EARTH SCIENCES

Susan West reports from the Mt. St. Helens symposia at the meeting in San Francisco of the American Geophysical Union

Mt. St. Helens update: Preparedness . . .

If geologists got report cards, they'd get an A on Mt. St. Helens, but they'd better bone up on other volcanoes, in the assessment of two U.S. Geological Survey scientists. The quick response to Mt. St. Helens's early rumblings in March was possible, say Donal Mullineaux and Dwight Crandell, because of a hazard evaluation based on the mountain's geological record that was completed by the Survey in 1978. That evaluation, which included information about the types and locations of work sites, recreation facilities and residential areas around the mountain, allowed officials to take precautions specific for the area, says Mullineaux. So far, he says, the volcano has followed the geologic sequence outlined in the 1978 report, particularly in the occurrence and distribution of mud flows, pyroclastic flows, ash falls and floods. Not anticipated, however, was the amount of debris that closed the Columbia River channel and the size of the lateral blast on May 18. The accuracy of the predictions demonstrates the value of using a volcano's historical record to evaluate specific potential hazards and to make long-term planning decisions, says Mullineaux. "The important goal for geologists," he says, "is to obtain similar geological information on other volcanoes and to become familiar with the region and the culture around them .... At Mt. St. Helens we were lucky, because the volcano that we picked based on its past record to erupt did erupt, but we have to recognize that we are not as well prepared at other volcanoes."

in hindsight . . .

With the 20/20 vision of hindsight, possibilities become probabilities and informed hypotheses become uncanny predictions. So too with Mt. St. Helens: Take, for example, the 1978 USGS report that has been touted for "predicting" the volcano's eruption, though it severely underplayed the possibility of a May 18-type lateral blast and underestimated its potential power by a factor of three. Another pre-May 18 report, discussed by Robert W. Decker of the USGS Hawaiian Volcano Observatory, shows an even more disquieting resemblance to reality.

When researchers recognized the extent of the swelling bulge on the volcano's north flank, landslide expert Barry Voight of Pennsylvania State University was asked to analyze the potential catastrophe that would result from the collapse of the north flank. In an achingly accurate assessment, he sketched a comparison of Mt. St. Helens with two well-studied landslides, and estimated that the volcano could yield a 1- to 3-cubic-kilometer avalanche. Posted April 15 on a bulletin board at the Survey's Mt. St. Helens office in Vancouver, Wash., the sketch includes these notes: "Slide mass front *can* reach Spirit Lake. Debris and mudflows generated at front can go much farther. Magma pocket — boils when surface load removed suddenly — possible trigger for pyroclastic event." When the bulge was loosed by an earthquake the morning of May 18, it followed this scenario almost to the letter. The avalanche splattered about 3 km^3 of the volcano's summit across the countryside, and the mountain's new profile — lower by about 1,000 meters — remarkably traces the dotted line on Voight's sketch. In his May 1 technical report, Voight expanded his earlier comments: "A catastrophic event of the kind observed at Bandia-san (Japan, 1888) — in which an explosively-motivated fragmental flow devastated an area of more than 70 km^2 — must be regarded as a legitimate possibility, particularly in view of the enhanced hydraulic pressure conditions implied by frequent summit steam explosions and the relatively high level of released seismic energy." More cautiously, he continues, "On the more prosaic side, a bulging slope associated with rock creep may simply lead to an increase of rockfall hazards from exposed rock areas such as Goat Rocks, increased snow avalanche hazard and increased risk of glacier falls."

While Voight's evaluation was chillingly on the mark, Decker notes that like all scientists trying to outguess the volcano, Voight did not assign a maximum likelihood to his worst-case scenario, but instead opted for a "judicious application of Ockham's razor — that the more catastrophic events are less probable than the least catastrophic." While such reports indicate high skill in making general forecasts, says Decker, they show the need for more specific ability. And such skill will come only with expanded monitoring of a number of volcanoes, he says: "I recommend one center for monitoring ten or 20 volcanoes.... If we concentrate on one volcano, we might pick the wrong one."

seismic precursors . . .

Strictly speaking, each of Mt. St. Helens's six major eruptions has had a distinct seismic precursor, says Steve Malone of the University of Washington in Seattle, though not all of them — such as the quake that preceded the May 18 blast by only seconds — have been on a timescale that is "socially useful." Even so, seismologists Malone and Elliot Endo and Craig Weaver of the U.S. Geological Survey have sifted out certain patterns. They have noticed, for example, three kinds of quake activity — continuous, low-level "harmonic tremor"; shallow quakes and deep quakes — each of which seems to signal something different. The eruptions of May 25, June 12 and Aug. 7 were preceded by an increase in harmonic tremor followed by a sudden hiatus in activity, Malone noted, while those of July 22 and Oct. 16 to 18 were heralded by a rise in the number of shallow-source quakes. After the eruptions, the seismologists recorded an increased number of deep-source quakes, although that number has diminished after each eruption and none — contrary to what was reported earlier — was detected after the October blast. Interestingly, the seismologists have also noted that when a lava dome has developed in the crater, shallow quakes precede the next eruption, but when no dome is present, harmonic tremor is the precursor. No dome formed after the October explosions, Malone notes, and while this is "simply observation," he says, if the pattern holds, shallow quakes should warn of the next round.

blast temperatures

With a resourcefulness that even Sherlock Holmes, the best known forensic geologist, would be proud of, scientists at Sandia National Laboratories in Albuquerque, N.M., have deduced the temperature of the May 18 blast from car taillights, turn signal indicators, dashboard knobs and camera bags. By reproducing the conditions that fried, bubbled and melted such items, M.J. Davis and co-workers conclude that temperatures in the so-called blast zone approached 650°F for a few minutes and then dropped to between 250° and 350°F for several hours. Temperatures were hottest northeast of the mountain, Davis says.

The researchers recovered various blast-damaged plastic parts from vehicles in the destroyed area, mapped their location and reconstructed the responsible thermal conditions using identical or similar items. A vinyl camera bag was found, for example, with camera and film intact but with large chunks of pumice melted onto the exterior. "In true scientific fashion," says Davis, "we heated rocks in an oven, threw them at the bag and at 300° they stuck to it." Upper limits were determined by noting that certain high-melting-temperature polymers were not affected and that extremely high temperatures were required to produce the densely packed bubbles found in some materials. The occurrence of the high-temperature pulse was inferred from the partial melting of taillights and other items.