VOLCANOLOGY

In New Guinea, Eruption Forecasting Scores a Success

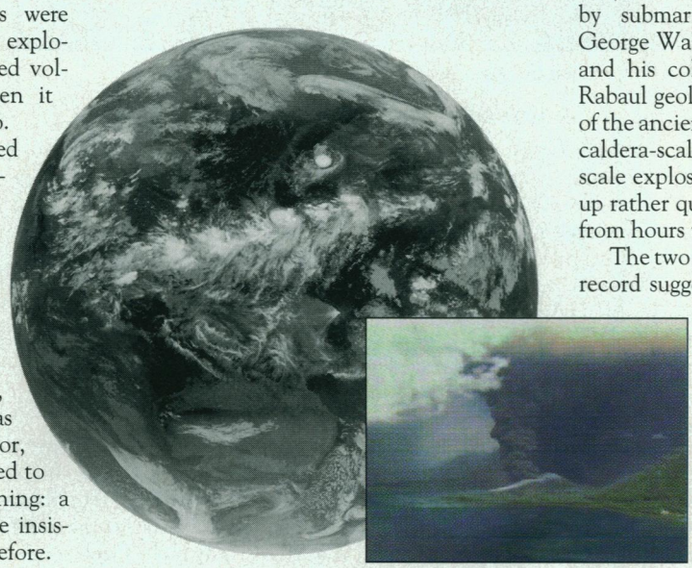
Luckily for the 30,000 residents of Rabaul, Papua New Guinea, the volcano under their feet telegraphed its punches. Its last-minute warning signals prompted the evacuation of the town on Sunday, 18 September, just hours before eruptions on either side of Rabaul's 6-kilometer-wide harbor began dumping a meter or two of ash on the town. Now residents are waiting at a safe distance to see whether the modest-sized eruptions were themselves a precursor to a full-scale explosion of the caldera—a vast, collapsed volcano that created the harbor when it formed tens of thousands of years ago.

But it wasn't luck alone that saved the residents of Rabaul, say volcanologists, noting that science also deserves credit. A 1937 eruption of about the same size, which killed 500 people, had prompted the creation of the Rabaul Volcano Observatory (RVO), now run by the Papua New Guinea government. After 50 years of monitoring the subterranean groanings, creakings, and bulgings generated as magma moves beneath the harbor floor, the RVO scientists were well prepared to appreciate the volcano's final warning: a chorus of seismic rumblings far more insistent than anything they had heard before.

Says seismologist James Mori of the U.S. Geological Survey in Pasadena, who worked at the RVO in the mid-1980s, "If the [RVO] scientists hadn't been there, there could have been hundreds dead.... This could have been disastrous." It's another success for volcano monitoring—an encore to the one at Pinatubo in the Philippines, where volcano watchers recommended an evacuation just before the mountain blew up in 1991. But it's also a reminder that for monitoring to succeed, the volcano has to do its part.

Rabaul had delivered its first strong warning a decade earlier. In 1983 and 1984, it unleashed a volley of earthquakes—some 10,000 per month. At the same time, the ground began to bulge, especially on Matupit Island in Rabaul Harbor. The unrest convinced RVO volcanologists that fresh molten rock had oozed up into a magma chamber lying just a few kilometers beneath the harbor and many of the volcanic vents ringing it. However, the unrest subsided without an eruption.

The second warning took its time coming. Until 18 September, less than 24 hours before the eruption, things had been pretty quiet. The RVO's 9 September report to the Smithsonian Institution's *Bulletin of the Global Volcanism Network* noted the relative quiescence of the past few months, except for one cluster of small earthquakes toward the end of August. Sunday morning, however, a magnitude 5 earthquake struck, and the seismic activity began to build. Innumerable small quakes shook the harbor area, especially Matupit Island, where they were felt every few minutes. These and smaller events detected only by seismographs soon merged into a continuous seismic drum roll known as "volcanic tremor," says Mori. Volcanologists have long recognized tremor as an unmistakable sign that magma is pushing its way up through rock. It was time to leave.



Sky high. Ash from Rabaul *(inset)* forms a wedge-shaped plume, seen just to the right of center on a satellite image.

The evacuation of 30,000 people—essentially the entire town, which lay at the far north end of the harbor—got under way Sunday evening by road and sea as the ground continued to shake. The operation, rehearsed many times in disaster drills, was complete before dawn on Monday when a volcanic cone on the eastern side of the harbor, called Tavurvur, burst into activity, followed by the cone called Vulcan on the west side. The vents, which also erupted in 1937, are both about 6 kilometers from the town and the RVO, where the staff remained to monitor the eruption.

According to press and relief worker reports forwarded to the volcanological community's electronic mail network by Sydney geological consultant Graeme Wheller of Volcanex International and by Kevin Vang of Macquarie University, the 5 days of more or less continuous eruption devastated the region. A meter or more of wet ash blanketed the town, destroying 25% of the buildings and damaging most of the rest. As the subterranean pressure was released, part of the airport subsided into the harbor, which was cluttered with floating rafts of pumice.

All told, the outburst was roughly the same size as Rabaul's half-dozen other eruptions since the historical record began in 1767. But it could get worse: 1400 and 3500 years ago, according to the geologic record, much larger eruptions convulsed the entire caldera, modifying its overall shape and possibly creating an inner caldera now marked by submarine seismicity. According to George Walker of the University of Hawaii and his colleagues, who wrote about the Rabaul geologic record in 1981, the texture of the ancient ash deposits suggests that both caldera-scale eruptions "began with small-scale explosions ... [and then] activity built up rather quickly to a climax," in anywhere from hours to a few years.

The two largest eruptions in the historical record suggest that this may be the typical pattern in huge caldera eruptions. Tom Simkin of the Smithsonian's National Museum of Natural History notes that Krakatau started off with a good-sized eruption in May of 1883, quieted down, and then blew itself away in August. Tambora, in the Lesser Sunda Islands of Indonesia, took 3 years of lesser activity to build to its 1815 eruption, the largest in the historical record. "That's sobering," notes Simkin.

No one is sure how to tell whether Rabaul is just clearing its throat, as it did in 1937, or is building up to a caldera-scale cataclysm. But there's plenty of speculation about what the signs might be, says Mori. Possibilities include dramatic, meters-per-day uplift of the caldera floor, a sign that the magma chamber is rapidly recharging, or a deepening of the seismic activity as new magma rises from the depths. Volcanologists have been watching for such signs at many of the world's 100-plus larger calderas, especially Rabaul, Long Valley in northern California, and Naples' Phlegraean Fields, all of which were particularly restless in the early 1980s (*Science*, 1 June 1984, p. 975). But for the next few months, the focus will be on Rabaul. Volcanologists don't want to miss its next cue.

–Richard A. Kerr

Additional Reading

C. G. Newhall and D. Dzurisin, Historical Unrest at Large Calderas of the World, *U.S. Geological Survey Bulletin 1855* (Government Printing Office, Washington, DC, 1988).

PHOTOS FROM THE MICHIGAN TECH UNIV. MOSAIC VOLCANOES PAGE; GLOBE: METEOROLOGICAL SATELLITE CENTER; INSET: "A CURRENT AFFAIR," CHANNEL NINE, MELBOURNE, AUSTRALIA, DIGITIZED BY GRAEME WHELLER