Ocean drilling: From aging crust to when continents bust

It's been smooth sailing this year for the *JOIDES Resolution* and the Ocean Drilling Program (ODP). After leaving the Bahamas and Leg 101 (SN: 5/11/85, p. 294), the drillship steamed to a site 360 nautical miles north of Puerto Rico for Leg 102, where scientists ran a battery of tests on old oceanic crust from March 21 through April 4. The ship then drilled into the continental margin off the coast of Spain until mid-June for Leg 103. The *Resolution* is currently on Leg 104, probing the rocks beneath the edge of the Norwegian Sea. Scientific highlights of these cruises include:

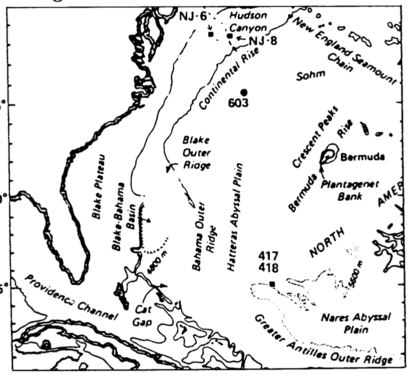
• Leg 102: The shipboard science party made the most complete set of down-hole measurements to date and would have done more experiments had they not run out of time. One notable technological accomplishment was the first *in situ*-oriented measurement of all three components of the magnetic field of crustal rocks.

The scientific aim of the leg was to characterize old oceanic crust, since previous studies have hinted that it may be quite different from its younger counterpart, which has been studied in much greater detail. During Leg 102 scientists reentered hole 418, which was originally drilled eight years ago on the southern edge of the Bermuda Rise, into 110-million-year (Myr)-old crust.

One important finding, confirming earth scientists' earlier suspicions, was that no water circulated through the older crust, says Matthew Salisbury of Dalhousie University in Halifax, Nova Scotia, who was co-chief scientist on the cruise. Previous studies of 6-Myr-old crust at hole 504B in the Pacific showed that seawater moves easily through fractures in younger crust. Salisbury and others think that the low porosity and permeability of the older crust as well as the geochemistry of the borehole water indicate that the fractures and spaces between pillows of lava in the crust have been sealed with clays and carbonates produced in reactions between the lava and seawater.

An interesting next step, scientists say, would be to study middle-aged crust in order to get a better grasp on the alteration process as the crust ages. A good candidate for future drilling is 60-Myr-old crust, since at this age seismic profiles show a marked change in crustal structure.

Seismologists on Leg 102 also did an experiment with the University of Texas sounding ship, the *Fred H. Moore,* in the hope of confirming an observation made previously at hole 504B. At that hole scientists found that sound traveled faster in a direction parallel to the ridge axis than in the direction perpendicular. Ralph Stephen at Woods Hole (Mass.) Oceanographic Institution, who conducted the recent experiment, says that the data have not been processed enough to tie down the velocity pattern at hole 418. Preliminary results indicate that this same "anisotropic" effect may also be present in older crust. But there may be horizontal variations in the crustal structure in addition to or even instead of this anisotropy, so it's too early to tell, he says. Stephen and others think the most likely explanation for anisotropy is that sound slows when it crosses fissures and fractures that lie parallel to the ridge axis.



On Leg 102, scientists studying old crust reopened hole 418 in the western North Atlantic to 868 meters below the seafloor.

• Leg 103: By drilling in the Galicia margin off Spain, scientists on Leg 103 took an important stab at trying to document the rifting process that tore apart Africa and Europe from North America 150 Myr ago as the Atlantic Ocean opened. While more study of the drilled core is needed, shipboard scientists were able to piece together a preliminary time sequence of the rifting events. According to staff scientist Audrey Meyer of Texas A&M University in College Station, the data indicate that about 150 Myr ago there was a shallow sea where the breakup was to occur. About 10 Myr later the continental crust began stretching and thinning. Faults cut through the crust, breaking off blocks at the edge of the continent. At the same time, she says, large amounts of sand and debris from the land piled onto the margin, which began to sink. By 110 Myr ago ocean crust began to appear, and from that time on, the sedimentation and sinking rates slowed.

From previous cruises, which had not drilled as far as the recent cruise, scientists had assumed that rifting took about 10 million years. "Now we've stretched that out to at least 25 million years," says Edward Winterer, co-chief scientist on the leg. Adds Meyer, "This is the first time we've gotten this complete a sequence, through all the sediments that were deposited before and during the event, down to basement rock." The question now, she says, is to what extent the Galicia results apply to other passive margins around the world.

One area of disagreement among the shipboard scientists concerns the interpretation of seismic profiles of the region taken prior to Leg 103. These profiles show a number of continuous deep reflectors (boundaries between different rock layers that reflect sound waves) underlying the margin. Before the cruise, some researchers thought these reflectors marked the transition between brittle and ductile rocks. As a result of drilling, however, "everyone now agrees that the seismic discontinuity [at Galicia] is not the brittle-ductile boundary," says Winterer, of Scripps Institution of Oceanography in La Jolla, Calif. That boundary must lie much deeper, he says. But there still exists strong disagreement over the interpretation of the reflectors. Winterer thinks they are low-angle faults in which the upper rocks have separated from and slid over the lower rock layers. Other scientists believe instead that the reflectors mark the interface between sediments and a carbonate platform.

• Leg 104: Scheduled to end August 11, Leg 104 will explore a different kind of passive margin from that studied during the previous leg. Instead of rifted blocks littering the edge of the continent, Norway's continental margin is underlain by a series of gently dipping reflectors that tilt away from the continent. These dipping reflectors are found under other continental margins, so they may also be fundamentally related to the rifting or seafloor spreading processes. Several models have been suggested to explain the origin of these reflectors but very little is really known about them, since past drilling projects have been limited. None, for example, has succeeded in drilling to the base of these reflectors—a feat targeted for Leg 104.

Scientists on Leg 104 will also probe the sedimentary, geochemical and paleontologic records of the Norwegian-Greenland Sea in order to study the past climate and ocean currents at latitudes neighboring the polar regions.

Meanwhile, the financial course of ODP has changed little. Japan, as expected, signed a memorandum of understanding last month, making it a full member effective October 1 along with Canada, France, West Germany and the United States. The United Kingdom is still trying to navigate through tight funding straits to join the program. (SN: 4/20/85, p. 249). Negotiations continue with both the United Kingdom and a consortium of European countries.

—*S. Weisburd*