VOLCANO!

Mt. St. Helens has already become a researcher's mecca, but the work is only beginning

BY SUSAN WEST

Wide World

Quiet for more than a month, Mt. St. Helens threw ash 10 miles high on July 22.

Fed. Emerg. Mgmt. Ag.

Once upon a time, according to one version of a Klickitat Indian legend, a great stone bridge called the Bridge of the Gods spanned the Columbia River. The Great Spirit was very proud of the bridge, and he told two of his sons to look after it. One son, Wyeast, ruled the tribe that lived south of the bridge, and another, Pahto, ruled the tribe north of the bridge. The two tribes lived in peace until their chiefs both fell in love with an exquisite maiden named Loowit, who had once been an ugly hag but was transformed by the Great Spirit. The brothers waged a cataclysmic war over the maiden, hurling fire and hot rocks at each other across the river. In their fury, they devastated the countryside and destroyed the Bridge of the Gods. Angered, the Great Spirit turned all three into mountains. Wyeast became Mt. Hood, Pahto became Mt. Adams and Loowit was to remain forever between them as the fair Mt. St. Helens.

Since that time, other, less romantic notions have supplanted the Indians' explanation for the existence of the three volcanoes. And since Mt. St. Helens rumbled awake this March, a much different tribe, composed of geologists, biologists, atmospheric scientists and others, has gathered to interpret the mountain's actions. Already, the tale of the monstrous May 18 eruption — what preceded it, the consequences of that blast and the three that followed on May 25, June 12, and July 22, and the volcano's future — are taking root in scientific lore.

To the geologist, Mt. St. Helens is known as part of the Cascade range, which includes 15 major volcanoes and stretches about 700 miles from Mt. Garibaldi in British Columbia to Lassen Peak in northern California. It is the North American slice of the "Ring of Fire," the volcanic circle that rims the Pacific Ocean through South America, Japan and the Aleutians.

All the Ring of Fire volcanoes have the same geological origin: They result when one of the earth's continental or oceanic plates slides beneath another. In this process, called subduction, the descending plate reaches regions of high temperature and pressure and partial melting occurs. The lower-density melted rock, possibly a mixture of materials from the descending plate and from the base of the overriding plate, rises to the surface.

The melted rock, called magma while it is still underground, achieves its violent character from the gases and the silica and water it contains. Under tremendous pressures at the depth where magma forms, water and gases are greatly compressed and dissolved in the magma. If the magma contains little silica, like that of the Hawaiian volcanoes, it flows easily and releases its gases readily as it rises to the surface. If the magma contains more silica, as in the case of the Ring of Fire volcanoes, it is more viscous and tends to clog the volcano's plumbing. When this thicker magma rises, the crystals that were saturated at high pressure with water and gases become supersaturated at lower pressures, the expanding water and gases are contained until they burst out of the magma and, as one researcher says, "the magma froths and boils over and the gases expand like mad." And there you have it — a violent eruption of ash.

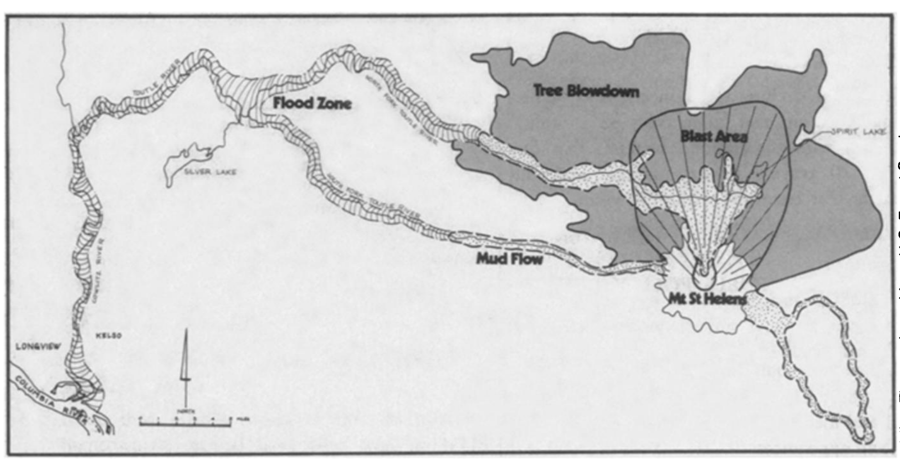
That's just what scientists had expected at Mt. St. Helens since March 20. At 3:47 p.m. local time on that day, a regional seismic network operated by the University of Washington and the U.S. Geological Survey recorded a Richter magnitude 4 earthquake just north of the summit of Mt. St. Helens. "At first we thought it was a tectonic-type event [caused by movement along a fault], but the aftershocks continued," recalls Eliot Endo, a USGS scientist working at the university seismology center. "By Saturday night [March 22] it seemed more like magma was intruding into the mountain .... By Tuesday afternoon [March 25] the activity reached a peak and we were sure we had a volcanic swarm." Endo explained that a tectonic-style earthquake is characterized by a main shock followed by aftershocks that diminish in size and frequency. "Volcanic" quakes are a series of moderate-sized, shallow (less than 5 kilometers deep) quakes that are probably due to rocks breaking under the force of moving magma.

Mt. St. Helens's first eruption since 1857 came on March 27. A plume of steam and ash rose about 6,600 feet above the volcano. This was the first of many moderate eruptions that continued intermittently for the next six weeks. In the meantime, the total number of earthquakes declined, although the number larger than magnitude 4.0 climbed from an average rate of 5 per day in early April to 8 per day during the week before the May 18 blast. As a result, says Endo, the total amount of energy released each day by the earthquakes remained about constant. By May 1, the earthquakes were clearly clustered in an area with a radius of 3 miles and centered about 1.2 miles directly north of the summit crater.

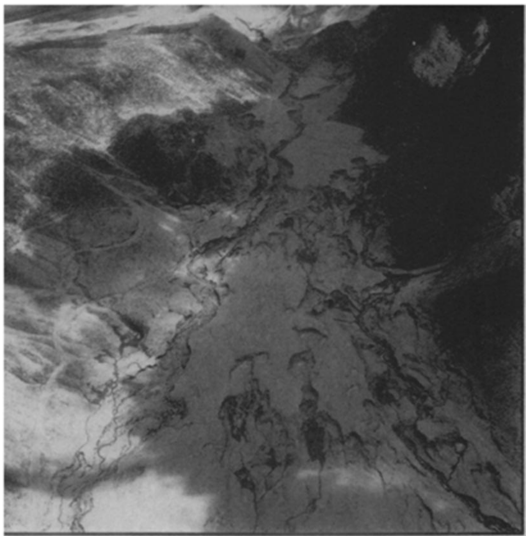
FEMA

Those earthquakes were clustered, the geologists found, in the same place as another interesting phenomenon — a rapidly growing bulge on the north side of the mountain. First spotted after the March 27 eruption, the bulge was initially studied by comparing aerial photographs and later repeatedly surveyed by James Moore and Donald Swanson of the USGS in Menlo Park, Calif., and Peter Lipman of the USGS in Denver. By the end of April, the bulge was 1 mile long and 0.6 mile wide and expanding horizontally at a very

USGS



Volker Zinser adapted from U.S. Forest Service map



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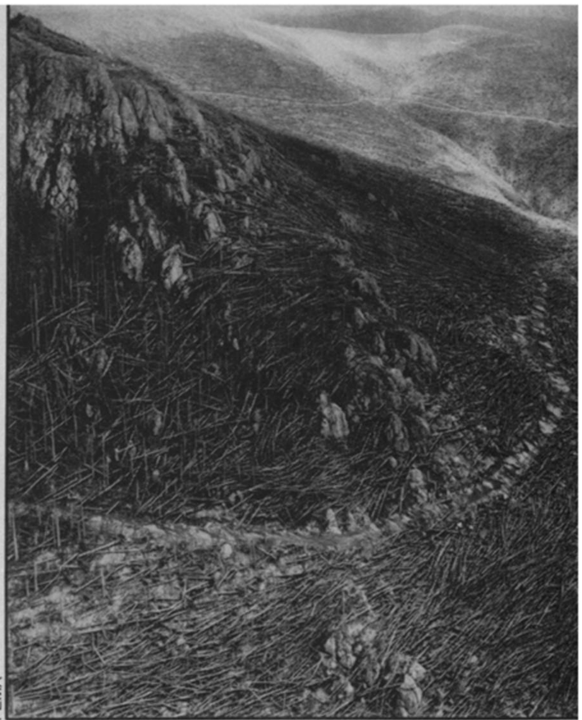

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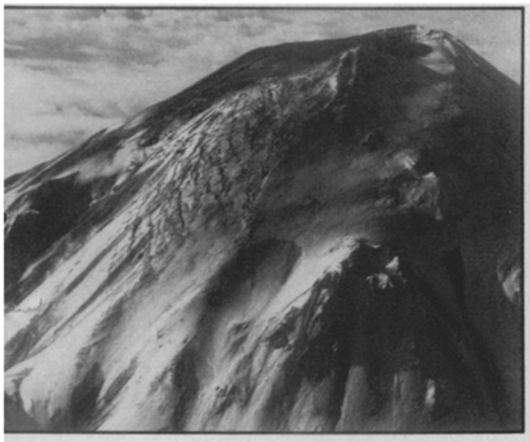
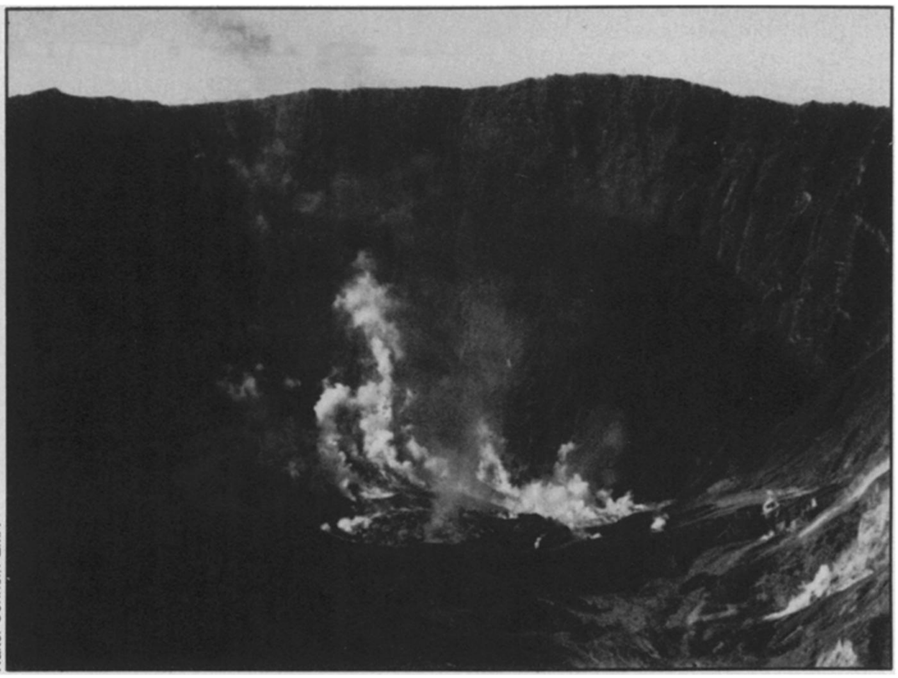
After the May 18 blast: Collapse craters (left), burned out fumaroles and heaps of debris form "moonscape" at base of volcano. Run-off from recent rains (top left) cuts gullies in mudflow. Now-cooled pyroclastic flow (middle), made of rocks and ash and propelled by hot gases, lies frozen at 7,980 feet up the mountain. Patterns of fallen trees (top right) mark blast path.



On April 7 north flank (above) shows ominous bulge — distinguished by extensive cracking. May 18 eruption removed the bulge and 1,300 feet of the mountain's peak. From June 15 until it was blasted out by the July 22 eruption, a fuming 250-foot-high lava dome (lower center) grew in the mile-wide crater.

Walter Conner/FEMA



steady rate of 5 feet per day — "as if the mountain was splitting," says Robert Tilling of the USGS in Reston, Va. "Clearly," says Robert Christiansen of the Survey's Menlo Park office, "it was deforming because magma was intruding."

With an eye cocked toward the foreboding bulge, scientists were also measuring the gases being given off by the volcano. Sulfur dioxide gas (SO_2) is less soluble in magma than are other gases, according to Richard Stoiber of Dartmouth College, and an increase in SO_2 has been found to correlate with increased activity in some volcanoes. Stoiber, Lawrence Malinconico and Stanley Williams found that Mt. St. Helens released SO_2 at a rate of about 30 tons per day during the steam eruptions before May 18. Volcanoes that are actively erupting fresh magma give off SO_2 at a rate of as much as 1,000 tons per day, says Malinconico, and the researchers concluded that Mt. St. Helens was not yet kicking out its pent up magma.

By monitoring all these things — the seismicity, the bulge and the gases — the researchers expected to see some change that would warn them of an impending large eruption. In particular, says Tilling, they expected to see an increase in the SO_2 given off, the build-up of earthquake activity often detected before eruptions or a "logarithmic increase" in the deformation of the bulge that would signal it was reaching its breaking point.

But no anomalous seismic activity occurred before May 18, the SO_2 was still low and at 7:00 a.m. local time that morning the bulge was still swelling at a rate of 5 feet per day. At 8:32 a.m. however, shaken by an earthquake of approximately magnitude 5, the entire north slope of the mountain unhinged along a crack at the upper edge of the bulge. As the north side of the volcano gave way, it uncapped the bottled-up gases and magma, and an eruption cloud blasted laterally above and over the collapsing slope. The avalanche and

Spirillum *bacteria, among first life detected in Spirit Lake. Botanist A.B. Adams suggests unique food chain: Blast exposed sugars in trees, allowing yeast to grow, which provide food for serphid and blow flies whose larvae eat bacteria.*

lateral blast of rocks, ashes and gas caused most of the casualties — now at 30 dead and 34 missing — and the destruction of 150 square miles. A vertical cloud of ash also rose immediately, broke through into the stratosphere and deposited measurable amounts of ash as far east as central Montana (SN: 5/24/80, p. 324).

The blast was unusual and surprising in both its direction and magnitude, say the researchers. "The magnitude was certainly within the range of expectation," says Christiansen, "but one doesn't assume that the maximum scenario is the most likely one. As far as the lateral blast, we realized it was a possibility, but again felt it was not very likely." While most volcanoes erupt straight up, lateral blasts have been observed elsewhere, he says, and points out the particularly striking parallels between Mt. St. Helens and the Soviet volcano Bezymianny, which went through a nearly identical pattern of seismic activity, ash eruptions, bulge and lateral blast. But such blasts were considered "sufficiently uncommon," he says, to be thought unlikely.

In retrospect, says Christiansen, the bulge may have been giving more clues to the character of the blast than the scientists were able to pick up. But the bulge was unlike anything scientists had seen before. "It was unprecedented," says Moore. "We were flabbergasted at the amount of movement and the size." "It was very clearly telling us that the north side was unstable, which is why that side was restricted and the loss of life so small," he continues, but experience with other bulges suggested that the worst might be a massive landslide, not the combined slide and blast.

But Mt. St. Helens is providing few backward glances. Instead, it has presented U.S. researchers with immediate, pressing problems. During the lulls between the eruptions of May 25, June 12 and July 22 — all vertically directed and weaker than the May 18 eruption — the volcano has allowed scientists to take stock of its unique effects on every aspect of the ecosystem.

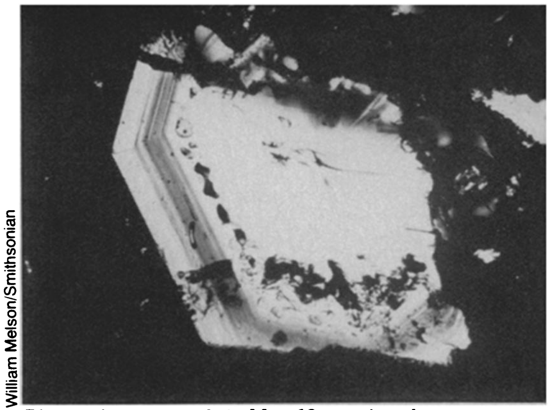
There is no other situation, for example, that poses similar problems to human health. Exposure to Mt. St. Helens's ash is not exactly analogous to exposure to industrial dust or to air pollution, says Jean French of the Center for Disease Control in Atlanta. The primary health threat from Mt. St. Helens, according to scientists from CDC and the National Institute for Occupational Safety and Health, is exposure to very fine ash particles (less than 10 microns diameter) that have been found to contain about 6 percent free silica (SiO_2). Free silica is also found in certain industrial settings — although in much higher quantities — where the lung disease silicosis has occurred. The exposure to volcanic ash, however, is not as frequent, intense and prolonged as exposure to industrial dust, says Robert Bernstein of NIOSH, and while the particles behave like those normally associated with air pollution, pollution particles do not contain free silica.

At present, says Bernstein, the only persons at risk from exposure to the free silica in the ash are those who are at risk already, such as loggers and clean-up crews, and those who may be exposed to high concentrations of the ash for extended periods of time. A recently completed study of 400 loggers confirms that they are exposed to significant amounts of free silica and should wear protective masks, he says.

The rest of the population runs "no significant health hazard from short-term exposure to the ash," says French. A two-state survey of hospital admissions and emergency room visits following the May 18 eruption shows an increase due primarily to eye and respiratory irritations, but no significant increase in cardiac or more serious respiratory problems. However, cautions Bernstein, should the volcano continue to spew significant amounts of ash — as its most recent activity indicates it might — "it will change the risk assessment."

Likewise, livestock have never had to cope with volcanic ash. Worried that the ash might be toxic to animals, James McGinnis of Washington State University in Pullman decided that "the proof of the pudding is in the eating." Using seven groups of 30 chicks, he gave one group feed containing no ash and gave the rest 10, 20 or 30 percent ash or sand in their feed. After seven weeks, McGinnis examined their intestinal tracts and fat content and found "no evidence of any effects from eating the ash." Long-term effects, however, may include lung congestion and reduced milk supply from cows that find ash-covered hay unpalatable.

The effects on wildlife are not as obvious or easily assessed. Some animals such as fish face particularly difficult problems. Those fish that survived the high temperatures — up to 100°F in some rivers — are suffering severe gill damage as the glassy ash slits the tender tissue, says Lyle Burmeister of the Forest Service. "The stuff is so abrasive it's like the gills were sandblasted," says a researcher at the Washington Department of Fisheries in Olympia.



Plagioclase crystals in May 18 pumice show glass (dark zones) and exploded water inclusions (jagged bubbles near edge.)

"We've had to throw our standards for turbidity out the window. It's not just the dirt in the water — they could survive that — it's the sharp stuff." Researchers at the University of Washington in Seattle are beginning studies to assess the size of the particles doing the damage, he says, and biologists are following migrating species as they travel up the damaged rivers.

Still other scientists are focusing on the most uncertain question of all — what will the volcano do next? Part of the answer may come from matching evidence from the current eruptions to similar bits of the volcano's past. For example, according to William Melson of the Smithsonian Institution, the glassy pumice from the eruptions of May 18 and 25 contains about 7 percent water, while the pumice from the June 12 eruption and from pieces of the dome of lava in the yawning crater — which was destroyed by the July 22 eruption — contain only 3 to 4 percent water. This means, explains Melson, that the volcano is tapping progressively less water-rich — and therefore less explosive — kinds of magma.

And that progression, says Clifford Hopson of the University of California in Santa Barbara, is similar to what has happened before at Mt. St. Helens. The pattern that Hopson sees in at least two eruptive cycles of the volcano is one or more catastrophic pumice and ash eruptions, the growth of a dome that partially or entirely fills the crater, avalanches of gas-charged ash and rocks, followed by flows of less siliceous, more Hawaiian-type lava and, finally, quiet. However, he adds, the mountain offers no conclusive evidence that it will follow that sequence. "The problem is that you can't predict at all the timing," he says. "The stage of dome growth is particularly uncertain," ranging at other volcanoes from months to one hundred years. Moreover, he adds, the volcano may quietly build lava domes and violently destroy them repeatedly — as the July 22 blast illustrates — until enough gas has been released to allow the growth of a permanent dome. And then, he says, the record sometimes shows that the volcano, "stops at the dome and doesn't go any farther."

But with a volcano in their backyards for the first time, other U.S. researchers are

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he says, "Normally it turns out that they didn't know who to ask... and went away unhappy. There are few instances I know of that someone was turned down. There is no reason for us to do that; there is plenty of work for everybody."

It conjures the image of one blind man studying an elephant and not allowing any other blind men to touch it.

Moreover, Tilling says, the USGS's small staff and the demands of the situation make it difficult to satisfy researchers' requests. But while the USGS continues to bemoan the lack of field scientists and the overwhelming task of monitoring the volcano, "all the universities are lined up waiting to get in."

According to one scientist who has repeatedly offered his services to USGS field teams, "A lot of the projects we've mentioned and we know they aren't doing, we see them out there doing the next day. So they aren't thinking of everything, but they won't let us help them." Often scientists get a classic runaround: "They say they don't want duplication in the field. So you try to find out what's being done and they won't tell you. Then you suggest something and they say it's being done. Then you ask for the results and they won't give them to you."

Many of the problems boil down to what is apparently an old sore spot in the geologic community: "It comes down to the basic question: Should a federal agency be involved in basic research?" Over the years, these scientists say, USGS scientists have become increasingly involved in basic research, and "there is always a conflict" between their roles in the publish-or-perish world of science and their roles as part of an agency assigned to hazard evaluation. Mt. St. Helens brings the conflict into focus: The most expedient way to handle a hazardous situation is to limit the number of persons who have access to information, but in doing so the Survey has assured that they will be the ones to publish, while others perish for lack of data. This is not the role that most scientists envision for a government agency: "One would think that the federal government would be out there to help the community of scientists rather than make more rules and make things more difficult."

None of the scientists interviewed by SCIENCE NEWS feels that the agency is deliberately withholding information or trying to prevent research from going on. "Some things happen by default," says one. "I got to know some of them and I can't believe from talking to them that they would keep people out." All agree with Tilling, who says, "It's a difficult trade-off between what is safe and what needs to be done now." He adds, "The situation has caused our people a lot of grief. It's put them in the role of policemen and they don't have that ability and it doesn't make them very popular." But researchers maintain that the police role is unnecessary: "Scientists have always reckoned these risks well worthwhile. There is no real excuse for restrictions, other than a waiver of liability, to unlimited access by scientists," says one in a letter.

However, says one scientist who has worked closely with the Survey, the agency is mindful of a recent volcanic episode where too many scientific cooks with too many hypotheses brewed an embarrassing stew. In 1976, when the volcano La Soufrière began rumbling on the Caribbean island Guadeloupe, volcanologists could not agree on what the volcano might do next or on the need for evacuation. Lacking any scientific guidance, local authorities moved more than 70,000 people from the area for 15 weeks, creating tremendous social and economic burdens for the island. In part to assure that conflicting scientific opinions do not create a similar, potentially hazardous situation in Washington State, suggests this scientist, the USGS is releasing few data.

Regardless of the reason, "It's an inhibition of our right to information by the federal government," and these researchers feel the situation could have been handled better from the start. In a letter to a federal official, one researcher claims, "The present complicated and multiple restrictions ... [are] preventing complete coverage of one of the most important scientific events of the century. The highly competent U.S. Geological Survey scientists have not (and never have been) able to monitor all the aspects of any geologic event, much less one of this magnitude. Geology has always relied upon professional competence outside the Survey."

They are like a small child with a sucker— they won't let go.

Pointing out that most U.S. experts in volcanology are not employed by the Survey, these researchers suggest that an advisory board of university, industry and government scientists should have been established to direct the research effort. "Obviously, the Survey should have called together local scientists and other volcano experts, but they never have—never got in touch with them at all."

According to Tilling, such a committee may be in the planning stages—albeit four months after Mt. St. Helens first erupted and two months after its historic blast. Says Peterson, who has encouraged the formation of an advisory board: "We've got to do something. The Survey is opening itself to heavy criticism if it seems to have exclusive rights to the mountain." □

... Volcano

taking a no-holds-barred approach to trying to predict Mt. St. Helens's next move. A prime candidate for a predictive tool is the volcano's seismic activity, since earthquakes are assumed to be the external signal for the rise of magma. Before the eruptions of May 25 and June 12, for example, the amplitude of harmonic tremor—a constant, rhythmic movement of the earth usually detected at volcanoes — built gradually to a peak, dropped off sharply and built again immediately before the explosions. Similar patterns have been observed at Japanese volcanoes, says John Dvorak of the USGS. No harmonic tremor, however, preceded the July 22 eruption. University of Washington seismologists detected a series of small quakes — most less than magnitude 2 — that increased in frequency throughout the day; that sort of sequence, if better understood, may also be useful in prediction, they note.

Based on studies in Hawaii and Iceland, other researchers are trying to piece together geological clues and the emissions of gases such as sulfur dioxide, hydrogen and carbon dioxide. With researchers from the USGS, Stoiber and co-workers from Dartmouth have been monitoring SO_2 emissions since shortly after the May 18 eruption. According to Tom Casadevall of the USGS, the SO_2 emissions increased from a rate of 30 tons per day to a rate of 100 to 250 tons per day during a three-week period after the May 18 eruption and rose again to a rate of 1,000 tons per day in early June. The researchers have also recently installed instruments to measure carbon dioxide emissions from the crater as well as hydrogen gas, which diffuses through the rock as magma moves inside the volcano. There may be a correlation, suggests Casadevall, between an increase in gas emissions and the onset of harmonic tremor and swelling, or inflation, of the volcano. At least one such event occurred in late June, says Casadevall, and the researchers hope to see others.

Whatever Mt. St. Helens decides to do next — and the most recent explosion points out that the show is far from over — scientists stand only to gain, says Tilling. By catching a volcano in the act, researchers will be able to study many aspects of the volcano's behavior that are not preserved in rocks from past eruptions, Hopson points out. "We will learn as much from this as possible on how to better do hazard assessment and build on this to analyze the hazards from other volcanos," says Tilling. To that end, the Survey has requested funding to establish a permanent Cascade volcano monitoring system. If approved, the system may allow researchers to distinguish small-scale precursory changes from normal variations or cycles in such behavior as seismic activity or inflation of the volcano. In the meantime, the long-reticent maiden continues to remind her geologic suitors that the full story is not yet told. □