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Scientists debate new evidence for electromagnetic earthquake predictors

STANFORD -- As a deepening voice signals a boy's adolescence, audible rumblings, shakings and ventings may warn us of geological change in the earth, according to scientists and engineers.

Enticed with tantalizing but inconclusive evidence, researchers have searched since 1982 for a signal to predict earthquakes. They have monitored extra-low frequency (ELF) and very-low frequency (VLF) radio waves from satellites and from the ground.

New findings suggest researchers may find what they seek at even lower frequencies, said Antony Fraser-Smith, an electrical engineer at Stanford University's Space, Telecommunications and Radioscience (STAR) Laboratory.

In 1989, in the days before the Loma Prieta earthquake, Fraser-Smith detected huge radio signals in the ultra-low frequency (ULF) range, 0.01 to 10 hertz, with an instrument placed 7 kilometers from the epicenter.

Scientists from five countries subsequently presented data at the recent meeting of the American Geophysical Union (AGU) in San Francisco that support a connection between ULF radio signals and earthquakes above magnitude 5.0.

Previously, Soviet, French and Japanese scientists had reported that ELF and VLF radio waves - detected by satellites - signaled the coming of mid-sized earthquakes. However, when former Stanford undergraduate Tom Henderson and his STAR Laboratory colleagues repeated the Soviet and French studies using data from a U.S. satellite and submitting the data to a rigorous statistical analysis, they found no difference in VLF and ELF emissions on days with earthquakes compared to days without temblors. Thus, they could not confirm the Soviet and French results.

"ELF/VLF is not yet a reliable frequency range for earthquake prediction," Henderson concluded during a presentation of the Stanford researchers' findings at the AGU meeting. ELF radio waves range from 10 to 3,000 hertz, VLF from 3,000 to 30,000 hertz.

"ULF radio signals can penetrate 10 to 20 miles of earth without too much trouble," Fraser-Smith said. "ELF and VLF get absorbed."

The first indication that ULF radio waves could be a much better predictor came as many scientific discoveries do - by accident.

"Our findings were complete luck," Fraser-Smith said. "We weren't studying earthquakes at all."

As part of a Navy-sponsored study to determine how natural noises interfere with satellite communications, Fraser-Smith and graduate student Arman Bernardi had been recording ULF radio waves for two years from Corralitos, a site in the Santa Cruz Mountains remote from ULF noise generated by the Bay Area Rapid Transit system. With a 6-foot antenna mounted on the ground, they monitored ULF radio waves produced primarily by solar wind as it distorts the earth's electromagnetic field, creating "background noise" that disrupts communications.

Twelve days before the Loma Prieta earthquake Fraser- Smith's detector recorded a large signal. The signal remained high until three hours before the earthquake, when it shot up even further.

"The signal was off scale, 20 to 30 times bigger than what we usually measure," Fraser-Smith said. "We nearly shut down the Corralitos system because we thought something was wrong with it."

Then the earthquake hit, disabling the system for eight hours.

Until the Loma Prieta earthquake, ULF radio measurements had not been used to monitor earthquakes. Since then, however, Soviet researchers have analyzed chart recordings of ULF signals made in the republic of Georgia during the December 1988 Spitak-Armenia earthquake (magnitude 6.9 to 7.0) that claimed more than 30,000 lives. They found changes similar to those observed by the Stanford group. Because the chart recordings were not complete (one recorder ran out of ink), and because they give less information than the Stanford computer-based measurements, Fraser-Smith said the results are encouraging but need further replication before scientists can be sure that ULF signals precede earthquakes.

But now the data are flowing in like hot lava. Scientists from Greece, China, France, Japan and the United States all presented findings at the recent AGU meeting that support the possibility that ULF signals may precede earthquakes.

No one knows what causes the signals. Stanford electrical engineering graduate student Alexandr Draganov has suggested that ground water carries an electrical current as it pushes through faults and cracks in the earth. Panayiotis Varotsos of Athens University believes rock on one side of a fault conducts electricity differently than rock on the other. When land masses with different conductivities slide past each other, Varotsos said, friction releases electricity.

Most scientists are cautious in their conclusions, knowing that publicity-seekers who erroneously predict earthquakes damage the credibility of seismologists.

Even legitimate scientists generate skepticism. Varotsos raised a few eyebrows during the AGU's earthquake prediction session when he said earthquakes may be detected with ULF waves only in "sensitive regions."

"Earthquake prediction has always been a questionable endeavor," said Stanford's Mark Fenoglio, a graduate student in geophysics who co-presided over the session. "People start to lose faith in what we (geologists) can do."

Geologists are concerned that the public will ignore legitimate earthquake warnings after someone cries wolf. An example is the New Madrid region of the Midwest, where major quakes occurred in the early 1800s. Geologists have been urging quake-resistant building codes for the area; they expect another major quake there, but so far cannot predict when it will occur. In December 1990, a non-scientific prediction of a massive quake turned up wrong, creating public exasperation and, some say, a postponement of building code reform.

"There's not a whole lot of evidence for precursor signals," said Fenoglio, whose studies of aftershocks to the Loma Prieta earthquake showed no correlation between ULF signals and aftershocks ranging from magnitude 3.0 to 5.0.

His results neither confirm nor refute the existence of precursor signals. An earthquake signal may be so loud it drowns out any aftershock signals, he suggested. Or an earthquake may have to reach a certain magnitude before detectors pick up a signal, he said.

Even Fraser-Smith is reserved.

"I'm not in the earthquake prediction business yet," he said, emphasizing the need for more studies to verify Loma Prieta's one-time finding. A finding based on only one or two occurrences runs the risk of being a fluke, he warned.

With support from the U.S. Geological Survey, he has set up two ULF detectors at Parkfield, Calif., where an earthquake of magnitude 6.0 or greater has occurred on average every 22 years for the past century. Dubbed "The Watched Pot" by geologists, Parkfield is overdue for a temblor that could put ULF detectors to the test.

"This field offers some hope but is very indefinite," said Seya Uyeda, a Texas A & M scientist who presided over the session with Fenoglio.

Uyeda has monitored electromagnetic waves in Japan, where his detectors have picked up ULF signals from electric trains, earthquakes and volcanic eruptions. He has found higher levels of ULF activity during the day, suggesting that human activity produces background noise that may make precursor signals harder to detect.

However, one hour before a November 1987 earthquake in Japan, Uyeda's ULF detector went off scale, he said. Like Fraser- Smith, he awaits further quakes to test his hypothesis.

"The question remains if any of these signals are real," said Uyeda. "We don't know yet."

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