Ocean Drilling Program
Public Information
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Fire and Ice: Scientists Seek Secrets of North Atlantic

ODP Leg 152

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College Station, Texas — Scientists aboard the Ocean Drilling Program's drill ship, the JOIDES Resolution, have discovered pieces to two separate puzzles in the North Atlantic–the timing of glaciation, and the infancy of the ancient ocean crust. The ship recovered large volumes of ancient lavas, which represented catastrophic eruptions during the birth of the North Atlantic. Our scientists found a surprise in the overlying sediments–7-million-year-old evidence of glaciation. This dates the onset of glaciation in the North Atlantic to millions of years earlier than previously thought. The scientists also discovered that cold bottom water currents ran along the ocean floor of this region long before ice sheets formed. These findings may change current scientific thinking on the onset of northern hemisphere glaciation, the relationship between glaciation ocean circulation, and the processes of climate change.

The JOIDES Resolution just completed a 2-month expedition, Ocean Drilling Program (ODP) Leg 152, off the southeast coast of Greenland, drilling a series of 13 holes at six sites to sample basalts (volcanic rocks) formed during the birth of the North Atlantic Ocean. The goal–to sample the oldest crust formed in the ocean's infancy–would help scientists understand how continents break asunder and drift apart, creating deep oceans. The sediments above the basalt document the later

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geological evolution of the area and provide an excellent record of glacial advances and retreats.

Nature did not yield her secrets willingly; extreme environmental conditions threatened the vessel. Severe Arctic storms with winds as high as 80 knots buffeted the ship as it dodged drifting icebergs. Low wind chills generated by the storms literally stripped the paint off the ship.

Initiation of Northern Hemisphere Glaciation

ODP scientists found marine evidence of continental glaciation in the North Atlantic in 7-million-year-old sands and clay. Previous evidence suggested a 2.5 million-year-age for the onset of widespread glaciation in the northern hemisphere, and geological findings in Iceland suggest the presence of continental glaciers 3 million years ago. The 7 million-year-old sediments contain dropstones, pieces of rock too large and heavy to be carried to the deep ocean by wind or ocean currents. They are eroded by and caught up in glacial ice. When the glacier spills into the sea, the dropstones drift out in icebergs. When the icebergs melt, the rocks drop to the bottom of the ocean, leaving a calling card of the iceberg's passing. Their presence in these deep ocean sediments indicates that southeastern Greenland must have been covered with ice about 7 million years ago. Southern Greenland may have developed ice before other portions of the North Atlantic because its highly mountainous terrain would have caught snow more effectively than lower elevations.

Sediments from the last 7 million years record a history of ice sheet advance and retreat. The climatic changes reflected in this record may help us to understand and predict climatic changes such as global warming or cooling.

Another finding questions current thinking about the relationship between glaciation and ocean circulation. Many scientists assumed a link between glaciation and the formation of currents on the ocean bottom. Scientists on ODP Leg 152, however, discovered evidence that a cold bottom-water current ran along the ocean floor of this region 6 million years before ice sheets formed. They recovered hard, rocklike surfaces, called hardgrounds, which were swept by ocean currents much as a broom sweeps a hard-packed dirt floor. The strongest development of these hardgrounds dates between 11 to 13 million years ago, long before the 7-million-year date of ice-sheet development.

Formation of Ocean Crust

Approximately 55 million years ago, Greenland and Europe were still connected; a narrow basin or depression may have existed where the Atlantic was about to open. Evidence was found below the oldest ocean lavas of sediments deposited in fairly deep water within this early basin. Surprisingly, shortly after the deposition of these sediments, the area began to be uplifted, the continental plate split apart, and large volumes of magma poured out onto dry land. The vessel drilled through 780 meters of these lavas, which had poured onto the edge of the Greenland continent with huge, catastrophic eruptions as frequent as one every thousand years. Farther offshore, where the lavas are 6 kilometers thick, the Joides Resolution drilled the upper 120 meters of these volcanic rocks. The volumes and eruption rates at the time of formation must have provided a tremendous spectacle. The lavas erupted some three to five times faster than on Iceland today. Nowhere, at the present time, do we see such activity.

The cause of the voluminous volcanic activity is probably linked with Iceland's evolution. Iceland owes its existence to a powerful thermal anomaly, or hotspot in the underlying mantle. This provides heat and material for the volcanism on the island. Fifty-five million years ago, that hotspot was trapped beneath the thick Greenland-European continent and developed a large thermal anomaly–perhaps as much as 2000 km across–beneath the continental lid. As the continent split, the hot mantle rose and melted to produce large quantities of magma. As the Greenland plate moved west, it left behind the volcanic rift zone. The margin subsided and the initial volcanic rift zone studied at Leg 152 evolved into the present day mid-Atlantic Ridge.

The southeast margin of the Greenland continent affords an excellent opportunity to study continental rifting and break-up. For several years, geologists from many nations have investigated the structure of the North Atlantic margins, mainly by ship-based geophysical studies. Deep sea drilling has also been heavily involved in these studies, although previous drilling concentrated on the European side. Leg 152 focused on the Greenland margin, where they penatrated the continental rocks below the old ocean floor lavas for the first time.

ODP Leg 152

ODP Leg 152, the 52nd expedition of the Ocean Drilling Program left Reykjavik, Iceland on September 28, 1993. The ship docked in St. John's, Newfoundland on Monday, November 22, 1993. Co-chief scientists Hans Christian Larsen of the Geological Survey of Greenland, Copenhagen, Denmark and Andrew D. Saunders, of the University of Leicester, United Kingdom led the expedition. Peter D. Clift of Texas A&M University sailed as staff scientist from the Ocean Drilling Program. The remainder of the scientific party follows:

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JOIDES Resolution and the Ocean Drilling Program

JOIDES Resolution is the research vessel for the ODP, which is funded by the U.S. National Science Foundation, Canada, Australia, the European Science Foundation Consortium, Germany, France, Japan, and the United Kingdom.

Texas A&M University, science operator, operates and staffs the drill ship and retrieves cores from strategic sites around the world. Lamont-Doherty Earth Observatory of Columbia University is responsible for downhole logging.

Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES), an international group of scientists, provides scientific planning and program advice. Joint Oceanographic Institutions, Inc., a nonprofit consortium of 10 major U.S. oceanographic institutions, manages the program.

Note: U.S. members of JOIDES are: University of California at San Diego, Columbia University; University of Hawaii, University of Miami; Oregon State University; University of Rhode Island, Texas A&M University, University of Texas at Austin; University of Washington, and Woods Hole Oceanographic Institution.

The European Science Foundation Consortium consists of Belgium, Denmark, Finland, Iceland, Italy, Greece, The Netherlands, Norway, Spain, Sweden, Switzerland and Turkey.