Volcanology

The giant Popocatépetl stirs

Servando De la Cruz-Reyna and Claus Siebe

On 30 June, Popocatépetl showered ash over Mexico City, about 72 km away, in its largest eruption since 1927. This comes after a few years of increasing activity, which could conceivably be the precursor of a huge eruption.

Popocatépetl, a 5,452-metre-high volcano, is in one of the most densely populated areas in the world. For centuries, its low eruption rate, the fertile volcanic soil, and the mild climate of the high plateau have favoured population growth on hazardous areas around the volcano. Currently, over one hundred thousand people dwell in an area that could be directly affected in the event of a major eruption, and nearly 20 million live within a radius of 80 km, where they are threatened by ash falls.

In 1993, after nearly 70 years of quiescence, Popocatépetl volcano reawakened, with increased seismic activity and gas emission from fumaroles.

This activity increased in late 1994, culminating in the early hours of 21 December in a series of small explosions at the crater. These explosions were followed by emissions of ash, which fell on several towns to the northeast of the volcano and on the city of Puebla. Around 75,000 people were evacuated from the most vulnerable towns. Pulsating ash emissions, lasting 5–20 minutes and occurring a few times a day, persisted through 1995. In March 1996, a lava dome was observed growing on the floor of the crater, and currently this lava has filled about 20 per cent of the crater's volume.

Although the lava extrusion rate seems to have decreased, ash emissions continue. Some emissions are more explosive. In April 1996, a small explosion killed five climbers trying to photograph activity at the crater rim, ignoring warnings. During 1996 and 1997, small explosions have thrown incandescent blocks of lava onto the upper slopes of the volcano. And over the past three years, Popocatépetl has been one of the largest SO₂ producers in the world. It has probably been acting as an open or semi-open system, thus allowing some sort of equilibrium to exist between the energy fed from deeper sources and that dissipated by exhalations and similar, medium- to low-level activity.

Today, we know that the present cone is not the first high volcanic edifice at this site. Geological evidence points towards a tremendous eruption 23,000 years ago, which destroyed the previous volcano. Since then, there have been many small eruptions and at least seven catastrophic eruptions which each produced several km³ of ash and pumice. The three most recent of these occurred within the period of human occupation, at about 3000 BC, 200 BC and AD 800, as shown by archaeological remains buried by ash, and pottery shards incorporated by mud flows. (The famous archaeological sites of Cacaxtla and Cholula were severely affected in this way by the AD 800 eruption.) Since AD 800, activity at Popocatépetl has been moderate.

The present episode has many similarities to the 1919–27 period of activity, which ended with the explosive destruction of the dome, forming a small crater on the floor of the main crater. The present dome has already exceeded the volume of the 1919–27 dome, although it may take several years to grow large enough to reach the lowest part of the crater rim. It has grown in a pulsating manner.

Because the area affected by prehispanic eruptions is today densely populated, Popocatépetl deserves the utmost respect and attention. Whether the current evolution will end without exceeding the levels of explosivity of the past few hundred years, or whether it leads to an eruption as large as the catastrophic event 1,100 years ago, is a question we cannot answer yet. Probability favours the former eventuality, but a larger eruption cannot be ruled out.

For this reason, an elaborate surveillance system has been established, which includes real-time seismic monitoring and observations of ground movements and chemistry; and a 'traffic light' alert code has been devised, which defines the responsibilities of the involved parties, namely, a scientific committee, the civil protection authorities and the population in danger. This code includes a simplified decision-making scheme, in which the number of options that may be taken in a particular volcanic crisis is reduced to a minimum. These colour-coded options are chosen, for each one of the hazardous regions defined by the volcanic risk map, according to the level of activity as judged by the scientific committee.

The decision-making involved in these colour-coded conditions is proving to be a difficult task. At present, the alert is at 'yellow'. The challenge is to recognize the earliest precursors that would necessitate changing the alert to a condition that may involve the evacuation of tens of thousands of people. Generally speaking, such a process involves comparison with other volcanoes. However, Popocatépetl has shown that volcanoes cannot be compared indiscriminately. Indeed, some of the observed parameters — namely, magmatic SO₂ gas production — have exceeded by a large factor levels observed at other volcanoes during their pre-eruptive phase, and even during intense explosive activity. So the main question remains unanswered. Is the present activity only another small intermezzo? Or are we witnessing the precursors of a large explosive eruption? □

Servando De la Cruz-Reyna is at the Instituto de Geofísica UNAM C Universitaria, México 04510 DF, and the Centro Nacional de Prevención de Desastres, Av. Delfín Madrigal 665, México 04360 DF. Claus Siebe is at the Instituto de Geofísica UNAM C Universitaria.

Figure 1 Ash emission earlier this year at Popocatépetl. In the background is Iztaccíhuatl, an older volcano to the north.