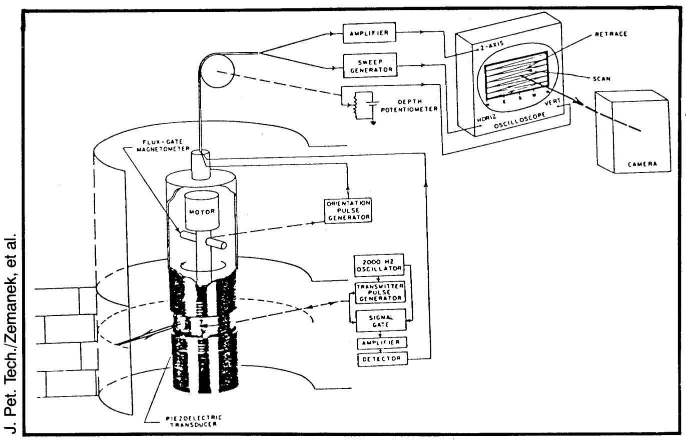
GETTING THE HOLE PICTURE

A new tool gives researchers insight into the ocean crust

BY SUSAN WEST



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Schematic of the Borehole Televiewer in a drill hole. Instrument sends out 1 MHz signal as it rotates in the hole; reflected signal is reproduced on a cathode ray tube as the picture of the hole wall.

Like the blind men who each declared the elephant was a different animal depending on the part they touched, ocean-going geologists have been getting just part of the picture. "Blinded" by the miles of water separating them from their goal, they have been able only to grope at the sea floor with the none too agile arm of a drill pipe. Not to slight the relative miracles wrought by the *Glomar Challenger* during its ten years of deep sea coring, the fact remains that each core recovers at best 30 percent of what it goes after. That gives scientists maybe a tail and a couple of legs from which to describe the whole creature.

Now, a tool first used on the ocean crust in July (SN: 10/6/79, p. 232) promises to improve their vision. With the no-nonsense name of Borehole Televiewer (BHT), the device produces an acoustic picture of the inside of a drill hole. Similar to the technique that produces a "picture" of a fetus in the womb, the ultrasonic BHT gives a black and white interpretation of the sound waves bounced off the ocean crust. Unlike techniques such as seismic reflection profiling, the BHT gives continuous, close-up detail of the crust. It can show the even bedding of sediments, the angle of fractures and the relationship between different types of lavas. Most important for the deep sea geologist, it can flesh out an incomplete core and provide a look at the core's host environment.

Deep sea geologists are second only to oil geologists in their desire and need to get a good picture of what they are drilling. In fact, the BHT was first used in 1966 by Mobil Oil Corp. to find the fractures and gaps in sediments that mean business to the oil industry. Later, Amoco Oil Field Research refined the computer processing system that turns the BHT's chirping signals into pictures. But finding fractures in sandstone is not easy and requires high resolution. Hoping to improve their technique by using a record of the better-defined cracks in ocean crust, Amoco loaned a BHT to the Deep Sea Drilling Project. After two years of persuasion by Roger N. Anderson of Lamont Doherty Geological Observatory and Mark Zoback of the U.S. Geological Survey in Menlo Park, Calif., the BHT was first used by the *Challenger* on the Pacific ocean floor between Ecuador and the Galapagos Islands. Some of the pictures obtained are on these pages.

Resembling a two-headed spear gun of sorts, the BHT is 3⅝ inches in diameter, and about 20 feet long. Bow-shaped gadgets at the top and bottom hold the televiewer in the center of the borehole. After core samples are taken, the BHT is attached to the end of the logging cable and dropped down the hole. As it is pulled up at a rate of .6 meters per minute (meaning one reading can take as many as 12 hours, depending on the depth of the hole), the rotating transducer emits a one megahertz (1 million cycles per second) signal 2,000 times per second. The transducer is keyed to magnetic north, and as it rotates three times each second it gives a north-to-north picture of the 21-inch circumference of the hole. The result is as if the borehole wall were split vertically and laid flat. Both outgoing and incoming signals are sent by the logging cable to a video tape recorder on the ship. The incoming signals build a picture "just like on your TV," says Anderson. A photograph can be made of the "TV" picture and a permanent record can be kept on videotape.

The picture it produces is, in essence, a record of the smoothness of the hole wall. A smooth surface, such as solid sediments, will reflect — produce white lines — better than a rough surface, such as crumbled lava. A hard surface, such as flinty chert, will reflect sound quite well; soft clays or fractures and holes will absorb it.

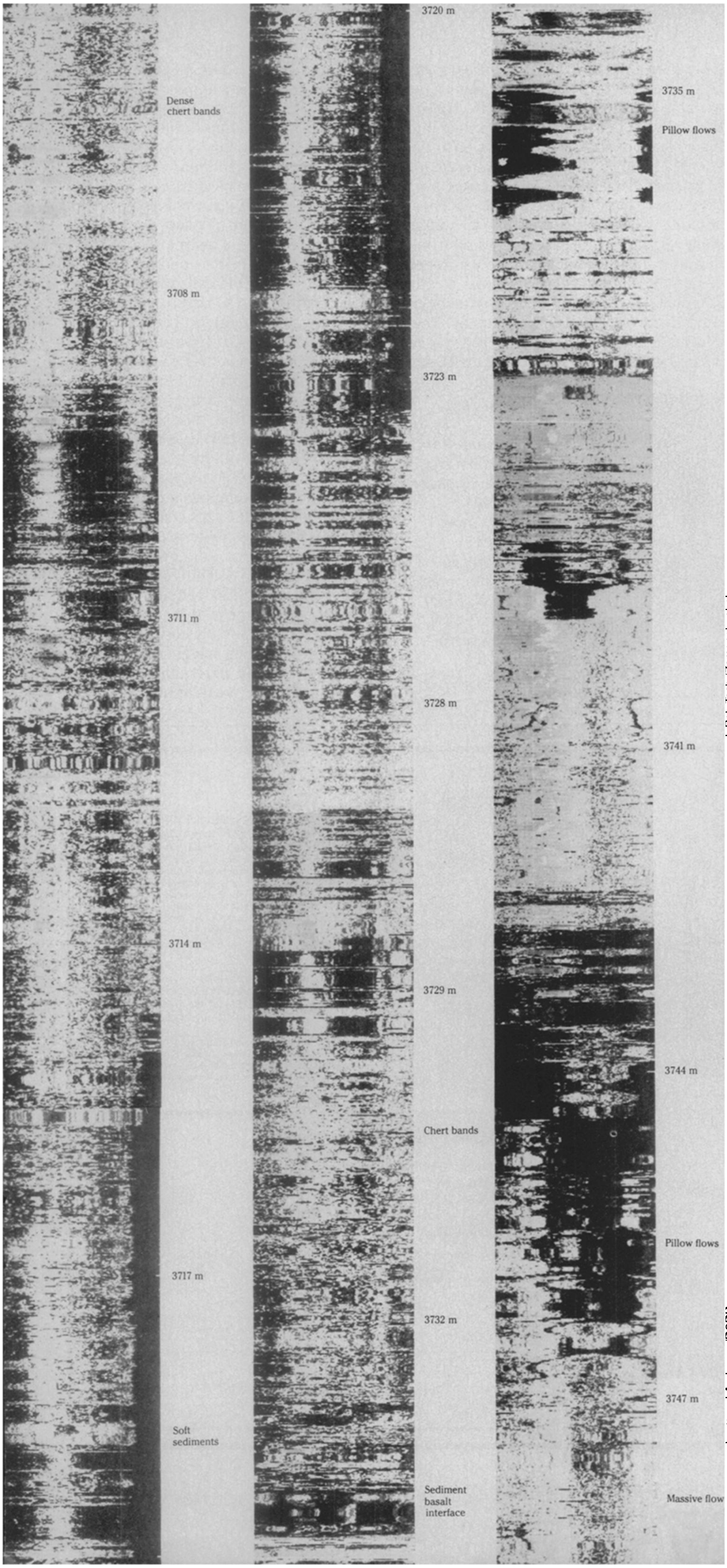
It is these distinctions, the "cracks and voids," says Anderson, that interest the deep sea geologist. A deep sea core is composed of a variety of rocks, each of which tells the researcher something different and each of which has a characteristic look on a BHT picture.

Starting at the top of the core, for instance, are the sediments, which are combinations of clays and chert. Chert, a flinty rock made from sediments under heat and pressure, is distinctive in the BHT image for its even banding and near-solid white reflection. Its origin and the conditions for its formation can be easily studied by comparing the amounts of clay and chert.

Soft and sound-absorbent, the "signature" of clays is a consistent lack of reflection (note the margins of black from 3,715 meters to 3,723 meters). Besides their relation to chert formation, clays reveal something of the water content of the sediments. Water in the ocean crust may control the volcanic activity that occurs when an oceanic plate is pulled beneath a continental plate (SN: 6/16/79, p. 393). But the "magic number," the percent of water that remains in the sediments, is unknown, says Anderson, and the answer cannot be obtained solely from drill cores: Because loose clays disintegrate in water, they are the first to be lost when a core is taken. In the BHT picture, however, the amount of clay is easily distinguishable.

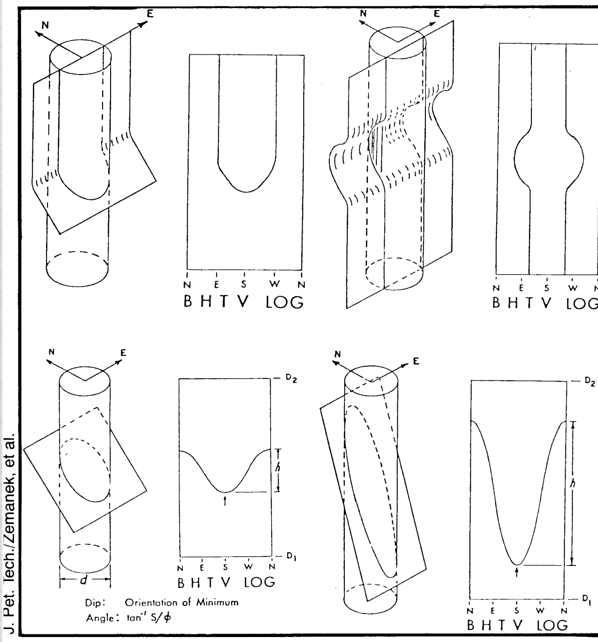
The second major component of a deep sea core is the basalt or volcanic rock. Like clays, the line marking the transition of sediments to basalts is often lost in the vigorous operation of drilling. This zone is important because it usually contains metal sulfides, evidence of hot water alteration of lavas. The accompanying images clearly show that interface, which was not recovered in the core. "At least we have a picture," says Anderson.

Two kinds of lavas make up the basaltic basement rock. When ocean crust is first formed, lava is spewed very rapidly onto the sea floor and forms large sheets called massive flows. As activity slows, the magma forms a bubbly rubble called pillow lavas. To the ear of the BHT, massive flows are solid patches of reflected white,



Zoback and Anderson/DSDP

An acoustic portrait (left) by the Borehole Televiewer of a section of ocean crust between Ecuador and the Galapagos Islands. Taken last July, the picture starts 3,708 meters below the sea surface. The reflected signal — seen as the amount of white — varies with the hardness and smoothness of the rocks. Below, possible fractures in a drill hole and the way they would look to the BHT.



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broken occasionally by the black of a hairline fracture. Pillow lavas show up as rounded or elliptical white patches surrounded by large black voids, which are spaces between the rocks.

The relationship between pillow lavas and massive flows has only recently been discovered, but their relative abundance appears to control the rate of water circulation through the crust. Water circulating in the spaces between the pillow lavas is believed to control the heat flow and ore formation in the sea floor. "The 'plumbing system,'" says Anderson, "is likely controlled by the most permeable areas — the areas where there is a lot of pillow rubble. ... Without [the BHT] we wouldn't know what layers the flows and pillows are in."

The BHT portrait performs its greatest service as one piece, says Anderson; it "puts rocks back in place." Drilling produces samples in hand for analysis, but it often destroys or confuses important relationships that the BHT picture preserves. For example, on the recent Leg 69 of the DSDP (SN: 12/15/79, p. 413), researchers struck a water-tight formation of rock. "We couldn't figure it out with the cores," says Anderson. "But on the camera we found more and more rubble....We couldn't have put it together otherwise."

Future adaptions of the BHT — such as color coding the video image for particular features — may reveal even more. And with that ability, researchers may begin to put together the entire animal. ☐