Delving deep into the Indian past

For the first time, scientists are raising undisturbed sediments and rock from a multitude of sites at the bottom of the Indian Ocean — a process that is bringing into focus major events in the geologic history of this relatively unexplored body of water. Within these layers of the past, scientists are finding details of phenomena ranging from prehistoric "greenhouse" effects to the origins of the Himalayas.

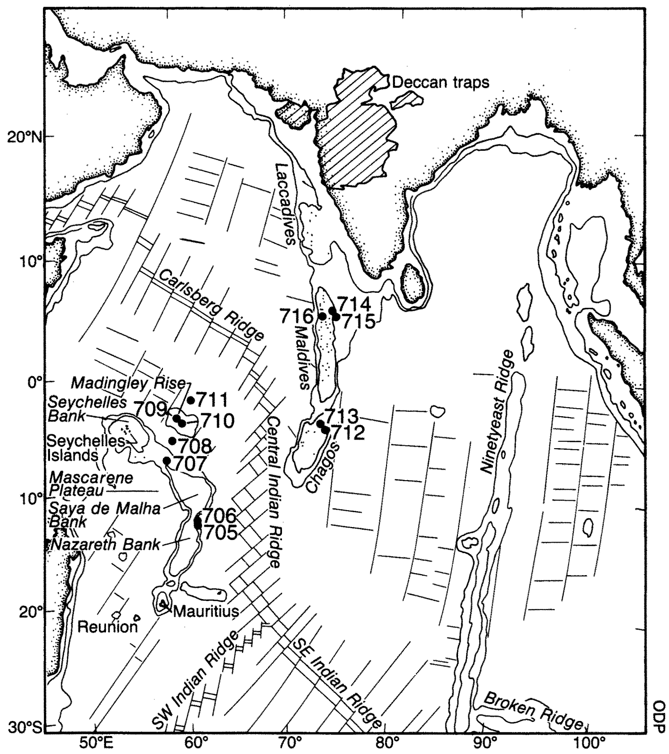
These results are emerging from the multinational Ocean Drilling Project (ODP), which this month completed the first of nine legs devoted to drilling and retrieving core samples at various locations in the Indian Ocean. From the drillship *JOIDES Resolution*, scientists recovered approximately 200 meters of basement rock and almost 3 kilometers of the overlying sediments. "It was a very successful leg," says Chief Scientist Jan Backman from the University of Stockholm, Sweden. "We got all the material we wanted, and we got undisturbed material for the most part."

So far, the preliminary results from Leg 115 have confirmed one theory scientists had sought to test: that the same deep-earth source could have fueled a line of volcanic activity that stretches over 5,000 kilometers across the Indian Ocean. This broken line begins on the west coast of India at the 65-million-year-old volcanic site called the Deccan Traps (SN: 4/18/87, p.249) and extends to the eastern coast of Madagascar, where it is punctuated by Réunion Island, site of the most recent activity along this line.

Scientists believe that this volcanic chain originates from a single plume of magma, called a hotspot, that rises from the lower mantle. According to theory, as the northbound Indian and African plates passed over this hotspot, volcanoes sprouted up, one at a time, to form a volcanic trail similar to the Hawaiian Island chain, which ends at the currently active volcano, Kilauea.

From the Deccan Traps, the hotspot first created the Laccadive-Maldive-Chagos Ridge and later the Mascarene Plateau. Nearly 35 million years ago, this line was split at the Mascarene Plateau by a spreading center that is currently pushing India and Madagascar apart.

Although geologists have had access to the beginning of this line at the Deccan Traps and the current hotspot location at Réunion, they had lacked data from the linking ridges. Leg 115 cored four sites along this line and recovered basement basalts, the rock formed from eruptions. "We've been able to show that the age of the volcanism does get older to the north ... in a way predicted by the hotspot model," says Co-Chief Scientist Robert Duncan from Oregon State University in Corvallis. Duncan expects that future chemical analyses of the basalts should provide additional support for this hotspot theory and will help scientists understand the melting processes of the upper mantle and crust.



Dating from cores confirms that the line of volcanic activity beginning at the Deccan Traps gets progressively younger as it travels south and west through the Maldives, Chagos Ridge, Mascarene Plateau and Réunion. The line was broken 35 million years ago by the mid-ocean ridge where new ocean crust is being formed. Numbers indicate drilling sites on Leg 115.

The hotspot record will also allow scientists to refine reconstructions of how the Indian plate moved during the last 60 million years, says Duncan. Included in this time is the 45-million-year-old collision between India and Asia — a slow but relentless crash that is even today shaping the Himalayas.

Moreover, by reconstructing the position of the hotspot throughout this time period, ODP scientists have measured a phenomenon known as true polar wander, whereby the earth's axis of rotation shifts. Seen in another way, the spin axis of the earth remains fixed while the entire earth shifts as if someone were tugging the tip of Africa in the direction of the South Pole and pulling Alaska in the direction of the North Pole. "What we're finding ... is that there is indeed a component of true polar wander," says Duncan. "In the Indian Ocean, the earth is moving from the south to the north — that is, the ancient latitude of the Réunion hotspot was about 8° farther south than it is today."

Some scientists have yet to be convinced that true polar wander occurs at all. However, this has not stopped speculations about the causes of this proposed massive realignment, which range from meteor impacts to the melting of icecaps.

Another major objective of Leg 115 was to retrieve cores of carbonate oozes, a sediment that blankets about half the floor of the world's oceans. At the ocean surface, one-celled animals and plants produce calcium carbonate that sinks as an ooze to the bottom. Subtle variations in global climate and ocean currents cause changes in the rates of carbonate accumulation, making these sediments a window through which scientists can view the climate of the past.

The rate of carbonate accumulation represents a balance between two opposing forces: production of carbonate at the surface and dissolution at deeper layers. Times of high productivity most likely represent increased levels of nutrients in the surface waters, says Backman. An abundance of nutrients could mean that colder temperatures dominated the equatorial Indian Ocean. Such a climate change, he says, would cause surface waters to sink, forcing up nutrient-rich water from the deep ocean.

The dissolution rate, on the other hand, can serve as a measure of atmospheric carbon dioxide. Scientists have long suspected carbon dioxide of playing a key role in the warming of the global climate, and some measurements indicate that mean global temperatures are on the rise today. In order to determine whether these trends are cyclic or are a by-product of human activity, scientists want to establish how much carbon dioxide circulated in the atmosphere throughout earlier periods of the earth's history and relate these levels to the coincident global temperatures.

Through these carbonate oozes, scientists can address a host of other questions, ranging from the changes in deep-ocean currents to the opening and closing of prehistoric oceans.

— *R. Monastersky*