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SCIENTISTS RECONSTRUCT SEA LEVEL CHANGE AND THE LINKS TO GLACIERS, CLIMATE, AND OIL AND GAS DEPOSITS

For more than 35 million years, the waxing and waning of polar ice sheets is thought to have caused alternate falls and rises of sea level of as much as several hundred feet, and in places, shifts in coastlines by hundreds of miles. In recent geological times, the end of the last Ice Age saw the melting of vast glaciers across north America, and between 19,000 and 6,000 years ago a rise in sea level of about 400 feet to its present position.

The Ocean Drilling Program will begin an expedition on June 21 to collect sediment and rock samples below the ocean floor about 80 miles east of Atlantic City, New Jersey. Scientists will drill several holes as much as half a mile deep at two sites near the edge of the continental shelf, in 270 feet water depth, to investigate the timing and magnitude of the sea-level changes and how these may be related to the waxing and waning of ice sheets over the past 25 million years.

Co-Chief Scientist Nicholas Christie-Blick of Columbia University's Lamont- Doherty Earth Observatory in Palisades, New York explains, "The Earth has written its autobiography in the sediments. Changes in sea level provide some of the chapter headings, natural breaks in the sedimentary record that define the boundaries between the observed sedimentary wedges."

The scientific party, members from seven countries, plans to extract more than two miles of long, thin plugs or cores -- each 2 1/4 inches wide and 30 feet in length -- from an immense pile of sediments that accumulated on the ocean floor over millions of years of geological time. The sediments have been shaped into a series of large, seaward-inclined wedges, now buried beneath the modern shelf. This pattern has been recognized using geophysical data from a number of locations around the world, and reflects the gradual outbuilding of the shelf and the alternate rise and fall of sea level.

By analyzing the sedimentary layers, the scientists seek to document the precise timing and scale of the sea-level changes. They hypothesize that the changes are due largely to the advance and retreat of continent-sized ice sheets, which for millions of years have periodically stored large amounts of water during times of cold climate, and then released the water to the oceans during times of comparative warmth. Earth scientists estimate that global sea level has ranged up and down by several tens to hundreds of feet over this part of Earth history, but the details have remained uncertain. This expedition will provide important new information that will fill in some of the gaps in existing knowledge.

After one team of scientists has retrieved cores from the drill hole in the sea floor, another team will insert instruments suspended by a wireline to make inch-by-inch measurements, or "logs," of rock properties that will help to interpret their geologic history. New technology, called logging-while-

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drilling, will also allow scientists to drill and log simultaneously. This technology will improve the quality of logging data that can be obtained in unstable holes through loose sediment.

Four years ago, the JOIDES Resolution drilled cores in the same region but farther seaward on the continental slope, where the sea floor drops more steeply than the shelf into the deep ocean. That expedition was led by Gregory Mountain of Lamont-Doherty and Kenneth Miller of Rutgers University and Lamont-Doherty. In the same year, Miller led a project, funded by the United States Geological Survey and the National Science Foundation, to obtain cores from boreholes drilled onshore at Island Beach, Atlantic City and Cape May. By integrating sediment samples from onshore, the slope and now the shelf, the scientists hope to develop a long-term record of sea-level change, using optimum sites across the continental margin for documenting different segments of the record.

The New Jersey margin is ideally suited for tracking Earth's sea-level history. Unlike some continental edges, the crust beneath New Jersey has been relatively stable for tens of millions of years. So it's a good place for geologists to measure when and by how much sea level has gone up and down. In contrast, continental edges around the Pacific rim, for example, are subject to local vertical motions that make it difficult to monitor the independent effects of sea-level change. The New Jersey drilling is nevertheless only the first step in the research.

"Drilling, sampling, and logging operations offshore New Jersey are just the beginning of what we hope to do to study sea-level changes along stable continental shelves around the world," commented co-chief scientist James A. Austin Jr. of the Institute for Geophysics at the University of Texas in Austin.

The location will provide some unique technical challenges for a floating drilling platform. It marks the first attempt by the Ocean Drilling Program in more than 25 years to sample a thickly sedimented continental margin in water less than 450 feet deep. In such settings, the drill pipe is susceptible to getting stuck in loose, sandy sediments, and even small vertical and sideways motions of the ship can place a lot more strain on the drilling equipment than is normally the case in deeper water. "We'll be pushing the engineers right to the edge of what is possible," Dr. Christie-Blick said.

What are the implications of the drilling for human time scales? Christie-Blick and Austin insist that the New Jersey project is aimed primarily at the longer-term geological record of sea-level change rather than the hazard to coastal communities of short-term sea-level rise. However, what is being learned from the sediments reinforces the idea of a strong connection between the behavior of the modern Antarctic and Greenland ice sheets and the position of shorelines many thousands of miles away. The geology shows that shoreline location is inherently ephemeral. In addition, by indirectly monitoring the growth and decay of polar ice sheets over millions of years, the drilling will provide a baseline for Earth's changing climate prior to the appearance on Earth of human beings. This is important for understanding just how human activity is influencing the environment today.

After completing the expedition on July 19, The JOIDES Resolution, the world's only deep-sea drilling ship for oceanographic research, will sail into New York Harbor and dock at Pier 92, on the West Side of Manhattan near 48th Street.

The JOIDES Resolution is named after Captain James Cook's ship, the HMS Resolution, which sailed two centuries ago. Unlike Cook's ship, it is equipped from top to bottom with laboratories, including ones for downhole measurements; core handling, sampling, and description; physical properties; paleomagnetism; paleontology; thin-section preparation; chemistry; X-ray analysis; and photography. Cores are stored in refrigerators in the lower two levels. It is also possible to make

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geophysical measurements while the ship is moving between drilling locations. Advanced computing equipment is available to aid the seagoing scientists in capturing and processing data electronically. The ship's complement includes about 28 scientists, 30 engineers and technicians, and a crew (including drilling personnel) of 62.

The Ocean Drilling Program, an international partnership of scientific institutions and governments, explores the history and evolution of Earth's crust. The Ocean Drilling Program is funded principally by the National Science Foundation, with substantial contributions from its international partners. These include the Federal Republic of Germany, France, Japan, and the United Kingdom. Australia, Canada, Chinese Taipei, and Korea hold a joint partnership. Another partner is the European Science Foundation, consisting of Belgium, Denmark, Finland, Iceland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and Turkey. The program is managed by Joint Oceanographic Institutions, a consortium of 10 U.S. institutions, with Texas A&M University responsible for science operations. Lamont-Doherty Earth Observatory is the operator for downhole logging.

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