Ever Downward Beneath the Ocean Deep

This fall in the North Atlantic, the Glomar Challenger will begin the next phase of its ocean drilling odyssey—deep penetration into the crystalline subsedimentary rock

by Jonathan Eberhart

Unlike the water that falls on the dry land, the ocean bottom exists in a constant deluge of silt, sand and ash from the continents and of shells and other remains from the microscopic plants and animals that teem in the waters overhead. The result is a flood—a flood of sediment, millions of tons of it, often thousands of feet deep and in places piled more than two miles above the rocky seabed.

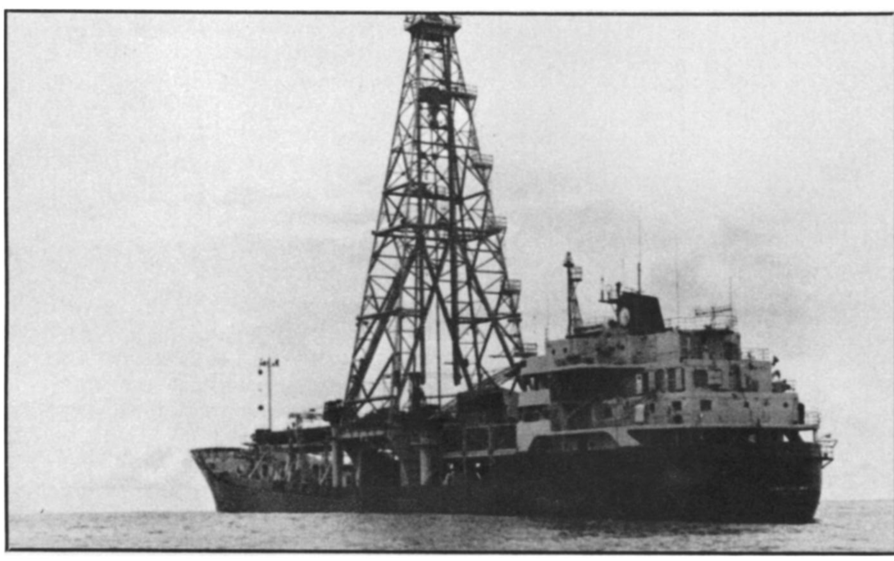
In the flood is a map. More than a map: a diary. Recorded in the accumulated debris of the ages are tales of continent-rending cataclysms, of appearing and disappearing oceans, of potential riches from the bowels of the earth, of life forms unseen on the planet for millions of years. And in the tracings of the past lie clues to understanding of the present, as well as guidance for the future.

Eight years ago, earth scientists decided to try reading the diary. With the signing of a contract between the National Science Foundation (whose budget provides the money) and the University of California (whose Scripps Institution of Oceanography manages the work), the Ocean Sediment Coring Program was established, the major part of which—"about 100 percent," says one official—is the Deep Sea Drilling Project.

Sediments have been the project's main stock in trade ever since its first hole was drilled in the Gulf of Mexico in August of 1968 from the 19-story-high rig atop the ship Glomar Challenger. Less than a year from now, however, the emphasis is scheduled to change, from the overlying sediments to the seabed itself—the solid basalt of the ocean floor.

Hard-rock drilling is nothing new to the Challenger team. It first penetrated basalt only 10 weeks after that initial hole, at a site east of Bermuda, and this year reached a record basalt depth of 1,910 feet. But only a tiny fraction of the more than 500,000 feet that have been drilled were into the solid rock, and even the Bermuda hole penetrated scarcely a third as far as project officials aspire to go.

It is there, in the hard substance of the crystalline oceanic crust, that the Challenger is to send its probing diamond-tipped bit during what is to be known as IPOD—the International Phase of Ocean Drilling. The name reveals little about the changes and additions to the program, since about a third of the more than 400 scientists who have sailed with the Challenger to date have come from foreign countries. IPOD, however, will also have some foreign money. In February 1974, the Soviet Academy of Sciences agreed to provide $1 million a year for five years (slightly under 10 percent of the project's budget) beginning in 1974, as well as to conduct site surveys and assist in laboratory analyses of the recovered samples. In July, the Federal Republic of Germany agreed to provide an additional $1.75 million. Both nations have also joined the JOIDES consortium (Joint Oceanographic Institutions for Deep Earth Sampling) which aids the project's scientific planning.



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The goals of IPOD's hard-rock drilling (sediment drilling will continue, this time emphasizing earth's early climate) are largely to study the origin and evolution of the solid subsea crust. Challenger samples have already gone a long way toward substantiating the theory of plate tectonics. Now the researchers want to look behind (or below) the scenes to see how the lumbering plates of the earth's crust have developed.

A major question, says John Ewing of Lamont-Doherty Geological Observatory, is "how the crust sorts itself out after birth." As new material wells up through mighty splits such as the rift in the Mid-Atlantic Ridge, evidence suggests that it embarks on a gradual outward journey, in the process known as sea-floor spreading. What chemical and physical changes take place as it moves and ages? What kinds of layering and other structure are formed in the process? One of the most exciting possibilities is that geophysicists may be able to extrapolate from their results to gain some understanding of the processes taking place far deeper in the earth—processes which determine, for example, what materials will be melted, blended and thrust upward to replenish the ever-eroding crust.

Even beyond the basic questing nature of science, the potential of IPOD's studies is far reaching, ranging from earthquake prediction to guidance in hunting the mineral riches of the sea floor. One of the early legs of the Glomar Challenger's travels, for example, revealed a 300-meter-thick lay-

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more immediate control measure. Since high moisture levels induce mold growth, the harvesting of drier corn and the better digging and drying of peanuts can help prevent contamination. Corn often is dried mechanically, and small dryer capacity, large harvests and scarce fuel supplies often prevent corn from being dried before it can mold in storage. Leaks in storage bins often re-wet commodities and should be repaired. High-moisture corn varieties can be blended with drier varieties and if done properly, can retard mold growth. The buildup of carbon dioxide during storage can prevent toxin formation, and many feed-lot owners are switching to bins designed for carbon-dioxide buildup.

These prevention measures, though, are applicable mainly to mechanized, technologically advanced agricultural systems and not to the systems of developing nations. "My personal feeling," Hesseltine says, "is that in the long run, the most promising approach to control of mycotoxins is the development of crops with genetic resistance to mold growth and toxin production."

One investigator working on this problem is corn geneticist Marcus S. Zuber of USDA's Agricultural Research Service and the University of Missouri at Columbia. Zuber is screening hybrid corn lines adapted to the cornbelt and "exotic strains" from Central and South America and Africa, hoping to find varieties with natural resistance to mold growth. He is also studying the link between insect damage and mold growth, since fungal spores have to be carried into the kernels through a break or tear in the kernel's outer covering. Kernels with thicker coverings may be more resistant to breaks and tears, Zuber says, so he is testing thick and thin "skinned" corn varieties.

An interesting sideline to the corn research, Zuber says, is the search for a natural toxin inhibitor. It is known that *Aspergillus flavus* will grow on soybeans, but no aflatoxin is formed on that substrate. "The big question is why, and all we have right now are wild guesses. We know that soybeans are high in trypsin inhibitor, but we don't know if this is important." If an inhibitor gene can be found and bred into the genetic complement of corn and other commodities, toxin formation could someday be prevented, regardless of harvesting, storage and processing techniques. This solution would therefore, be the most practical one for developing nations.

The study of mycotoxins, born in 1961, has already amassed an extensive body of information. Complete control of the unwanted contaminants, however, lies years away. □

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er of sediments east of Cape Hatteras that was unexpectedly rich in metals, well mixed into the other sediments. Usually, says Ewing, such metallic deposits are concentrated near the sediment-hard-rock boundary. How did they get mixed in? Answering such questions is likely to require going back to the source—which is just what IPOD is doing.

Drilling into more than a mile of hard rock beneath thousands of yards of sediment and water is an ambitious undertaking. When IPOD gets under way next fall, the Challenger team may find itself spending more than two months at a single hole. The ship may well have to pull up its drill string occasionally, return to port for restocking and go back to the hole again. Fortunately, the project has already developed and successfully applied a technique for relocating and reentering a hole. A more difficult task will be to find improved methods of recording the magnetic orientation of the core samples—which way was north when the core was in the ground? Patterns of magnetism in the rocks are clues to their ages, as well as to the heating and cooling to which they have been subjected. In addition, says Melvin Peterson of Scripps, careful surveying of proposed sites, more accurate positioning of the ship and increased reliability of the drill system will be needed.

Beyond the hard-rock drilling, perhaps four years away, the project's planners hope to tackle an even more ambitious objective: probing the vast accumulations of sediments—possibly more than three miles thick—that lie along the margins of the continents. These continental sediments should preserve detailed records of changing climate and evolving life forms going back to even before the great land masses rose above the waves.

So IPOD is not really changing directions; it is broadening its focus. Seismic velocity spectra, magnetic signatures and other such data are merely tools, not even the answers to the real questions. IPOD, in fact, may well reveal whole new questions to be asked. The first IPOD holes are likely to begin next September in the North Atlantic, probably in the vicinity of the Mid-Atlantic Rift. The Deep Sea Drilling Project sprang from redirection of Project Mohole, a plan to drill into the Mohorovicic Discontinuity between the earth's crust and mantle. IPOD will not get that deep, but it is asking—and answering—some of the same questions. □