# EARTH SCIENCES

## New tool carves cost of volcano study

When a boulder bounced down the face of Mount St. Helens last month and smashed an electronic monitoring device, volcano watchers didn't even wince, though replacing the tiltmeter would have cost more than $6,000. Innovations by a researcher at the California Institute of Technology have led to design of a tiltmeter that is easier to install, easier to maintain and costs only a few hundred dollars.

"They work, as best we can tell, as well as the more expensive models," says Jim Westphal. His thrifty measurer of the mountain's movement is essentially a carpenter's level attached to an electronic package that converts the movement of a leveling bubble to an electrical signal. Radio messages relayed every ten minutes from the tiltmeter combine with variations in the waves of a seismograph to warn geoscientists when an eruption is likely. "The two of them together make an awfully good prediction technique," says Westphal.

Tiltmeters have been used experimentally for a number of years as early-warning predictors of earthquakes along California's San Andreas fault. Part of the expense of the older models stemmed from the sensitivity required to detect the tiny changes in the earth's tilt that precede an earthquake, but shifts in the earth around a volcano are so great that such sensitivity isn't required, according to Elliot Endo of the U.S. Geological Survey. The new tiltmeters also require manual calibration less often, Endo says, an important characteristic on Mount St. Helens where bad weather and few roads make checking instruments difficult and dangerous.

By measuring the earth's bulges and contractions from several spots close to the crater, multiple tiltmeters considerably increase researchers' understanding of the volcano's plumbing. Seven of the devices will eventually dot the mountain.

## 'Martian' crater in the Sahara

Once hidden between the windswept dunes of the eastern Sahara desert, a recently discovered crater measuring about 4 kilometers from rim to rim could provide researchers with clues to the dust-laden winds and possible ancient rivers that may have carved the face of Mars. "This is the only well-preserved, large crater that we know of that's in the middle of a sand field," says Farouk El-Baz of the Smithsonian Institution. El-Baz, whose report appeared in the July 24 SCIENCE, told SCIENCE NEWS that by exploring every cranny of the circular crater in an expedition next autumn he hopes to better understand the arid interactions of wind and sand that shape Martian features. (A smaller crater in a similar environment in Saudi Arabia has eroded too much to provide scientists with the same kind of information, he added.)

Deflection of dunes by the crater's rim, a sand-free zone at its leeward edge, and a dark splotch south of the rim especially intrigue El-Baz, who discovered the crater early this year when reexamining a 1977 Landsat photo. By checking the age of rocks in the area, and measuring the side of the rim that is nearly intact, El-Baz says researchers will be able to determine the rate of wind erosion. The dark splotch, similar to those in photographs of Martian craters, appears to be caused by a glaze of clays and iron oxides visible when the sands are swept away. A closer look at the El-Baz crater should add new information to theories of the source of such splotches. Although the atmospheres of earth and Mars are far from identical, El-Baz maintains that one can at least partially correct for environmental differences between the two planets to focus on effects of the wind regime. The dunes surrounding the crater, 100 meters high and 100 kilometers long, can't be replicated in a wind tunnel, he says, so they make the life-size model in Egypt a rich source of information.

# SPACE SCIENCES

## Ganymede: Interior ocean unlikely

In recent years, some scientists have raised the intriguing possibility that Ganymede, largest of Jupiter's icy Galilean satellites (about half of its mass is water), might have a deep ocean of liquid water hidden away beneath its frozen crust. It would be kept that way by heat escaping from radioactive elements in the rock that concentrated at the big moon's core during its early history. Other researchers, however, have since maintained that such a water mantle would be frozen just as solid as the rest of the satellite, since enough heat could escape through the ice by solid-state convection to keep temperatures from building up to the melting point.

It had been an essentially hypothetical argument, with little to go on but numerical calculations, until a recent report by three French researchers who simulated a tiny piece of Ganymede's interior in a laboratory test cell, concluding that a liquid mantle indeed seems unlikely.

Jean Paul Poirier and two colleagues from the University of Paris made their bit of Ganymede in the minuscule cavity formed by a 0.6-millimeter hole in a piece of annealed copper foil sandwiched between two disks cut from a single-crystal rod of sapphire. They filled the hole with tap water containing particles of fine aluminum grit, and (by turning a screw) began to apply increasing pressure while lowering the temperature, monitoring the results with a microscope aimed through one of the transparent disks. At 20°C and a pressure of 9 kilobars (about 9,000 earth-atmospheres), the liquid water changes to a form of ice known as "ice VI," one of several high-pressure forms that differ from your average icecube primarily by their more compact molecular structure. What the researchers wanted to know was whether, at the still greater pressures near the bottom of Ganymede's icy blanket, ice VI would indeed flow readily enough for solid-state convection to carry out heat fast enough to prevent the temperature from reaching the melting point. (Earlier calculations by E. M. Parmentier and J. W. Head of Brown University had already shown that solid-state convection would be sufficient as long as the viscosity of the ice was less than $10^{17}$ Poise; the cube of ice I in your drink, by comparison, has a viscosity of about $10^{14}$ to $10^{15}$ P.)

The French researchers measured the viscosity of their bit of Ganymede by noting how fast the aluminum-grit "tracers" were carried by the ice from the center of the cell, where the pressure was highest, to the edge. They found that, with pressures of 10.8 to 12.2 kilobars and temperatures from 10°C to 16°C below the melting point, the viscosity of the ice VI ranged from $2.4 \times 10^{13}$ P to a maximum of $1.4 \times 10^{14}$ P—easily low enough for the solid ice to stay that way.

The finding, reported in the July 16 NATURE, suggests that the ice hundreds of kilometers deep in Ganymede's interior is no more viscous than that at the surface (or in your drink), even though it is under thousands of times as much pressure. The reason is thought to be that, although the greater pressure forces the crystal lattice structure of the frozen water molecules into a different, more compact arrangement, such an arrangement can be just as flexible or mobile, from a viscosity standpoint, as the original.

Even if there is no liquid layer beneath the surface of today's Ganymede, however, the French result does not rule out the chance that there could have been one in the satellite's early days, perhaps due to the intense heat of a rapid accretion. But over time, this extra heatflow from the deep interior would have died out, leaving only more gradual gravitational and radionuclide heating, which could be released by solid-state convection. If it ever existed, Ganymede's inner ocean (an admittedly intriguing idea that inspires thoughts of submarine explorations on other worlds) would by now be long gone.