Raising the Stakes at Mount St. Helens

Scientists predicting the behavior of Mount St. Helens have been doing so well that the U.S. Forest Service is opening the mountain to the public; scientists have some doubts

SEVENTEEN times since the 18 May 1980 cataclysm at Mount St. Helens, magma has oozed upward to create the 320-meter-high, 1-kilometer-wide dome that now squats on the crater floor. Scientists predicted days to weeks ahead all but one of those dome-forming eruptions, which were accompanied by earthquakes, rockfalls, noxious fuming, and more than 400 relatively small, rock- and ash-tossing explosions.

With the mountain now being so predictable, the U.S. Forest Service is opening it, including the crater but not the dome itself, to limited public access in the summer and unrestricted access in the winter. The presence of the public gives volcanologists pause. They have learned much about how this particular dome grows, but, to judge by other volcanoes, there will be other hazards.

For instance, major explosions will likely be widely interspersed with the relatively quiet dome building. The volcanologists who have such an impressive record predicting dome-building eruptions are less sanguine about predicting large explosions at Mount St. Helens. What the warning signs will be and how readily they will be detected remain uncomfortably uncertain. Donald Swanson is scientist-in-charge at the U.S. Geological Survey's Cascades Volcano Observatory (CVO) near Mount St. Helens. "Clearly, the responsibility falls upon us," he says, "to understand much better than we do now how this volcano works."

Since the fall of 1980, Mount St. Helens has behaved in a surprisingly predictable way, despite a disturbance in the plumbing system that supplies magma to the crater. For more than a year, dome-building eruptions came at regular intervals of a couple months, the dome growing at a steady rate of 1.8 million cubic meters per month. Then at the end of 1981 the mountain's behavior changed. The rate of growth halved, and the pattern of eruptions changed but remained predictable. Eruptions now come in cycles of decreasing frequency but increasing volume. Swanson and his colleagues at CVO suspect that the shift was brought on by an injection of new magma into a chamber that supplies the dome from 8 to 10 kilometers beneath the crater floor. The new pattern is consistent enough, says Swanson, that the next dome-building eruption could be expected in another month or two if the pattern holds.

CVO scientists are reasonably confident that they will be able to warn days or even weeks in advance of the next dome-building eruption, whenever it comes. The dome is studded with tiltmeters and seismometers that provide a few hours warning of an eruption, but for long-term warnings researchers depend on the monitoring of imperceptible dome movements. The instrumentation may be as sophisticated as laser distance-measuring instruments or as simple as a steel tape, but the results have consistently revealed slow but accelerating outward movement of the dome well before an actual eruption.

This precursory dome movement is a sluggish version of one way that the dome grows during a full-blown eruption. In a model of dome growth dubbed the ruptured onion, new magma enters a molten core within the dome, which adds to the dome and expands it laterally to form the layered onion structure. Some of the highly viscous magma may also escape as lava nears the top of the dome.

On the basis of the volume of precursory growth and the presence of shallow earthquakes, Swanson surmises that the slow, accelerating dome growth used for prediction is driven by magma rising from temporary storage about 2 kilometers below the crater floor. This magma must push less buoyant, more viscous magma ahead of it through a conduit only 5 to 10 meters wide. It is slow going at first, but as more and more of the volcano's "throat" is cleared, flow increases, producing the characteristic accelerating dome growth.

CVO researchers have found a curious connection between eruption precursors and the moon that might help the prediction effort. All but 3 of the 17 precursory episodes have occurred after the maximum Earth tide that the moon raises every 14.7 days but before the tidal minimum. "That suggests that the volcano's plumbing system is in a very delicate state of balance," says

Lyn Topinka, USGS/CVO

The growing dome of Mount St. Helens. *The conduit that has been quietly supplying new magma to the dome (seen here in 1985 at a width of 820 meters) rises directly beneath it. The conduit could also still deliver a large explosive eruption.*

Swanson. Presumably, the additional stress caused by the moon's gravitational distortion of Earth's crust can, given nearly but not quite enough pressurization by new magma, touch off an eruption.

If CVO scientists are increasingly familiar with dome-building eruptions, they are considerably more uneasy about large explosive eruptions. There were only five of them at Mount St. Helens during the summer of 1980. They were predicted on the basis of precursory seismic activity, but only hours ahead. Two other volcanoes might serve as analogs—Bezymianny in Kamchatka and Santiaguito in Guatemala. They have been forming domes since 1956 and 1922, respectively, and have produced several large explosions each. Unfortunately, they have not been monitored closely enough to provide any reassuring precursors.

Swanson declines to speculate on when Mount St. Helens might produce its next explosive eruption, but he mentions three possible hazards that may yet arise. A catastrophic landslide might fall off the dome, or a new injection of magma into the plumbing system might lead to an explosive eruption. More likely, he says, congealing magma might cork the throat of the volcano as dome-building eruptions become less frequent. The resulting pressure buildup could produce a major explosion. "It's likely the dome will continue to grow episodically and perhaps it will have some relatively large explosions," says Swanson. "I wouldn't be surprised if we had a large explosion at any time."

The problem is that CVO scientists are not at all sure how to predict large explosive eruptions more than a few hours ahead. That should give little comfort to climbers in the crater this summer. If pressure builds deep within the mountain, the heretofore crucial monitoring of the dome may be of no use. Instead, predictions more than a few hours ahead will probably depend on detecting slow swelling of uncertain magnitude of the whole mountain.

"This worries us very much," says Swanson. "We don't really know what to expect if there would be some pressure increase. I have a nagging fear that we just wouldn't see it." Precursory swelling might be too small to be noticed, monitoring might be interrupted by bad weather, or increased seismicity preceding an explosion could easily be taken as a precursor of dome-building, he notes.

Obviously, the public pressure that led to the reopening of Mount St. Helens and its crater has done more than create new challenges for climbers. It is also pushing the science of volcano prediction near its limit. ■ **RICHARD A. KERR**

Broad Issues Debated at AIDS Vaccine Workshop

Both scientific and policy issues, including the effect of an acceptable AIDS vaccine, the utility of certain preclinical tests, and the design of vaccine trials, dominated the discussion

"I think it is virtually certain that there will be initial clinical trials of an AIDS vaccine in the United States this calendar year," Gerald Quinnan of the Food and Drug Administration (FDA) said at a recent workshop on the subject.* In an atmosphere of not wanting to waste time, while striving to maintain high scientific standards for an AIDS vaccine, workshop participants raised many tough issues, few of which met with general consensus. Their comments will help to guide FDA officials who must identify quickly what requirements should be met by candidate vaccines as they enter clinical trials and what the designs of those trials should be.

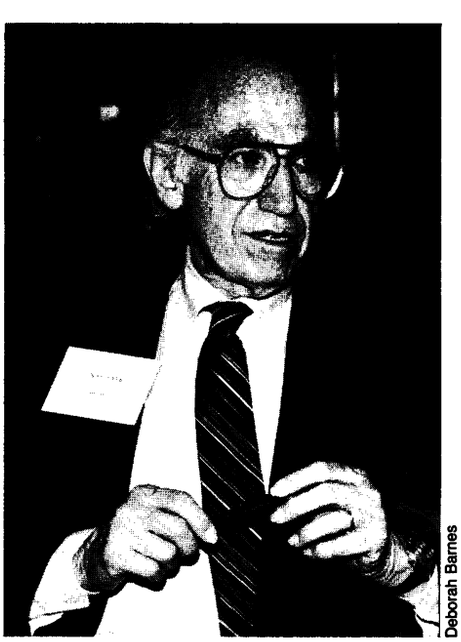
The FDA is now considering at least two proposals from researchers to do initial toxicity tests of candidate vaccines for AIDS in humans and anticipate several more proposals soon. But despite the ability of these and other potential vaccines to stimulate various test animals—mice, rabbits, guinea pigs, and primates—to make antibodies against the AIDS virus, none has induced protective immunity in chimpanzees, which, until very recently, were the only animals that researchers could infect with the AIDS virus.

Any new vaccine has to be judged both safe and effective by the FDA, and officials must determine that an AIDS vaccine meets these standards as well as passing requirements that are unique to the AIDS virus and the immune deficiency disease it causes. Workshop participants focused on three issues in particular. First, what is an acceptable end point for an AIDS vaccine trial—protection against infection or protection against viral transmission or disease? Second, how well do the results of preclinical tests predict vaccine efficacy in humans? And third, which human populations should receive test vaccines?

Nearly all researchers agree that an ideal AIDS vaccine should protect an immunized person from infection by the virus, but some doubt that such a vaccine will ever exist. To prevent infection, a vaccine must stimulate a spectrum of immune responses including production of antibodies directed against specific viral proteins and cell-mediated immune responses that are antibody-independent, says Anthony Fauci of the National Institute of Allergy and Infectious Diseases.

However, researchers are finding that the theoretical efficacy of an ideal vaccine is difficult to translate into reality because of two major obstacles. Dani Bolognesi of Duke University Medical Center in Durham, North Carolina notes that one is the high mutation rate of the AIDS virus. This results in many different viral strains against which a single vaccine may not be effective. The other is the necessity to protect against both free virus particles and cells infected with the virus. Bolognesi notes that, to date, none of the potential vaccines meet these criteria completely.

Some researchers question whether it may be unrealistic to require an AIDS vaccine to



Deborah Barnes

Jonas Salk *advocates identifying the in vivo immune responses that protect against the AIDS virus.*

*The "Scientific Workshop on AIDS Vaccines," held 25 to 27 March at NIH, was sponsored by the U.S. Public Health Service AIDS Task Force Subgroup on Vaccine Development and the U.S. Army Medical Research and Development Command.