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Scientists report results from Chicxulub crater impact located in the Caribbean Sea

February 1996 SAN JUAN, Puerto Rico -- Departing from Miami a few days before Christmas, the Ocean Drilling Program's research vessel JOIDES Resolution set out to the Caribbean Sea on a two-month expedition in order to gather new evidence on one of the greatest known catastrophes in the history of the Earth: the meteorite impact that caused the extinction of the dinosaurs and many other life forms 65 million years ago. The global effects of this impact were so severe that it closed one chapter in Earth history (the Cretaceous), and opened up another (the Tertiary). Recent studies show that the meteorite impact occurred on the north end of the Yucatan Peninsula in Mexico, creating the 180 km wide Chicxulub crater, which is now deeply buried under younger sedimentary rocks. By drilling deep into the ocean floor in the Caribbean Sea, scientists on this expedition have extracted valuable materials thrown out of the Chicxulub crater at the time of the great impact. These samples were recovered in three drill cores, one from a kilometer deep drill hole north of Colombia and two from half-kilometer deep drill holes near Jamaica. These samples show that the meteorite impact deposited a layer up to 20 cm thick in this region of the Caribbean, at a distance of over one thousand kilometers from the Chicxulub crater. The lowermost part of the drill-core samples recovered in the Caribbean consists mainly of altered glass spheres or tektites. These glasses were formed when the explosive collision of the meteorite with the Earth generated very high temperatures that melted the crustal rocks in the Yucatan Peninsula. The molten rock was ejected as fine droplets of hot liquid high into the atmosphere, where the droplets quickly cooled to form glass beads before falling to the Earth's surface. The altered glass beads discovered by drilling into the ocean floor of Caribbean are several millimeters in diameter. Overlying this layer is a bed of clay that contains grains of shocked quartz crystals. The quartz is referred to as "shocked" because the structure in these crystals can only be formed by the enormous

pressures generated by the high velocity impact of a meteorite with the Earth. The quartz and other mineral fragments in the upper layer are thus from material ejected from the Chicxulub crater in Mexico. The shocked quartz grains were a part of a huge, dark dust cloud that enveloped the Earth for some time after the impact. It is likely that this dust cloud, as well as a fine sulfate aerosol cloud in the Earth's stratosphere, brought about profound darkness and rapid cooling of the Earth in the wake of the impact. Shore-based laboratory studies of these valuable samples will contribute further to an understanding of the link between the great meteorite impact and the sudden extinction of the dinosaurs. Central American Volcanism A totally unexpected discovery on this expedition was that great explosive volcanic eruptions in Central America have repeatedly spread volcanic ash over the entire Caribbean in the past. The evidence from the new drill cores extracted from the ocean floor shows that thousands of volcanic ash layers occur in the Caribbean sediments, with some individual layers up to 35 centimeters (14 inches) in thickness. These ash layers indicate that Central American volcanic activity was particularly severe during two periods in the geologic record, about 34 and 19 million years ago. The sources of these volcanic ash layers lie over a thousand kilometers to the west, in the ancient volcanoes of Guatemala, El Salvador, Nicaragua, and Honduras, from which the Mayans quarried volcanic rocks to build the great pyramid at Coban. The majority of these volcanic eruptions are larger than any historical volcanic event and it is probable that they caused climate change. The great volume of dust and sulfate aerosols introduced into the stratosphere by explosive eruptions of this scale would produce a veil that decreases the amount of solar radiation reaching the Earth's surface, bringing about the cooling of the Earth. The new findings show that explosive volcanism in this region is highly episodic, with very vigorous periods followed by millions of years of dormancy. Scientists are at a loss to account for this phenomenon, which may be linked to the rates of motion of crustal plates beneath the Pacific Ocean. The Foundation Beneath the Caribbean The Caribbean Oceanic Plateau is the foundation of a great crustal plate of uncertain origin, which lies hidden beneath the sediments on the Caribbean floor. By drilling into this crustal plate on this expedition,

scientists have discovered that the upper part of the plateau consists of a thick pile of submarine basaltic lava flows that were erupted onto the ocean floor about 77 million years ago. These eruptions produced great sheet-flows of hot magma, which spread rapidly along the Caribbean ocean floor over great distances. They have furthermore discovered that these volcanoes, which had been constructed on top of the plate, and are currently 3.5 kilometers below sea level, reached up into shallow water when they were active. The evidence of 75 million year old volcanic sand layers containing fossils of relatively shallow water origin indicates that some of these volcanoes may have formed islands. A study of the magnetic properties of the basalt lavas indicates that the Caribbean Oceanic Plateau may have been located at a more southerly latitude when the submarine volcanoes were active. These findings are consistent with the idea that this crustal plate was originally formed in the Pacific and that it has subsequently drifted northeastward to its current position between North and South America. Ancient Global Warming, An Analogy to Today? With evidence mounting for global warming, scientists have been probing the Earth's geologic record for past events that might help us to understand the effects of rapid climatic changes. During the last few years, geologists have found evidence in sediment cored from the deep ocean basins for dramatic global warming, about 55 million years ago. This warming was coincident with massive extinction of microscopic organisms living on the sea floor; the most devastating event to strike these microorganisms in the past 100 million years. Chemicals locked up in the shells of these organisms indicate that ocean temperatures close to the poles, and in the usually frigid deepest waters of the ocean, rose by an astounding 15 degrees over a span of 5 to 10 thousand years. This is one of the most significant warming events in Earth's history. Warm water holds less oxygen than does cool water, and so, a warmer ocean should be poorer in oxygen. Like humans, most microscopic organisms require a certain level of oxygen. When the rapid warming occurred 55 million years ago, it reduced the oxygen level in the deep oceans, causing many inhabitants to literally asphyxiate. One of the main problems facing scientists that study this warming event is that it was so brief that it is rarely preserved in the geologic record. In fact, it

had previously been found in only five deep sea cores. During the expedition, striking records of the dramatic warming episode were brought up from the Caribbean's depths at two sites, one just north of Colombia and the other south of Haiti. The finely layered sediments show, for the first time, direct evidence of oxygen poor oceans. Sediments which are deposited under well-oxygenated conditions are continuously stirred up by worms and other deep-dwelling organisms. However, few organisms can live in stagnant conditions and the structures in the sediments are preserved. At the two Caribbean sites, scientists observed fine layering in the sediments, indicating that deep-dwelling organisms either temporarily inhabited other areas, or in many cases became extinct. Clues to Recent Climate Change Drilling in the Caribbean has brought back a rich record of evolution, extinction, and rapid changes in the ancient ocean. Dramatic changes in ocean circulation and in the distribution of heat and salt on the planet have their origins in the Caribbean. The rising of the Isthmus of Panama and the closing of a tropical ocean gateway between Êibbean and the Pacific occurred in step-like fashion between 12 and 3 million years ago. The ice age world of the recent past, and the modern patterns of ocean and atmospheric circulation became established during this time.

Bridging the gap between ancient and modern climate is a quarter million year record of tropical climate change preserved in Cariaco Basin on the northern margin of Venezuela. Cariaco Basin is the largest open ocean example today of anoxic, or totally oxygen-free, conditions. Here, the stagnant waters and rapid accumulation of sediments result in a record of past climate and oceanic conditions of almost unparalleled resolution. Scientists expect the Cariaco Basin sediments recovered to produce an important record of how tropical climate has varied on time scales of 10's to 1000's of years over the recent geologic past. This will allow for the first time a direct comparison of tropical and polar climate change over the past 250,000 years. The Cariaco Basin will also be studied as an analog for how anoxic conditions in more ancient oceans may have contributed to the formation of petroleum source rocks. The Ocean Drilling Program is funded by the U.S. National Science Foundation, Canada, Australia, the European Science Foundation Consortium, Germany, France, Japan, and the United

Kingdom to investigate such topics as earth's history and evolution, climate change, and formation of the ocean crust. 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. Texas A&M University, science operator, operates and staffs the drill ship that retrieves core samples from strategic sites in the world's oceans. Lamont-Doherty Earth Observatory of Columbia University is responsible for downhole logging. 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, the Netherlands, Norway, Spain, Sweden, Switzerland, and Turkey.