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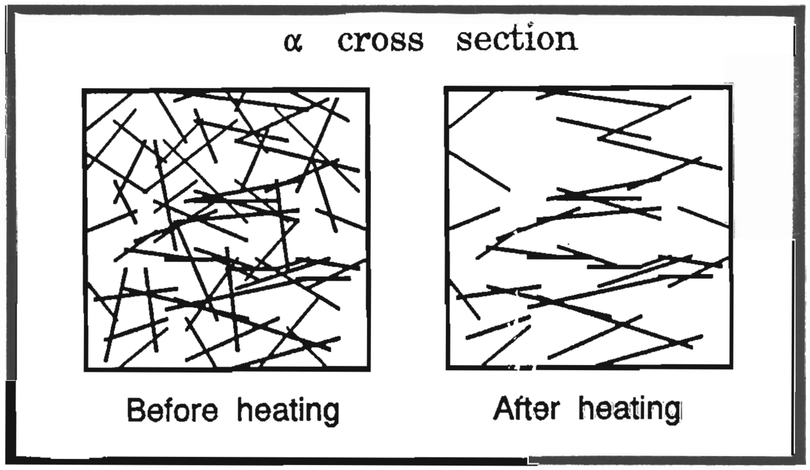
"BLACK SMOKERS" UNDER THE SEA: NEW THEORY EXPLAINS FORMATION OF OCEAN VENTS WHICH PLAY A ROLE IN GLOBAL CLIMATE CHANGE

A Georgia Institute of Technology scientist has proposed a new theory to explain the circulation of fluids which form "black smokers," undersea hot water vents that alter oceanic chemistry and play a role in global climate change on geologic time scales.

Because these undersea hydrothermal vents may affect deep ocean circulation and produce carbon dioxide, information about them is important to a complete understanding of global climate change. The hydrothermal vents are also of interest because they produce rich deposits of mineral ores and shelter a class of organisms able to survive at temperatures three times the atmospheric boiling point of water.



This cross-sectional view shows how heating affects cracks that are part of the fault zone through which heated fluid flows to form "black smokers" on the ocean floor.

Hydrothermal vents exist along ridge crests separating the massive tectonic plates which form the earth's crust. These plates move apart by as much as twenty centimeters a year, producing numerous cracks into which seawater flows. At the same time, molten magma from the earth's mantle rises into these zones of fractured rock. When the water and magma meet, the resulting hot water ascends buoyantly to the seafloor, creating hydrothermal vents that release water as hot as 400 degrees Centigrade.

To better understand the development of vents, scientists would like to learn more about the processes that affect the flow of water through a complex network of cracks in the rock structure. In particular, they want to know how water circulating in crack networks extending laterally for tens of meters becomes focused into a few vents just centimeters in diameter.

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In a report published March 20 in the journal Science, Dr. Leonid N. Germanovich -- now at the University of Oklahoma -- and Dr. Robert P. Lowell of Georgia Tech's School of Earth and Atmospheric Sciences suggest that thermal expansion may control the permeability of these rock structures.

"The stress fields exerted by the flow itself -- hot fluids coming up through cold cracks -- exerts forces that tend to close the vertical cracks by thermal expansion of the rock," explained Lowell. "Our research is aimed at estimating what kind of thermoelastic stress would be needed to close enough cracks to focus the flow into a single pathway. It's a start toward trying to understand the complexity of hydrothermal systems in a way that hasn't been done before."

Scientists have theorized that a chemical sealing process restricts the fluid flow. Heated water passing through the rock dissolves chemicals such as silica and sulfides. As the hot water encounters cooler rock near the surface, the chemicals come out of solution and may seal the vents.

The new theory advanced by Germanovich and Lowell offers an alternative to the chemical sealing mechanism, though Lowell believes the two processes probably work together.

Because they were discovered within the last ten years and lie at depths of more than two kilometers, little is known about the hydrothermal vents, known as "black smokers" for the chemicals which color their plumes.

By studying former ridge crests that have been tectonically emplaced on dry land, geologists believe the hydrothermal venting process has existed for a long time. But while the study of these "fossil" records can be helpful, Lowell believes the study of active processes underway on the seafloor is critical to a full understanding.

Lowell's modeling has so far been theoretical, based on a knowledge of the vents' temperatures and flow rates, and how thermoelastic stress affects rock. "The physical laws of nature suggest this sort of thing would happen," Lowell said, "but it is not clear how to do the actual testing of real hydrothermal systems in the field."

In terms of geologic time, the black smokers may be short-lived. Scientists have seen individual vents operating for at least six years, but their tremendous heat output suggests their lifetime is limited.

An average vent may put out more than 100 megawatts of thermal power, substantially more energy than scientists estimate is provided by a single batch of magma. So like a consumer spending more money than he is earning, the vents should eventually run out of energy and shut down until heat is again supplied by a new pulse of magma.

Lowell is also modeling that mechanism -- and studying whether active vents can cycle on and off through the thermoelastic processes.

"As certain parts of the rock are heated up and the cracks closed, the flow is directed somewhere else," he said. "Once you close the crack and stop the flow, the thermoelastic stress is relaxed and the cracks may re-open. You may then get another burst of hot fluid."

As much as 10 percent of the heat leaving the earth's mantle escapes through these hydrothermal vents. "This whole energy transfer system is something we need to understand because it is fundamental to understanding how the earth works as a heat engine," Lowell noted.

As the heated water flows through rock formations under the seafloor, it dissolves a number of chemicals, including calcium sulfate and silica. Complex chemical reactions create carbon dioxide, some of which ultimately enters the atmosphere. Global changes in plate motions may affect seafloor hydrothermal activity and thus the amount of carbon dioxide that enters the atmosphere. Researchers attempting to model climate change on geologic time scales must therefore account for this natural source of carbon dioxide.

Scientists had long believed that the chemistry of the oceans was determined by run-off from the land surface. But they now recognize that dissolved chemicals released by the hydrothermal vents also play an important role in changing the chemistry of the ocean, Lowell noted.

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