ON SHAKY GROUND

Greek researcher claims to predict earthquakes from electrical measurements

For more than a decade, Panayiotis Varotsos, a solid-state physicist at the University of Athens, has attempted to predict earthquakes in Greece. His technique (dubbed VAN, after the last names of its three originators: Varotsos, Kessar Alexopoulos and Konstantine Nomicos) involves planting electrodes in the ground and extracting precursory electrical signals. By doing so, this researcher says, he can anticipate temblors weeks ahead. Although other scientists are also attempting to find links between low-frequency electromagnetic pulsations and subsequent earthquakes, only Varotsos has been bold enough to issue predictions on this basis. In January he and his colleagues explained some of the theory behind their method in the *Journal of Applied Physics* and were credited with predicting most major earthquakes in Greece in the pages of *Physics Today*. Such exposure lends credence to their approach, which relies on the earth's ability to transmit small electrical signals from stressed rocks over long distances. But does their prediction scheme truly have merit?

In fact, the performance of VAN is almost impossible to score. Some scientists who examined the question in detail in 1996 concluded that the forecasts had no predictive power. Others, such as Stephen K. Park, a geophysicist at the University of California at Riverside, who is trying to monitor electrical precursors to earthquakes in his home state, concluded that the Greek predictions were doing better than chance. Others said the warnings were so vague no objective test was even possible.

The largest earthquake that Varotsos claims to have successfully predicted illuminates the many vexing questions involved. In April 1995, the month before the quake struck (on May 13, near the Greek town of Kozá:ni), Varotsos sent three faxes to scientific institutes abroad noting signals recorded near Ioαnnina and predicting that a quake would occur. But the epicenter proved to be well north and east of this monitoring station, away from either of two anticipated locations and well outside the general region that he and his co-workers had at the time said this station was capable of monitoring. So in this sense, the prediction failed.

"This is purely a misunderstanding," Varotsos remarks. He points out that the focal zone of the earthquake had previously been aseismic, so he had no way to tell that this locale was also a candidate area. His explanation is reasonable, yet it reveals a key flaw in logic. If the scope of a forecast can change after the fact, then the validity of the method cannot be rigorously tested.

The Kozαni earthquake was also the wrong size. Varotsos's April warnings said that the magnitude would be either about 5.0 or about 5.5 to 6.0, depending on location. Because the May event ranked 6.6, Varotsos considers his prediction a success. (He generally claims an accuracy of plus or minus 0.7.)

In a lengthy critique, Robert J. Geller, a seismologist at the University of Tokyo and one of Varotsos's chief faultfinders, observes that the range of precision usually proffered (1.4 of these particular magnitude units) corresponds to a factor of about 1,000 in earthquake energy. For the April 1995 VAN predictions, the allowable magnitude span would be even greater (from 4.3 to 6.7 units), corresponding to a factor of about 250,000 in earthquake energy.

A 6.7 quake could cause considerable damage, but 4.3-level shaking would be only marginally perceptible. So even if Greek authorities deemed the 1995 forecast to be 100 percent reliable, they could not have reasonably evacuated a large chunk of western Greece for what might have been a pip-squeak quake in some remote spot. In fact, the prediction warned of nothing out of the ordinary. By Geller's count, Greece experienced 139 quakes in that magnitude bracket over the previous year.

Others have voiced concerns about the signals themselves. Sylvie Gruszow, then a graduate student at the Institut de Physique du Globe de Paris (IPGP), was in Greece in 1995, hoping to duplicate the VAN measurements. Her instruments also picked up the erratic electrical activity at the time. But she and her colleagues later showed that the 1995 signal resembled one recorded at the same spot by the VAN group in 1988. (Varotsos had linked this earlier signal to an earthquake some 200 kilometers to the south.)

Both waveforms were strangely regular and had curious 13-minute gaps in the midst of their oscillations, and both lasted 70 minutes overall. Gruszow and her colleagues concluded that "the similarities in shapes and durations of the 1988 and 1995 signals seem too remarkable for the hypothesis of primary sources located in two distinct tectonic areas, hundreds of kilometers apart... to be plausible." They posited that both signals came from nearby industry, a conclusion Varotsos hotly contests.

Indeed, Varotsos is dogged in defending his measurements, methodology and public warnings. But his combativeness and unorthodox style irk many scientists. Pascal Bernard, a geophysicist at the IPGP says, "He's a physicist, but he's not acting as a researcher." Geller is more acerbic, characterizing Varotsos's work as a "funky combination of science and witchcraft." Even Park, a mild supporter, notes: "I wouldn't be issuing predictions at this point."