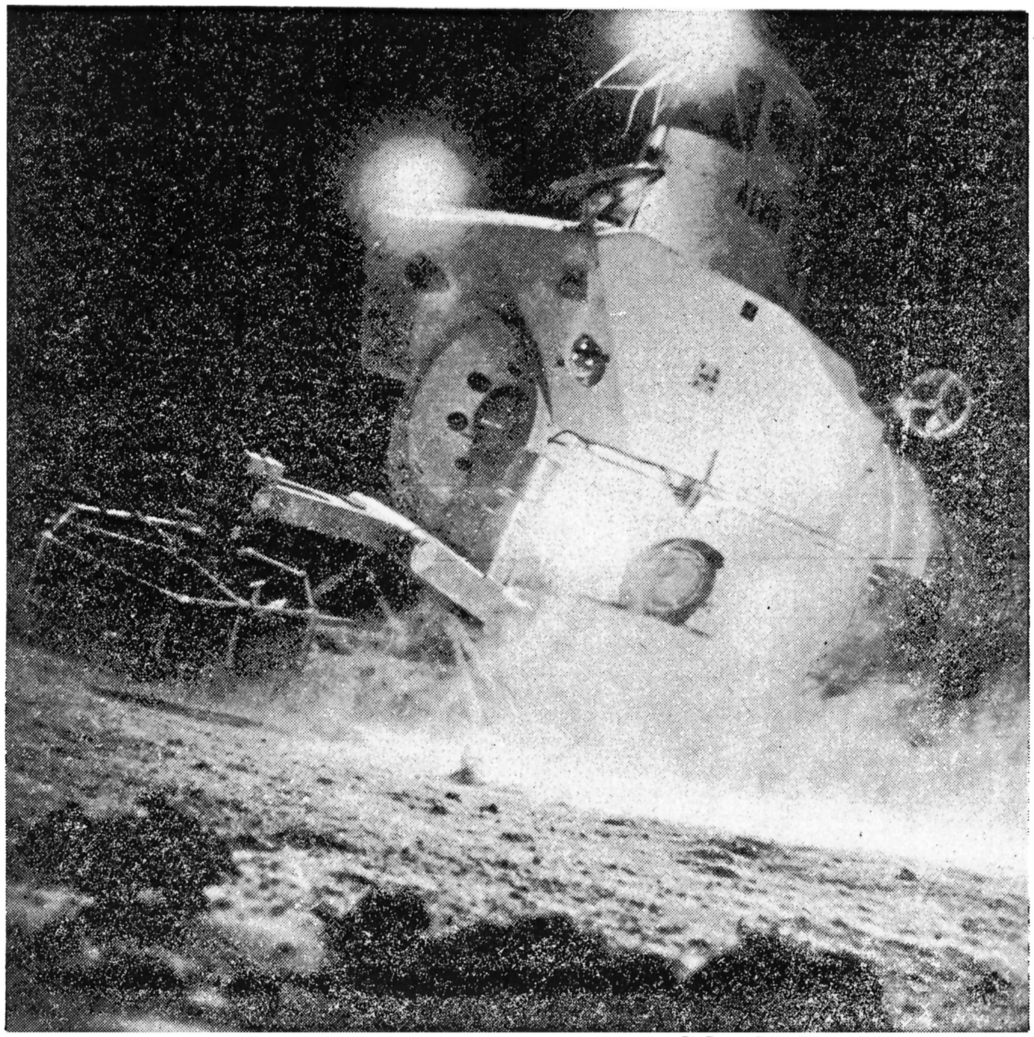

By Emory Kristof Copyright National Geographic

The research submarine Alvin took its own picture on the ocean bottom with a special camera and flash

Sea Bottom Stirs Deep Questions

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half the heat that escapes from the planet's interior.

Along the Galapagos rift the rate of this heat flow is extremely high, but there are many spots in the area where no heat at all is rising. Edmond believes this confirms the "attractive hypothesis" that sea water in these places is moving downward from the cold ocean bottom deep into the crust, encountering hot rock there, and setting up huge "convection cells" of circulating water.

The Galapagos rift zone is known as a "spreading center," because here the new lava pushing up along the axis of the zone is spreading the earth's crust apart.

There are many spreading centers along the world's mid-ocean rifts, but on some rifts the great plates grind against each other to touch off violent earthquakes, while other plates dip under continental margins to thrust up mountains and ignite volcanoes.

On this Galapagos spreading center, Edmond and his colleagues reason, the vast volume of water circulating in and out of the heated crust must create chemical reactions on a huge scale.

Not only does the water leach great quantities of valuable metals from the hot crustal basalt — manganese, iron, nickel, cobalt and the like — but the water itself changes in the process.

Lou Gordon of Oregon State and the other chemists aboard the Knorr are analyzing the sea-bottom water samples. They find the magnesium content of the water on the ocean floor is significantly lower than on the surface. Its calcium content is higher, its acidity is higher, and so are its levels of silica, helium and radioactive radon.

But it will take more detailed shore-based analysis to determine the precise effects on ocean chemistry of steady, large-scale "hydrothermal" circulation systems in this and other rift zones. Analyzing the major reacting elements in the deepest waters — the sodium, potassium, strontium and chloride ions — will, in fact, ultimately tell us "why the sea is salty," as Edmond phrases the question.

The forces that give the Galapagos rift zone its character are powerful indeed: volcanic action drives fresh molten magma at tremendous heat up into the heart of the zone, where circulating brines can quench the glow and cool the lava into solid new crust.

Then tectonic forces — faulting, folding, uplifting, slumping — tear the new crust into huge blocks while it spreads farther from the rift zone's center and sediments pile deeper and deeper over the bare rock.

However powerful these forces are, they work slowly as humans measure time. Sediments thicken an inch every thousand years. The moving plates of the earth's crust on either side of the rift spread apart at 22 miles every million years.

"Yet the earth below this ocean," Ballard says, "is a living, breathing organism. A butterfly sitting on a redwood tree goes through a time warp; he can never feel the tree growing. On the planet, we're like the butterfly: we sit on the crust and never feel it move except when an earthquake jolts us or a volcano erupts.

"But it does move, and our goal is to understand how and why. Once we have a good model of the earth, we'll be able to predict its future and describe its past."