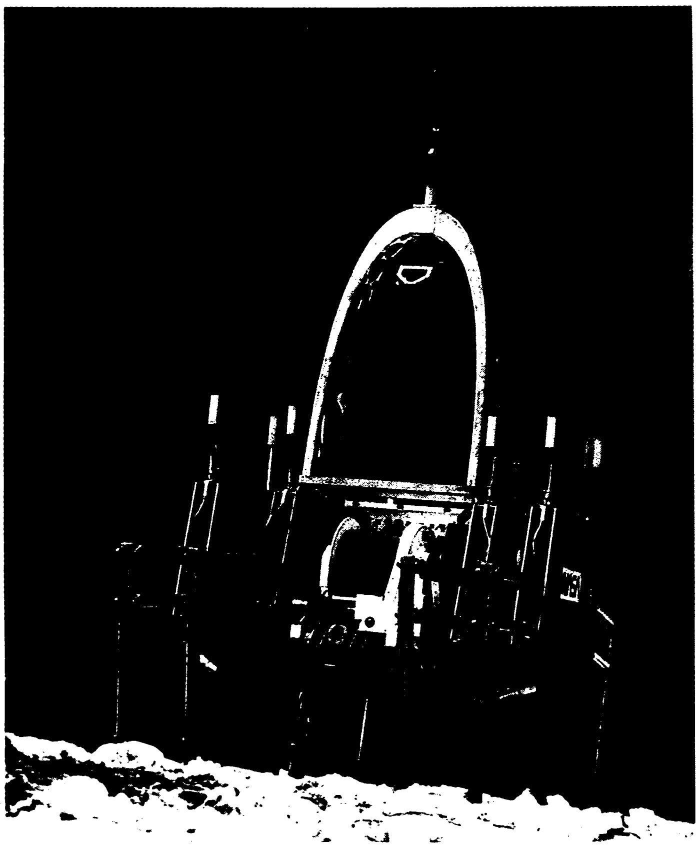
Dante conquers the crater, then stumbles

The robot explorer Dante 2 discovered last week that the road home is often the roughest. After spending 8 days successfully navigating the steaming crater of Alaska's Mt. Spurr and enduring attacks by falling boulders, the spiderlike machine flipped over while climbing out. The Dante crew will attempt to airlift the helpless robot this week.

Despite the late setback, engineers connected with the mission say Dante performed beyond expectations in a harsh environment. "From the science and technology side, it's a clear victory and a success," says William "Red" Whittaker, a principal investigator on the project and a robotics researcher at Carnegie Mellon University in Pittsburgh.



Bill Ingalls/NASA

Dante: Before the fall.

The eight-legged robot descended 660 feet into the crater of the active volcano, analyzed gases escaping from several fumeroles, and collected terrain information for mapping the interior. For parts of the trip, the robot controlled its own movement by sensing the environment, picking a route, and planning where to place its feet. At other times, the Dante team controlled aspects of the robot's walking from a command center 80 miles away in Anchorage and from NASA's Ames Research Center in Mountain View, Calif.

Dante was connected by a tether to an electric generator and a satellite dish on the rim of the crater. During the first part of its trek, the robot descended snow-covered slopes of 20° to 30°; it later encountered bare rock, mud, and fields of large boulders. At certain points, the 10-foot-long, 10-foot-high robot climbed over rocks larger than itself.

Mt. Spurr erupted in 1992 and let loose smaller blasts in 1993. But even more than the threat of eruption, the primary danger inside the crater came from falling rocks. As the walker neared the crater floor, its video cameras showed several refrigerator-size boulders bounce close by. A 1-foot-diameter rock knocked one of the legs out from under Dante but did not cause major damage.

While in the crater, the explorer used onboard analyzers to test for sulfur compounds in the volcanic gases. Those tests did not detect hydrogen sulfide or sulfur dioxide, which suggests that no fresh magma lies at a shallow depth beneath the volcano waiting to erupt.

The robot had climbed about one-third of the way out of the crater when it rolled over while crossing a 35° slope and could not right itself. "We were just on terrain beyond our capability," explains Project Manager John E. Bares.

Dante 2 evolved out of a walking robot that Whittaker's team took to Antarctica's Mount Erebus in late 1992. This earlier version descended only 20 feet into the crater before broken connections in its tether ended the mission (SN: 1/9/93, p.22).

The Dante 2 project pushed the bounds of robotics by exposing a walking machine to a range of demanding conditions never before experienced. "It sets the state of the art in walking on rough terrain. It's a pretty impressive accomplishment," says Roger D. Quinn, who designs walking robots at Case Western Reserve University in Cleveland.

NASA, which funded the mission, is encouraging the development of autonomous robots for planetary exploration. "The moon is the place for the fulfillment of this work," says Whittaker.

– R. Monastersky

Comets: Icy studies probe sunny behavior

When a comet gets too close to the sun's warming rays, some of its ice turns to vapor. The sudden transformation spews jets of vapor that drag dust out along with them, rendering the comet visible millions of kilometers from Earth.

Though a familiar scenario, one detail of this picture still puzzles scientists. Volatile gases trapped in cometary ice at low temperatures shouldn't remain at higher temperatures. Well before water ice becomes warm enough to vaporize, it changes its structure to a more ordered, crystalline form that expels such trapped molecules. So why are gases such as carbon monoxide and carbon dioxide found in the jets of water vapor released by comets? Researchers now suggest that the answer may lie in the nature of a newly discovered form of water ice.

Peter Jenniskens and David F. Blake of NASA's Ames Research Center in Mountain View, Calif., identified the new form while monitoring structural changes in water ice as it warmed over a wide range of temperatures in the laboratory. Using beams of electrons to probe the frozen water, they confirmed the existence of two previously observed forms of ice – a colder, high-density form and a warmer, low-density form – both of which lack the orderly structure of a crystal.

More significantly, the researchers discovered a third type of amorphous ice. Found at higher temperatures – 148 to 188 kelvins – this form coexists with one of the two crystalline forms of frozen water, Jenniskens and Blake report in the Aug. 5 SCIENCE. Because it coexists, this amorphous type may allow comets to retain at surprisingly high temperatures – greater than 150 kelvins – some of the trapped gases that crystalline water ice would normally expel, they note.

In addition, new data about the two amorphous types identified earlier may help distinguish between the proposed sources of comets – the Kuiper belt, thought to lie well beyond Pluto, and the more distant Oort cloud. Astronomers believe that despite its chillier location, the Oort cloud formed in a warmer region than the Kuiper belt, probably between Uranus and Neptune.

Because Oort cloud comets may preserve the ice structure created in their warmer birthplace, the researchers believe that these comets are most likely to have the warmer, low-density form of water ice previously found. In contrast, Jenniskens and Blake calculate that the Kuiper belt members are most likely to have the high-density form. This structural difference may lead to noticeable differences in activity when comets from either group first visit the inner solar system, they suggest.

– R. Cowen