Leg 104: Rifting, currents and climate north of the Arctic Circle

One of the more satisfying aspects of the international, cooperative Ocean Drilling Program (SN: 2/2/85, p. 68) is that it sometimes enables scientists to finally get their hands on real pieces of crust after being tantalized by the strange forms that appear in seismic imaging of the otherwise unseen crustal layers. And the most recent Ocean Drilling Program (ODP) excursion — Leg 104 to the Vøring Plateau in the Norwegian Sea — is no exception.

Seismic profiles of the Vøring Plateau had revealed a series of reflectors — lines marking the boundary between layers of different rock types — that dip away from the continent toward the sea. Similar dipping reflectors have been observed at other margins around the world where continents ripped apart, making way for new oceans millions of years ago. For this reason, these reflectors are thought to be key to understanding the rifting and seafloor spreading processes. Many theories have been proposed to explain the origin of the Vøring Plateau reflectors, but these ideas have remained untested, since previous drilling bárely pierced the reflectors.

On Leg 104, which lasted from June 24 to Aug. 12, scientists drilled 1,200 meters beneath the seafloor — straight through the reflectors and into the layers below, producing the longest hard-rock core ever obtained during one leg. Under 315 meters of sediments, they recovered volcanic rocks of Eocene age (approximately 36 million to 56 million years old) that contained 121 separate volcanic flows, 49 layers of debris from volcanic explosions and seven magma dikes.

The researchers found that the dipping reflectors are caused by variations within a thick stack of lava flows in the upper 750 meters of these rocks. According to Elliott Taylor, ODP staff scientist on the cruise and a marine geologist at Texas A&M University in College Station, some of the flows appear to have been extruded above the sea surface while others were produced in very shallow water — all indicating that the region was considerably higher in the Eocene than it is today. Because these rocks also seem to resemble lava flows found in east Greenland, Iceland and elsewhere, the shipboard scientists suspect that they were part of a large surge of volcanic activity that engulfed the entire North Atlantic area about 55 million years ago.

Below the reflectors, the basalts become more glassy and contain much debris from explosive eruptions. Within this debris, "we found fragments of continental crust that have been either ripped out or brought out through the magma chamber," says geochemist Anne LeHuray at Lamont-Doherty Geological Observatory in Palisades, N.Y. Preliminary results indicate that these fragments may be related to the Caledonite Mountains, the extension in northern Europe of the Appalachian chain, she adds.

Taylor and LeHuray both note that the recent findings fail to support any of the theories proposed before Leg 104 to predict and explain the crustal structure of the Vøring Plateau. Some scientists had thought that as the ODP ship, the *JOIDES Resolution*, drilled into the lower section of rocks, it would hit oceanic crust characteristic of seafloor spreading centers. Others predicted encountering continental basement rocks left from rifting. There still may be a thin slice of continental crust beneath the Vøring Plateau, says LeHuray, but if so, it lies much deeper than predicted.

For sedimentologists and other scientists interested in studying climates of the past, Leg 104 also hauled in a treasure of nearly complete sediment cores from three sites. The last time oceanic crust was drilled at such high latitudes, only 30 to 50 percent of the sediment layers were recovered, says sedimentologist Larry Krissek at Ohio State University in Columbus. But with the advanced coring techniques used on Leg 104, scientists got recoveries of 90 to 95 percent without disturbing most of the sediments. "It's an extremely good set of sections," says Krissek. "There were people there who were taking samples every 20 to 30 centimeters, so there's going to be some very detailed work in the future."

While the bulk of the chemical analysis and dating remains to be done, the shipboard party did arrive at a few preliminary conclusions. They found, for example, that the cores are marked by a number of discrete cooling events, which they think are linked to similar cooling periods in Antarctic waters. "People have always thought of the southern oceans as going through these cooling events and the northern oceans as biding their time," says Krissek. "Now it looks like the whole system is better tied together than people thought."

The shipboard scientists also discovered that the onset of major glaciation in the Norwegian Sea occurred 0.5 million years (Myr) before North Atlantic waters to the south were beset by colder climates. Since glacial records for the Arctic Ocean to the north are at least 4 to 6 Myr old, Leg 104 now enables researchers to trace the southward progression of that ice age.

Cores from Leg 104 also provide some clues to past ocean currents. At all three sites, the last 2.5 Myr or so of sediments reflect major glacial and warming cycles. But at Site 644, the spot closest to the Norwegian coast and the southernmost site, this record is embedded with a couple of layers of calcium carbonate mud and oozes. These layers, the scientists believe, come from the increased productivity of ocean organisms that results from the infusion of warm waters. This means that warm North Atlantic currents flowed up into the Norwegian Sea in the past and that these incursions were strongest near the coast — similar to modern-day current patterns, says Krissek.

The preliminary findings for both the sediments and volcanic flows will be published in upcoming issues of NATURE and GEOTIMES. Meanwhile, the *JOIDES Resolution* is on Leg 105 in the Labrador Sea and Baffin Bay between Greenland and Canada, where scientists hope to nail down the timing of the opening and seafloor spreading history of that part of the North Atlantic as well as to study ocean circulation, causes of glaciation and the evolutionary responses of marine organisms to extreme environmental changes. — *S. Weisburd*

Ozone controversy lifts off in Congress

Alan Miller, an environmental lawyer with the Washington, D.C.-based World Resources Institute, might almost have been talking about an impending war: "It's really just an opening skirmish," he said, "in something that's not controversial yet, but that's really going to blow up later." He was referring to the Senate's anticipated ratification of the Vienna Convention, a formal international agreement orchestrated over the past year by the United Nations Environmental Program (UNEP). The agreement, negotiated among 50 countries, calls for international cooperation in studying activities that adversely affect the earth's stratospheric ozone layer.

The underlying issues involve the setting of internationally agreed-upon limits on chlorofluorocarbons (CFCs) — trace gases released into the atmosphere. In the United States CFCs were previously used as aerosol spray propellants and continue to be used as foam-blowing agents and refrigeration system additives. Although worldwide CFC production has been reduced by 21 percent since 1974, according to the Washington, D.C.-based Chemical Manufacturers' Association, worldwide aerosol and nonaerosol uses of CFCs increased by 7 percent from 1982 to 1983.

In the stratosphere, sunlight breaks down CFCs into chlorine atoms, which catalyze a series of reactions that ultimately destroys ozone. A group of countries, including the United States, Canada, Finland, Norway and Sweden, has already reduced CFC emissions, and has advocated that all European countries, the Soviet Union and Japan cut back on nonessential uses of aerosols. A counterproposal from the Common Market countries would essentially limit the opening of