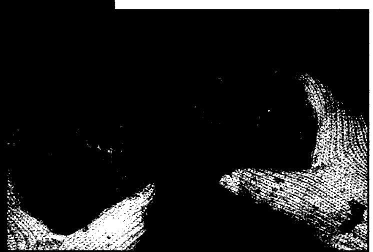
ENERGY RESEARCH

Ocean Project Drills For Methane Hydrates

TOKYO—Next week a Japanese drilling ship will begin taking a bite out of an underwater layer of frozen methane and water to assess its potential as a major source of energy for the world. The exploration of these gas hydrates—one of many hydrate deposits thought to occur near continental margins worldwide—is also expected to shed light on their role in past and future changes in global climate (see p. 1465) and their contribution to the stability of continental slopes.

Gas hydrates are a mixture of water and methane from the decay of organic material, frozen into the pore spaces of marine sediments and under permafrost on land. By some estimates, the energy trapped in the hydrates beneath the sea and in polar regions is more than double all of Earth's known oil, gas, and coal deposits combined. The cruise to the Nankai Trough, 60 kilometers off Japan's Pacific coast, is the culmination of a 5-year Japanese effort to understand whether the energy is commercially recoverable. Half a dozen countries around the world, including the United States, are also studying hydrates, but "this is the first legitimate [program] looking at their resource potential," says Timothy Collett, a geologist with the U.S. Geological Survey (USGS) in Denver.

Frozen energy. Japan hopes to augment knowledge of methane hydrates shown in core samples, inset, from a 1998 Canadian well.

What little is known about marine deposits is largely based on seismic surveys, which trace a layer of hydrates beneath many continental slope sediments. But there's no substitute for drilling into the deposits to learn how much gas they contain and how easy they might be to exploit. Hydrate researchers have tried before, most notably in 1995 at the Blake Ridge, 320 kilometers off the coast of South Carolina. But previous drilling has been limited both in scope and in technical capabilities, and the methane often escapes before the core sample reaches the surface. "Because we know so little about the real condition of gas hydrates in the ground, we can't yet formulate [methane recovery] as an engineering problem," says Charles Paull, a geologist at the Monterey Bay Aquarium Research Institute in Moss Landing, California, and co–chief scientist on the Blake Ridge project.

The latest effort is led by the Japan National Oil Corporation (JNOC), supported by the Ministry of International Trade and Industry and a consortium of 10 Japanese companies. The team has developed or extended technologies to capture samples in their natural state and to measure the permeability of the hydrate-bearing strata, a key to determining if the methane can be induced to flow to a well. JNOC has not disclosed the program's budget, but scientists estimate it at $60 million.

Floating in 950 meters of water, the *M. G. Hulme Jr.* expects to drill through an unknown thickness of soft silt before reaching a layer of gas hydrates and retrieving samples. It will also seal off parts of the well, pump in various fluids, and measure how quickly they disperse to determine flows in and out of the deposit.

The Japanese researchers tested the techniques on land, in a 1150-meter-deep test well drilled into permafrost in early 1998 at a site about 200 kilometers north of Inuvik, in Canada's Northwest Territories, in collaboration with the Geological Survey of Canada and the USGS. The drilling suggested that the Canadian field likely contains "a few trillion cubic feet" of methane, says Tatsuya Sameshima, technical project director for JNOC, although it is not clear how much of it could be recovered and whether the technology would be economical.

The Canadian project is already being used to develop a computer model of a gas hydrate deposit in Alaska for which only limited data are available. The Nankai Trough test well will provide a similar benchmark for marine deposits, which are particularly important for temperate-zone countries such as Japan. The data will allow scientists to calibrate seismic data and sketch a more accurate picture of the location and extent of other deposits.

At stake is more than future energy supplies. Methane is a greenhouse gas, and hydrate deposits are thought to be very sensitive to changes in temperature and pressure. University of Tokyo sedimentologist Ryo Matsumoto says that any warming of the oceans could result in massive releases of methane and "cause a catastrophic acceleration of global warming." Hydrates are also suspected of playing a role in previous global warming cycles, he says, yet "they haven't been taken into account in [climate change] models." Increasing evidence also suggests that undersea hydrate deposits may help to cement in place the soft sediments on continental slopes, says Monterey's Paull. As a result, large-scale drilling or ocean warming could conceivably trigger landslides that would generate tsunami.

The drilling is expected to continue through the rest of the year, followed by laboratory tests and data analysis that will run into next spring. And researchers emphasize that this is just the beginning. Last month both houses of Congress approved plans for a 5-year, $40 million effort by the Department of Energy to expand a small program now under way, and Russia, India, Norway, and Canada all have active hydrate research efforts. The Nankai Trough well "is a logical step in a progression [of research] that will go on for a long time," says Paull.

—DENNIS NORMILE

ASTRONOMY

Lumpy Infrared Points To Earliest Galaxies

Astronomy hit the front pages in 1992 when NASA's Cosmic Background Explorer (COBE) satellite discovered "lumps"—the seeds of later giant structures in the universe—in the even glow of radiation left over from the big bang. Less well reported was another discovery that emerged later from COBE data: a glow like that of a city that is just over the horizon, produced by the universe's very first generation of stars and galaxies. COBE's small infrared telescopes did not have the resolution to pick out any lumps in the cosmic infrared background that might indicate the structure of the primordial galaxies, but two French astronomers announced last week at a meeting* near Munich that data from the European Space Agency's Infrared Space Observatory (ISO) do show lumps in the IR background, presumably caused by large seas of galaxies emitting strongly in the infrared.

"What they presented is very convincing.

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* ISO Surveys of a Dusty Universe, a Max Planck Institute of Astronomy Workshop, Ringberg Castle, Germany, 8 to 12 November.

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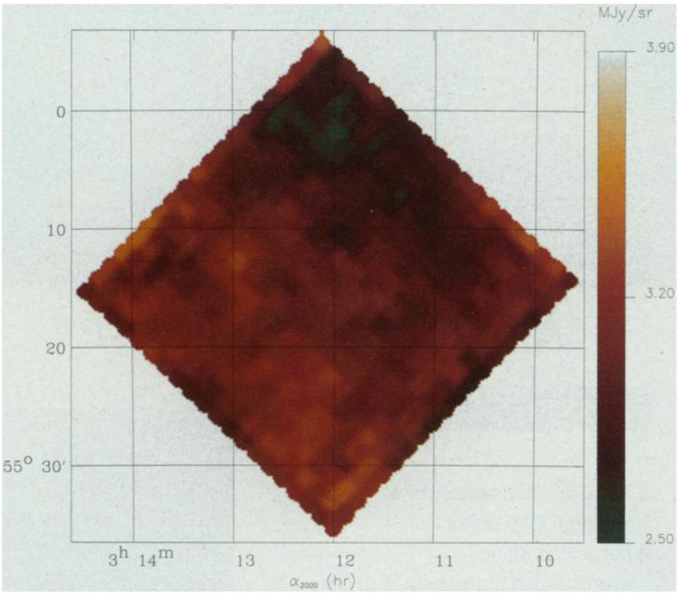

Stellar baby boom? Bumps in the infrared background of this ISOPHOT image show that the early universe was awash with star-forming galaxies.

I have no doubts," says Dietrich Lemke of the Max Planck Institute for Astronomy in Heidelberg, Germany, principal investigator for ISOPHOT, the ISO instrument involved. "Potentially this [discovery] is quite important, because we are trying to understand what the sources are of this background radiation," says Michael Hauser, deputy director of the Space Telescope Science Institute in Baltimore, Maryland.

Astronomers want to know more about the infrared background because the signal detected by COBE was much stronger than expected. The infrared glow is thought to come from primordial galaxies, full of young stars blazing within heavy shrouds of dust, which would have reradiated the starlight as heat. Hauser says observations from ISO and the SCUBA instrument on the James Clerk Maxwell Telescope in Hawaii suggest that this bright infrared background may have been caused by an early generation of "ultraluminous galaxies." Because of their cloak of dust, our only view of these early beacons may be in the infrared. "The results show that there has to have been a very strong presence of the infrared sources in the past, much more than now," says Jean-Loup Puget of the Institute for Space Astrophysics in Orsay, near Paris.

The discovery is actually a posthumous achievement for ISO, which ceased observing in May 1998 when the liquid helium coolant for its telescope ran out. Puget and his Orsay colleague Guilaine Lagache analyzed data collected during ISO's 3-year life by ISOPHOT's four infrared photometers. The photometers measured the brightness of the infrared sky as seen by ISO's 60-centimeter telescope, which has a resolving power more than 25 times that of COBE's best effort.

Puget and Lagache focused on data from small patches of sky—an area totaling 4 square degrees—that were specifically selected to avoid infrared radiation coming from dust in our own galaxy. Even so, the astronomers had to do much work to remove "foreground" radiation from within our galaxy and from point sources of infrared light elsewhere in the universe. The brightness variations that remain "are galaxies that we cannot resolve with the instrument," says Lagache.

Astronomers are now keen to learn more about these early galaxies and when star formation began. Puget says that the observations show that star formation was already intense during the first billion years of the universe's 12- billion-year life, while previous optical observations seemed to indicate that star formation started much later. For more detailed data, astronomers will have to wait until NASA launches its Space Infrared Telescope Facility (SIRTF) in 2002. SIRTF will have a slightly higher resolving power than ISO, and its detector will be much more sensitive, says Michael Rowan-Robinson of London's Imperial College. Puget adds that the Atacama Large Millimeter Array, an array of 64 infrared dishes to be built as an international project in Chile, "will allow real progress."

—ALEXANDER HELLEMANS

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PLANETARY SCIENCE

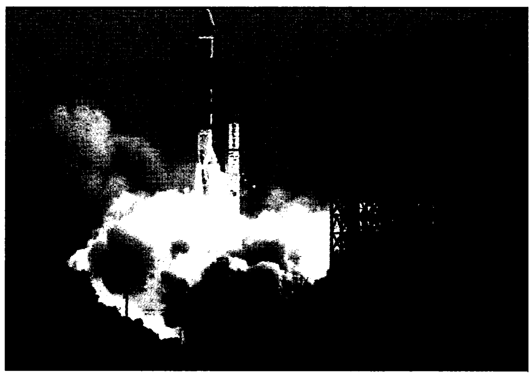
A System Fails at Mars, A Spacecraft Is Lost

Just in time to protect the Mars Polar Lander from risking a similar fate when it reaches the Red Planet next month, NASA investigators have wrapped up their inquiry into the loss of the Mars Climate Orbiter (MCO) spacecraft in September. Confusion over units of measurement used during mission navigation set the craft on its fatal course into the martian atmosphere, investigators announced last week, but the failure of mission team members to fully follow existing checks and balances turned a correctable snafu into a disaster. Why spacecraft operators broke the rules remains unclear, but NASA's new "faster, better, cheaper" approach to planetary missions is taking some of the blame.

The investigation board confirmed that the root cause of the loss was a misuse of English units, as previously reported: The MCO's operator, Lockheed Martin Astronautics of Denver, supplied data about the firing of the spacecraft thrusters in pound-seconds. The recipients of the data, spacecraft navigators at the Jet Propulsion Laboratory (JPL) in Pasadena, California, assumed the units were the newton-seconds required by mission specifications.

Although that error was not found until later, the navigators knew the spacecraft was off course. "The navigation team realized as the spacecraft approached Mars that it was coming in lower than intended," says Arthur Stephenson, director of NASA's Marshall Space Flight Center in Huntsville, Alabama, and the head of the NASA investigation board. He adds that they did not realize the gravity of the situation. "They never saw that the spacecraft was in jeopardy. They were more worried about tuning the orbit than a catastrophic loss."

Even so, Patrick Esposito, who supervises navigation of all three current Mars missions, strongly recommended almost a week before arrival at Mars that a modest trajectory correction be made, according to an internal investigation at JPL. The suggested correction possibly could have saved the mission, but it "was denied for good reason," says Stephenson.



Mars Climate Orbiter. Off to an ignominious end.

"The [operations] team was not ready to perform it." A fifth and final tweaking of the trajectory was in the mission plan, but the operations team had done none of the planning needed to ensure that a last-minute course correction could be executed if needed.

That was just one of eight contributing factors that turned an oversight into a catastrophe, according to the NASA report. Other problems included the navigators' unfamiliarity with the peculiarities of this spacecraft's behavior, poor communication between spacecraft teams, and understaffing (the navi-

CREDITS: (LEFT TO RIGHT) ISO; NASA