

# MEXICAN SINKHOLE MAY LEAD NASA TO JUPITER



It may not show up on MapQuest, but NASA scientists are betting that the best route to Jupiter and its ice-crust moon Europa runs through an underwater cavern in Mexico. Though the space mission is probably 30 years off, the trek begins in earnest today outside the city of Tampico. A 60-ton crane is scheduled to lower a giant orange robot dubbed "Clementine" into what is believed to be the deepest flooded sinkhole in the world.

For the next two weeks, the fully autonomous robot, which bears an uncanny resemblance to a Volkswagen Beetle, will plumb the previously inaccessible microbial mysteries of the sinkhole – or "cenote" – El Zacatón. Relying on an eclectic team of scuba divers, engineers, biologists and geochemists, NASA is hoping the mission will be the first leg on its journey to Europa.

"We're learning to explore Europa by first exploring a Mexican cenote," said John Rummel, a senior scientist for astrobiology at NASA. Scientists consider the Jovian moon, with its evidence of liquid water and thermal energy sources, to be "one of the hottest targets for potential life" beyond Earth, said Peter T. Doran, an Earth scientist at the University of Illinois at Chicago who is part of the team. In the past, if researchers "wanted to explore geologically, we sent a graduate student," Rummel joked. However, even if NASA had a Jupiter shuttle, it would be impossible for those students to take a look around.

"If we walked without a spacesuit onto [Europa] – at 123 degrees below Celsius and no air – the radiation would kill us before the lack of air or the cold," he said. "About eight years ago, NASA realized if it was going to effectively explore other worlds, it had to get a lot better about robotic activity."

For NASA, the \$5 million, three-year Deep Phreatic Thermal Explorer (Depthx) project is an important test drive of a computerized, underwater vehicle that makes all of its own decisions – where to swim, which samples to collect and how to get home. Each day, the battery-powered robot will travel deeper

into the sinkhole, exploring nooks and crannies that human divers could never reach.

If Clementine performs well, a retooled version will head to Antarctica's Lake Bonney next year. Scientists think the conditions there – vast thermal waterways below frozen ice – more closely resemble those of Europa.

In developing Depthx, engineers aimed to build a machine that behaves like a microbiologist, said John R. Spear, an environmental microbiologist at the Colorado School of Mines. "I wanted this robot to be me."

Once the 3,300-pound vehicle, designed by Texas-based Stone Aerospace Inc., is lowered into the sinkhole, it "feels" changes in temperature, "sees" shifts in topography with 56 sonar sensors and "sips" water samples. Those are taken to a laboratory on the surface for further study. Most important, it does its own thinking. As it swims down the limestone cave, which is 367 feet wide and at least 1,000 feet deep, the vehicle will probe the most interesting areas – namely places where temperature, oxygen levels or other characteristics change, suggesting something is happening biologically, said Marcus Gary of the University of Texas, one of the lead scientists. Using a long arm with a pinkie-size knob, Depthx can grab samples from those spots.

At the end of each day, the vehicle must navigate back to the surface in much the same way a person lost in the woods searches for a route out – except that Clementine has no map or trail. It creates its own. Using supercomputers built by scientists at Carnegie Mellon University, the robot works off 500 three-dimensional maps that it is constantly sketching, said robotics professor David Wettergreen.

Each new tidbit of information – a rock jutting out, a narrow tunnel – is fed into the computers, and the maps are updated in real time. The process is called simultaneous localization and mapping, or SLAM. Like most humans, Clementine has gotten lost, prompting what Spear described as "freak time." On a practice dive in March in La Pilita, the second-deepest sinkhole in the collection of cenotes known as the Zacatón system, the robot did not resurface.

"I was awakened at 1:30 in the morning," said Gary, who was a commercial diver before he became a hydrogeologist. "I threw on my scuba tank and luckily found it wedged under some rocks."

As it turned out, the team had sent the robot down without all 56 sensors operating. It was a lesson worth the heart palpitations.

"The goal, from a technical point of view, is not to achieve perfect success," said Wettergreen. The scientists want to know "how it responds to failures."

Although NASA's long-term goal is to build a smaller robot that can function independently in outer space, the project is generating important earthly discoveries. With Clementine, scientists for the first time can examine specimens from the undisturbed netherworld of the sinkholes. Diver Jim Bowden set a depth record of 925 feet in El Zacatón in 1994, but he never reached the bottom and his partner never returned.



"This really is an example of exploration in a completely unknown, undeveloped environment," Wettergreen said. "Everything we're finding there is unique and bizarre," Gary said. In preliminary sampling, the team has collected dozens of "previously undescribed" bacteria. Those new types

of bacteria could conceivably lead to medical therapies, new plastics, stronger dental materials or better manufacturing processes.

Understanding the chemistry of the cenote – how it formed and changed over thousands of years – should help researchers locate and protect future water supplies, Spear said. Smaller versions of the robot, meanwhile, might be used to examine underwater dams or drilling platforms, he said.

Soon after the Mexico dive, Doran will begin preparing Clementine for the more challenging conditions of Antarctica. For the past 20 years, Doran's exploration of Lake Bonney has been severely limited.

It often takes days for scientists to drill a few holes through the ice, which is about 15 feet thick, and then retrieve water samples from the narrow opening with a manual device. The robot will not have those limitations.

The Lake Bonney project, known as Endurance, "will probably take Depthx to its limits," Rummel said. After that, he is hoping for a smaller, tougher Clementine – to send to Antarctica's Lake Vostok, where the ice layer above is even thicker – 2.5 miles.

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## CAVE MANAGEMENT AND RESPONDING TO THE CHANGING MANAGERIAL ENVIRONMENT

– Elery Hamilton-Smith

This is a brief note on the workshop session at the Buchan Conference which set out to examine changes in cave management, but it soon became clear that the title above would have been much more appropriate.

Andy and I firstly made it clear that in our reference to Jenolan Caves, we did not intend any criticism of the management and staff at Jenolan. They suffered from the worldwide problem of the changing ideology and hegemony of modern western governments coupled with major problems in the governance of World Heritage sites (and other protected areas), particularly in Australia.

They acted exactly as they should have done in getting their development approved by the relevant government agencies. Regrettably, this has caused some minor problems in the development, but the workshop was not the place to even raise these, as they are very specific to Jenolan. Thus, we apologise for our lack of initial clarity and the subsequent misunderstandings.

Moreover, it is clear that Jenolan has taken immense steps forward in improving the quality of

visitor experience and deserve great praise for what they have achieved in this area.

During the discussion, I referred to the report on Governance of Protected Areas from the 2003 Durban World Parks Congress. Members who are interested can download this from the Web. Go to the Canadian Institute of Governance at: <http://www/iog/ca> Type "Protected areas" into the publications search engine.

Then download: [pa\\_governance.pdf](#) (418599 bytes) *Last Modified:* 5/26/2004 2:21:49 PM  
*Description:* GOVERNANCE PRINCIPLES FOR PROTECTED AREAS IN THE 21ST CENTURY A DISCUSSION PAPER BY THE INSTITUTE ON GOVERNANCE IN COLLABORATION WITH PARKS CANADA

I also offered to provide details of key books on the worldwide changes taking place in governmental policies. If anyone would like this, let me know and I will send an annotated list. The whole workshop will, of course, be reported in the Conference Proceedings.

