WATER FACT SHEET
U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

CAN RAIN CAUSE VOLCANIC ERUPTIONS?

Volcanic eruptions are renowned for their violence and destructive power. This power comes ultimately from the heat and pressure of molten rock and its contained gases. Therefore we rarely consider the possibility that meteoric phenomena, like rainfall, could promote or inhibit their occurrence. Yet from time to time observers have suggested that weather may affect volcanic activity. In the late 1800's, for example, one of the first geologists to visit the island of Hawaii, J.D. Dana, speculated that rainfall influenced the occurrence of eruptions there. In the early 1900's, volcanologists suggested that some eruptions from Mount Lassen, Calif., were caused by the infiltration of snowmelt into the volcano's hot summit. Most such associations have not been provable because of lack of information; others have been dismissed after careful evaluation of the evidence.

The types of eruptions most likely to be influenced by weather are small ones that expel only rock fragments entrained in steam or magmatic gas, and no new lava. In at least one series of such eruptions, at Mount St. Helens, Wash. between 1989 and 1991, an association with rainfall has been statistically documented.

THE GAS ERUPTIONS OF 1989-91: SMALL BUT POTENTIALLY DEADLY

Between August 1989 and June 1991, after nearly 3 years of quiescence, Mount St. Helens produced 6 small eruptions of gas and pulverized debris from the still-hot lava dome. On 22 more occasions, seismographs recorded shaking of the sort associated with gas eruptions. During 4 of these 22 events, observers verified that no eruptions had occurred. The remainder took place when the dome could not be observed, though later visits found no new ash or other evidence of eruptive activity.

Some blasts were powerful enough to hurl blocks of rock a meter (3 feet) in diameter as far as a kilometer (0.6 mile) from the vent and to destroy three nearby seismic stations. Plumes of ash that wafted up to 5 kilometers (3 miles) above the crater floor were carried by wind nearly as far as Yakima, Wash., 140 kilometers (90 miles) away, and in one case prompted flight cancellations at the Portland, Oreg. airport. Within the crater, debris was ejected or avalanched northward onto the crater floor (fig. 1). Some of the hot ejecta mixed with snow and produced small floods or slurries of rock and water (termed debris flows) that flowed out of the crater.

Compared with the eruptions of the early 1980's these events were small, but had there been visitors in the crater the eruptions could have been deadly. In January and March 1993, eight volcanologists and three tourists lost their lives in two similar explosions in South America: at Galeras Volcano in Colombia and Guagua Pichincha Volcano in Ecuador. Another explosion of this type killed nine tourists on Mount Etna, Italy in 1979.

Small gas eruptions are potentially deadly because they are hard to predict. Between 1981 and 1986, magmatic eruptions at Mount St. Helens were preceded by uplift of the crater floor and by earthquakes. In nearly all of those cases, scientists accurately predicted eruptions a few days to a few weeks in advance. No such precursors preceded the gas eruptions in 1989-91.

THE ASSOCIATION WITH STORMS

At Guagua Pichincha and Mount Etna, scientists suggested that the deadly explosions were associated with rainfall although they did not have enough information to document it.

Figure 1: Mount St. Helens dome following an explosion on November 5, 1990. Eruption vent shown by white arrow. A flood channel (f) was scoured by snowmelt through the main eruption deposit (d) and was then covered by snow. Blocks that pepper the left side of the crater were ballistically ejected from the vent.

At Mount St. Helens, the association is well documented. Of the six confirmed eruptions, all took place within 3 days after a major storm (fig. 2). The eruptions not only followed individual storms, they also tended to occur after sequences of storms lasting many days to a few weeks. Statistical tests show that the chances are very small (one in many thousands) that this correlation is coincidental. Of the remaining 22 explosion-like seismic events, most (but not all) also followed storms.

WHAT IS THE CAUSE?

Seismic and other evidence show that the source of gas in the Mount St. Helens eruptions came from well below the dome. An increase in earthquakes below the volcano between 1987 and 1990 may have been an indicator of this rising gas. The gas presumably ascended to the base or interior of the lava dome and discharged explosively following storms.

How could rainfall have caused the release of this gas? A little information on the dome might provide some clues. From magnetic measurements, we know that the interior of the dome is still hotter than 350° C (650° F)--hot enough to ooze like warm tar--even though the outer several tens of meters of the dome has solidified (fig. 3). Over time, the dome cools from the outside inward. As it cools, the rock shrinks, fractures, and opens pathways to greater depth. Cooling and fracturing take place primarily during storms when water flows into the dome.

At the surface the pervasive growth of cooling fractures has caused entire outcrops to disintegrate to piles of rubble. Cooling fractures also reduce the strength of rock masses that cling precariously to the dome's slopes, promoting slides and avalanches of debris. Between 1989 and 1991, large avalanches removed massive amounts of rock from the vent area (fig. 3). Much of the avalanching appears to have occurred during eruptions, although it is not known whether the eruptions caused the avalanches or vice versa.

One could speculate at least two ways that rainfall could have caused these eruptions. First, during storms, some fractures may have opened pathways for the release of pressurized gas from within or below the dome. Second, storms may have triggered rock slides or avalanches that exposed zones of pressurized gas. In either case, the infiltration of water into the dome probably acted to open some escape route for gas that was already present.

COULD IT HAPPEN AGAIN?

As of mid-1993, earthquake activity that peaked in 1987-90 below Mount St. Helens had decreased nearly to pre-1987 levels. If, as suspected, these earthquakes signalled the rise of gas that caused the eruptions, then new eruptions are not likely to occur in the near future. Beyond mid-1994, the likelihood of future eruptions is unknown. Mount St. Helens is still active and potentially dangerous.

FURTHER READING

Mastin, Larry G., 1994, Explosive tephra emissions at Mount St. Helens, 1989-1991: The violent escape of magmatic gas following storms?: Geological Society of America Bulletin, in press.

For further information, contact: U. S. Geological Survey, Cascades Volcano Observatory, 5400 MacArthur Blvd., Vancouver, WA 98661 tel. (206) 696-7693.

Open-File Report 93-445 L.G. Mastin, 1993

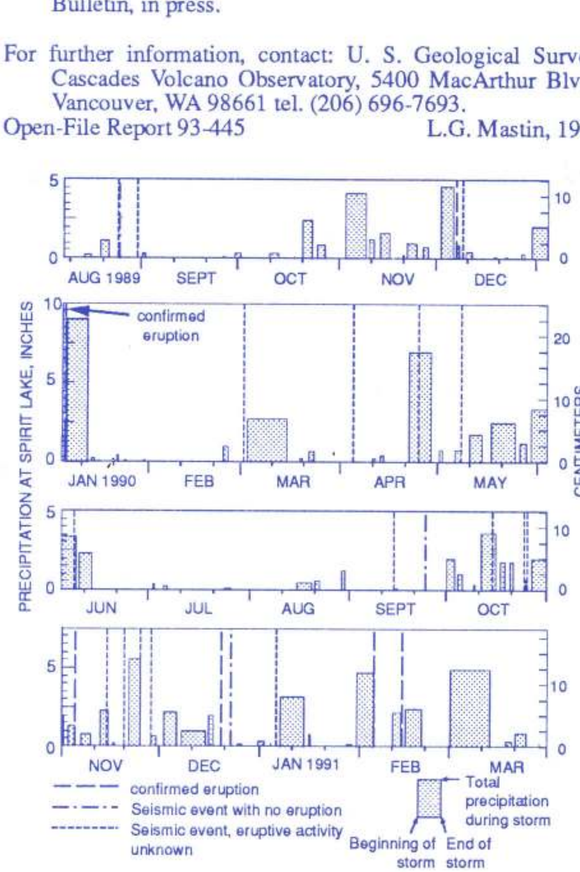

Figure 2: Timing of storms and explosion-like seismic events at Mount St. Helens, 1989-1991.

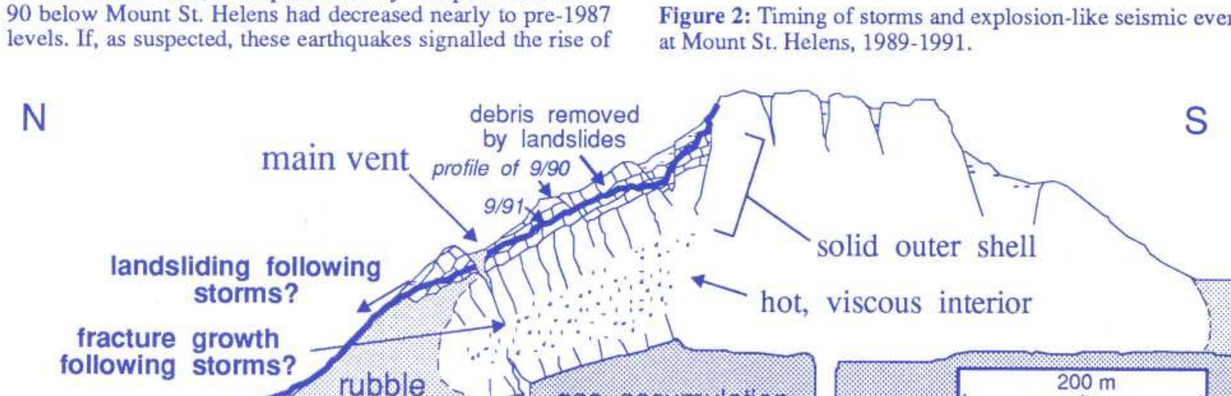

Figure 3: North-south profile through the the lava dome, with a speculative sketch of the interior structure on the dome's north side. The heavy line on the north side of the dome indicates the change in the dome's profile due to rock avalanches and explosive activity between September 1990, and September, 1991.