A Volcano's Hum
by Holly Davis

This writing sample is a manuscript of a "New Scientist"-type magazine article.

Listening to the heartbeat of an erupting volcano and accurately modeling its pulse will give scientists a key to predicting eruptions better. Previous computer models of the Costa Rican volcano, Arenal, represent its inner workings as an organ pipe ("What's this volcano trying to tell us?" New Scientist, 20 February 1999, p.26). New analysis of recent data suggests this model should be replaced with a more accurate non-linear model to provide better predictions.

Arenal's heartbeat is irregular. Along with regular eruptions at the summit it has a low rumble that sounds continuously. This low frequency tremor is pitched too low for human ears to hear. Microphones and seismometers capture its vibration. Mike Hagerty of the University of California, Santa Cruz used five seismometers and two microphones placed on the volcano's flanks to record both the summit explosions and the tremor, publishing some of the results recently in the Journal of Volcanology and Geothermal Research, vol 101, p 27-65. Hagerty's data show a series of harmonics that frequently sound above the base tremor.

"What makes this data so unique is the continuous eruptive nature of Arenal and the fact that we have a continuous record," said Susan Schwartz, a study co-author. This wealth of data provides Hagerty with a solid basis to examine the validity of previous models that use an organ pipe to represent the channel through which molten rock flows to the surface. When the flow is just right, the pipe is set into harmonic resonance.

This model, however, does not accurately describe the data, Hagerty says--it is too simple. Based on linear mathematics, it is easier to solve and is a logical first step, but to match the data Hagerty has had to rely on more complex models that are non-linear and involve chaos theory.

"I think linear models should be abandoned," he says. For the organ pipe model to match observed changes in the harmonic tremor, one end of it must be closed off part of the time. When the end of an organ pipe is blocked, the odd harmonics drop out and the even harmonics shift to half their original frequency. While the data show a shifting of frequencies, they do not shift far enough and the odd harmonics don't all drop out, Hagerty says. He adds that to seal off one end of the conduit as quickly as the data requires is not physically realistic. When Hagerty uses a non-linear model to portray the dynamics inside the volcano, he can exactly match the shift in harmonics.

A non-linear model not only explains many of Arenal's behaviors, but the behavior of other volcanoes as well even if they have different geometries, Hagerty says. "My feeling is volcanoes are very complicated things but if you compare them, there is a range of behavior that all volcanoes share."

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