Leg 146

January 6, 1993 COLLEGE STATION, TX -- Thirty scientists drilling through sediments to study fluid flow off the coast of Canada believe they have obtained evidence of critical factors that could affect major shifts in the global climate. They also have correlated a particular kind of seismic profile with vast reserves of natural gas in an ice-like form. From subsequent studies they hope to have a better handle on these "methane hydrates"- their stability, quantity and location.

The scientists from 10 nations representing the internationally funded Ocean Drilling Program were on board the research vessel *JOIDES Resolution*. They drilled into sites where thriving communities of clams, worms and other creatures sustain life from the warm sulfide-rich waters rather than the energy from sunlight that all other plants and animals depend on. The same processes governing these fluids also produce vast reserves of methane hydrate. Methane hydrate not only serves as a potentially vast source of natural gas, but could also be one of the most critical contributors to global climate shifts manifested in glacial periods and atmospheric warming.

The samples were obtained from an accretionary prism, a site where the small Juan de Fuca tectonic plate is being pushed underneath the North American Plate. As the Juan de Fuca plate plows under, the western edge of the North American continent acts like a gigantic bulldozer, scraping off kilometers of the plate's sediment cap. The tremendous forces deform the sediments and rocks, squeezing dissolved chemicals out of their layers. The sediment layers break, tilt and slide past each other, forming faults. During the process, organic materials in the sediment are first converted to methane (natural gas) and then cooked to the same hydrocarbons we find in petroleum.

Instead of bubbling up through the sediments as gas, methane reaches a depth where the temperature in the sediments and pressure from the overlying seawater cause methane to freeze with seawater and produce methane hydrate, a white, ice-like substance.

Layers of methane hydrate are believed to be represented in bottom simulating reflectors, seismic profiles that parallel the outline of the sea bottom regardless of the intervening jumble resulting from the crust's faulting and folding. This kind of reflector is found along the oceanic margins of many of Earth's continents, and methane hydrate layers appear to always be associated with this kind of seismic profile. Scientists have inferred that where bottom-simulating reflectors appear in conjunction with oceanic margins, a layer of methane hydrate exists, potentially making these sites some of the largest sources of natural gas in the world.

Methane hydrate is also a powerful "greenhouse" gas, trapping the sun's heat even more effectively than carbon dioxide. If the oceans were to warm, the heat could potentially melt some of the hydrate layer and release the methane, which would produce a chain reaction of global warming.

The scientists found that how the chemical-rich water and the natural gas were released depended on how much the sediments were faulted. Off Vancouver Island, where the faults are less well developed, the water and methane were found to diffuse gradually through the layers of sediment. The scientists found that the bottom of the hydrate layer was not at the depth they expected and that there were small quantities of "free" methane gas below the hydrate, both reasons to go back and rethink the theoretical models for hydrate that were based on laboratory experiments.

Equally surprising was chemical evidence that in the past hydrates existed below the present-day base of the hydrate layer. The hydrate layer could have extended deeper if the sea had been colder, as was the case during the ice age. The chemical signature of melted hydrate can tell us how much the oceans have warmed since the last ice age, raising the question of whether melting hydrate occurred because the ice age was ending or whether it contributed to a "greenhouse effect," which helped make the earth warmer.

South of the Oregon margin, scientists drilled at places where faults were known to be well developed. A camera survey of the sea bottom showed clam colonies near where the faults were known to come to the surface. And drilling confirmed that the chemical-rich water was being channeled up the conduits formed by the faults.

Methane also moves up the faults, and produces hydrate. Scientists found evidence of methane hydrate in the cores. The hydrogen sulfide, and the petroleum type of hydrocarbons that were also found in small quantities in the cores, are evidence that fluids and gases are being squeezed out from the deepest, hottest parts of the sediment layers.

The scientists came away from their drilling near Vancouver Island and Oregon with a much better idea of how and from where water and gas are squeezed out of the off-scraped sediments. They have confirmed that bottom-simulating reflectors indicate layers of methane hydrate, but they must now rethink theoretical models of the conditions under which hydrate is stable. They also have first-hand knowledge of the way in which fluids and gas are channeled up faults from deep down in an accretionary wedge.

Co-chief scientists for the cruise were Dr. Graham K. Westbrook, University of Birmingham, United Kingdom, and Dr. Bobb Carson, Lehigh University, Bethlehem, Pa. Dr. Robert Musgrave was the ODP staff scientist, Texas A&M University.

About the Ocean Drilling Program

JOIDES Resolution, registered as SEDCO/BP 471, 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 for the Ocean Drilling Program, Federal Republic of Germany, France, Japan, United Kingdom and Russia (inactive).

The 470-foot-long drill ship's derrick towers 200 feet above the waterline. Seven levels of laboratories provide facilities for on board examination of sediment and hard-rock cores.

Texas A&M University, as science operator, operates and staffs the drill ship and retrieves cores from strategic sites around the world. Texas A&M maintains shipboard scientific labs and provides logistical and technical support for shipboard scientific teams. On shore, in the Texas A&M University Research Park, the science operator manages post-cruise activities, curates the cores and publishes the scientific results.

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 (JOI Inc.), a nonprofit consortium of 10 major U.S. oceanographic institutions, manages the program.

"The results from this cruise will go a long way in helping us identify conditions under which our global climate changed," said Dr. Philip D. Rabinowitz, director.

Note: JOIDES Institutions are (national) 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.

(International) Canada and Australia Consortium for the ODP, European Science Foundation Consortium for the ODP: Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland and Turkey; Federal Republic of Germany; France; Japan; the United Kingdom and Russia (inactive).

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