Volcanoes to Keep an Eye on

The western United States has scores of volcanoes likely to erupt in the future; some of them may be waking from long slumbers

How does a volcanologist distinguish between a harmless pile of old lava and ash and the next Mount St. Helens? When that mountain erupted in 1980, it had been dormant since 1857, only yesterday to a geologist but long enough for the memory to fade from the public's mind. Even 50,000 years of quiescence may not be enough to silence some volcanoes, as evidenced by the recent rumblings at Long Valley east of San Francisco. Even a million years of dormancy can be interrupted by a major eruption.

One way of assessing future hazards is the determination of a volcano's recent behavior from the study of its rocks. The U.S. Geological Survey (USGS), which is making such a nationwide assessment, has recently released a preliminary list of more than 35 U.S. volcanoes that are likely to erupt in the future, along with a caution that Mount St. Helens could be only the harbinger of renewed volcanic activity in the western United States.*

Volcanic activity is widespread in western North America, but it had managed to seem rather innocuous until the eruption of Mount St. Helens. Many of the active volcanoes of the United States are in Alaska, where they are too isolated to do great harm, or in Hawaii, where the fluid lava quietly oozes across the landscape. More violent volcanic eruptions riddled the American West in prehistoric time. Robert L. Smith and Robert Luedke of the USGS in Reston, Virginia, have compiled a map of geologically recent eruptions that shows 75 centers of activity arrayed in linear bands extending from the north-south trend of the Cascades in Oregon and Washington eastward through Idaho to Yellowstone, and southeastward along the entire California-Nevada border. Another band curls from southeast Utah through Arizona and New Mexico. Because the pattern of activity 5 million years ago closely resembles the pattern since 10,000 years ago, Smith and Luedke concluded that all 75 centers may have the potential for future eruptions, and new centers of activity might form within these broad bands at any time.

One way to separate the dangerous volcanic site from the innocuous one is to search the historical records, an exercise that suggests that the Cascades at least can be livelier than they have been in recent memory. Historical records compiled in the USGS report show that only two eruptions have disturbed the quiet of the Cascades in the 90 years prior to 1980—a minor ash eruption of Mt. Hood in the central Cascades in 1906 and the more spectacular eruptions between 1914 and 1917 of Lassen Peak, the southern most of the Cascade volcanoes. It was not always so. Between 1832 and 1880 four of the northern U.S. Cascade volcanoes—Mt. Baker, Mt. Rainier, Mount St. Helens, and Mt. Hood—erupted ash or lava during periods of 10 to 30 years at each volcano. Perhaps as many as three erupted in the same year.

In 1851 an eruption even came out of nowhere, much as Parícutin Volcano did one day in 1943 in a Mexican farmer's field. The 19th-century eruption spewed lava over 10 square kilometers of forest near Lassen Peak. Similar isolated eruptions have occurred in prehistoric times in northern California and southwestern Oregon, according to the report. None of these recent Cascade eruptions approached the size of the larger eruptions of Mount St. Helens since its reawakening in 1980.

After the events of the past decade, some volcanologists are wondering whether they are witnessing just the reawakening of Mount St. Helens or the first signs of increasing volcanic activity across the Cascades and the rest of the western United States. The USGS report reviews the evidence in support of this speculation. In 1975 fumarolic steaming in the summit crater of Mt. Baker increased dramatically; summit ice continues to melt at a high rate. The most likely cause, according to the report, was magma intrusion into the cone of the volcano. Since the late 1970's, earthquake swarms, which can be caused by subterranean magma movement, have been

Where the next eruption might be

The USGS preliminary assessment of the potential for volcanic eruptions in the United States lists volcanoes in order of decreasing concern, by group according to frequency of eruption, and within groups according to specific geologic hazard indicators. The first group includes volcanoes that have erupted on average every 200 years or less, have erupted in the past 300 years, or both. In the western United States, this group includes Mount St. Helens (1), Mono-Inyo Craters (2), Lassen Peak (3), Mt. Shasta (4), Mt. Rainier (5), Mt. Baker (6), and Mt. Hood (7). The second group includes volcanoes that erupt less frequently than every 1000 years and last erupted more than 1000 years ago. These include Three Sisters (A), Newberry Volcano (B), Medicine Lake Volcano (C), Crater Lake (Mt. Mazama) (D), Glacier Peak (E), Mt. Adams (F), Mt. Jefferson (G), and Mt. McLoughlin (H). The third group includes those volcanoes that last erupted more than 10,000 years ago but overlie large magma chambers. These include Yellowstone caldera (AA), Long Valley caldera (BB), Clear Lake volcanoes (CC), Coso volcanoes (DD), San Francisco Peak (EE), and Socorro (FF). [Adapted from USGS Open-File Report 83-400]

*R. A. Bailey, P. R. Beauchemin, F. P. Kapinos, D. W. Klick. *The Volcano Hazards Program: Objectives and Long-Range Plans* (USGS Open-File Report 83-400, 1983).

detected at or near Mt. Hood and Mt. Shasta.

Farther to the south, the earth has been restless as well. In 1979, after the two quietest decades since 1850, the frequency of moderate earthquakes in California shot up. Four of those moderate earthquakes struck near the southern edge of Long Valley east of Yosemite National Park, and at least one seems to be associated with magma that has forced its way within a few kilometers of the surface (*Science*, 10 June 1983, p. 1138). Earthquake swarms have been striking 150 kilometers to the south in the area of the Coso Range, another volcanic area that last erupted about 40,000 years ago. And Yellowstone caldera was hit by an earthquake of magnitude 7.1 in 1959. Its floor rose a maximum of 70 centimeters sometime between 1921 and 1975. The California seismic activity, at least, could conceivably result from a regional change in the stress felt by the crust (*Science*, 12 June 1981, p. 1258).

The USGS report notes that all this activity has prompted some to speculate "that the Cascades, and possibly other western U.S. volcanoes, are on the threshold of another episode of increased eruptive activity similar to that of the mid-1800's." More restrained observers recognize this speculative possibility but find no evidence of a trend. The appearance of seismic swarms in the Cascades, for example, could reflect the previously inadequate monitoring of the area. They also point out that volcanologists' understanding of volcano behavior is poor, especially during the quiet times between eruptions. At most volcanoes, distinguishing between behavior precursory to a major eruption and the harmless murmurings of a slumbering volcano is hardly an art yet, much less a science.

Amid this uncertainty, USGS volcanologists are reassessing the hazards of U.S. volcanoes. In order to set research priorities, they have developed a preliminary list of volcanoes that are "potentially active and likely to erupt in the future . . . grouped in general order of decreasing concern." At the top of the list is the group of volcanoes that tend to erupt more frequently than every 200 years, have erupted in the past 200 to 300 years, or both. Mount St. Helens has been at the top of this group since anyone gave it serious thought back in the 1970's, but the Mono-Inyo Craters are not far behind. Not yet a household name, this 25-kilometer chain of lava domes and pumice craters arcs southward from Mono Lake into the western end of Long Valley. That places its youngest vents 6 kilometers north of the ski resort of Mammoth Lakes, which has understandably been preoccupied with the suspected magma intrusion 3 kilometers to the east of it on the southern rim of the Long Valley caldera.

According to the USGS report, the Mono-Inyo Craters are, after Mount St. Helens, "the most frequently active volcanoes in the western U.S. . . . during the past 1,500 years, eruptions have occurred every 200–300 years, the last being 250 ± 50 years ago. Based on these data, an eruption from some part of the chain is likely within the next 50 years." The two most recent eruptions covered the site of the town of Mammoth Lakes with ash that, nearer the vent, was "hot enough to incinerate entire forests." These craters are of particular concern because they appear to overlie a magma chamber that has reached a dangerous point in the evolution of its chemical composition. As judged from the composition of their expelled lavas, the magma remaining below the craters has become high in silica and thus viscous enough to retain large amounts of the gases that drive explosive eruptions. In its final stages, such chemical evolution can produce the kind of cataclysmic eruption that 7000 years ago created Crater Lake by collapsing the summit of Mt. Mazama, or 700,000 years ago created the 32-by 17-kilometer Long Valley caldera by spewing 2400 times the mass of ash from the Mount St. Helens eruption.

Among recently active volcanoes, the next in order of decreasing concern are Lassen Peak and Mt. Shasta, which gained their positions in part because they too seem to draw on magma high in silica and gas. In contrast, Mt. Rainier's lavas are much lower in silica, suggesting a lower likelihood of a dangerous explosive eruption. Nonetheless, it ranks above Mt. Baker and Mt. Hood because it is near heavily developed areas and has sent massive mudflows 50 kilometers and more down the surrounding valleys. The largest swept down the valley of the White River, inundating the sites of Enumclaw and Buckley and probably sending flood waters as far as Tacoma.

The hazards of the remaining volcanoes on the USGS list are even more difficult to gauge on a geologic basis because they have not erupted frequently in the recent past. The remaining eight Cascade volcanoes have experienced bursts of activity separated by 1000 years or more but have not erupted in 1000 years or more. Three of them—Three Sisters, Newberry Volcano, and Medicine Lake Volcano—have also evolved into the range of hazardous magma compositions.

U.S. Geological Survey

Restless Mt. Baker

Steam emission from the crater of 3500-meter Mt. Baker increased suddenly in 1975 to 10 to 100 times its normal rate. The increase at the Washington State volcano is the largest reported there during this century. According to historical records, Mt. Baker last erupted in the mid-19th century. Melting of the summit ice continues at a high rate.

The third group of volcanic sites on the list, those that last erupted more than 10,000 years ago, includes Yellowstone, Long Valley, and four other sites underlain by large, shallow magma chambers. The group is at the bottom of this geologically oriented list because, according to the basic principles of geology, what happened rarely in the past will likewise be rare in the future. That principle failed volcanologists at Mount St. Helens; the 1980 lateral blast was unprecedented in the geological record. Ironically, these long-dormant volcanoes are providing the most ominous signs of possible volcanic activity in the West outside of Mount St. Helens. There have been earthquakes and ground bulging at Yellowstone. Long Valley's earthquakes, seismic swarms, bulging, new hot springs, and other signs have prompted a continuing volcanic hazard alert, although the Long Valley magma chamber has produced no eruptions in 50,000 years. It seems that Nature need not strictly heed geologists' lists.

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