Leg 149

July 9, 1993 COLLEGE STATION, TX -- An international team of scientists discovered the western edge of the European continent where present-day Portugal and Spain broke away from the North American continent.

On board the drill ship *JOIDES Resolution*, operated by Texas A&M University, the scientists looked at the processes that led to the breakup of tectonic plates and subsequent formation of the Atlantic Ocean.

A giant continent called Pangea began to sunder more than 200 million years ago. As it ripped apart, what is now the North American continent floated west on one huge tectonic plate, pulling away from the European continent to the east. Between the two land masses, molten lava welled up in a spreading center to form a new ocean floor. A spreading center in the middle of the Atlantic Ocean continues to separate these two land masses, which are still inching apart at about the same rate that fingernails grow.

During this 49th cruise of the Ocean Drilling Program (ODP), scientists discovered a wide zone of Earth's mantle that was exposed on the seafloor and the recovery of the second oldest rocks during the program's nine-year history. The Jurassic Period rocks were 150 million years old, concurrent with the rifting process that tore Europe and North America apart and during the time dinosaurs dominated Earth.

The ancient continental edge of the Iberian Peninsula now lies 5,000 meters beneath the sea surface and more than 150 miles out in the Atlantic. The scientists found that when the Iberian peninsula separated from the Grand Banks of Newfoundland, the intervening continental crust stretched and thinned like taffy before breaking apart. At the breaking point, upper mantle rocks, which normally are found more than 30 kilometers (19 miles) below Earth's surface, were uplifted and exposed on the seafloor over a region at least 19 kilometers (12 miles) wide. The width of the region of exposed mantle rocks surprised the scientists. They had originally surmised that a single ridge of

mantle rocks marked the boundary between continental and oceanic crust. They now believe a series of ridges created by a complicated sequence of faulting, extension and upheaval of crustal blocks make up the continental edge. Today hundreds of meters of sediment bury these dense greenish mantle rocks rich in iron and magnesium.

As the two future continental margins slowly moved apart, the faults became more extensive, causing the continental crust to stretch and thin. This led to the formation of deep troughs that filled with sediment (now the source of the oil and gas found beneath the Grand Banks).

Scientists hope that by studying the recovered rocks, they may be able to explain how the continental crust off Spain and Portugal has thinned to such an extent that the mantle rocks below the crust became exposed on the seafloor. The study of crustal thinning and the concurrent mechanisms of faulting interest investigators because these processes address fundamental questions on how Earth's plates originate, break and drift apart. Scientists can compare the continental breakup and new ocean formation with other regions where this is currently taking place, such as the Gulf of California or the Red Sea. These processes can also lead to new insights in the search for natural resources.

This expedition was the first in a series of drilling cruises to investigate the processes that accompanied the breakup of the supercontinent, Pangea, and formed the North Atlantic Ocean. Ongoing investigations at sea by American, British, Canadian, French and German scientists will identify sites for deeper holes on the Portuguese and Canadian margins for future drilling in the mid-1990s. These multinational, integrated geological investigations should help scientists better understand two key elements in the plate tectonics puzzle: the breakup of continents and the formation of new oceans.

"This cruise marks our return to the Atlantic Ocean after seven years of scientific exploration in the Pacific," said Dr. Philip D. Rabinowitz, director of the ODP. "We will be studying how a variety of factors such as plate tectonics as well as human activity affect changes in global climate, sea level and ocean

circulation."

JOIDES Resolution is the research vessel for the ODP, which is funded by the United States National Science Foundation, Canada and 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 Geological 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, a nonprofit consortium of 10 major U.S. oceanographic institutions, manages the program.

Note: JOIDES members 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; Canada and Australia Consortium; European Science Foundation Consortium(Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland and Turkey); Germany; France; Japan; and the United Kingdom.

Participants of Leg 149 were: Co-chief scientists Dale S. Sawyer, Rice University, Houston, Texas, and Robert B. Whitmarsh, Institute of Oceanographic Sciences, Wormley, Surrey, United Kingdom; Adam Klaus, staff scientist, Texas A&M University, College Station; Marie-Odile Anne Beslier, Laboratoire Geodynamique Sous-Marine-CNRS, Villefranche-sur Mer, France; Guy Cornen, Universite Nantes, France; Eric S. Collins, Dalhousie University, Halifax, Nova Scotia, Canada; Maria C. Comas, University of Granada, Spain; Elisabeth Gervais, INTERGEOS, Leiderdorp, The Netherlands; Ian Gibson, University of Waterloo, Ontario, Canada; Dennis L. Harry, Rice University; Eric de Kaenel, Florida State University, Tallahassee; Toshiya Kanamatsu, University of Tokyo, Japan; Charlotte M. Krawczyk, GEOMAR, Kiel, Germany; Li Liu, Florida State University,

Tallahassee; Kathleen M. Marsaglia, University of Texas at El Paso; Philip A. Meyers, University of Michigan, Ann Arbor; Doris Milkert, Geologisch Palaontologisches Institut und Museum, Kiel, Germany; Kitty Lou Milliken, University of Texas at Austin; Julia K. Morgan, Comell University, Ithaca, N.Y.; Luis de Menezes Pinheiro, Universidade de Aveiro, Portugal; Pedro Ramirez, California State University, Los Angeles; Karl E. Seifert, Iowa State University, Ames; Timothy Shaw, University of Maryland, Solomons, Md.; Chris Wilson, Open University, Milton Keynes, United Kingdom; Xixi Zhao, University of Califomia, Santa Cruz.