BY GRACE V. JEAN

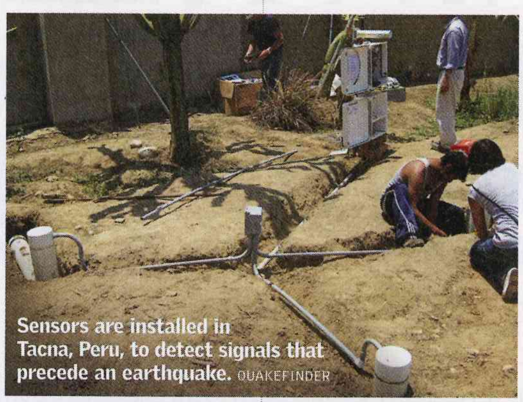
Scientists Say They Are Closer Than Ever to Predicting Earthquakes

Every time a major earthquake strikes, governments are criticized for not responding faster. The U.S. military, often called upon to assist in relief operations, usually arrives on the scene within hours or days. One way to speed up response efforts is by predicting exactly when and where a quake will occur so that authorities can mobilize in advance. But nailing down a specific time and place has remained an elusive endeavor despite considerable research by seismologists who for decades have had mixed results attempting to forecast quakes. Now new findings are offering hope.

Researchers have discovered that there are warning signs that can be detected in the weeks and hours prior to temblors. If monitored with proper sensors, the signals could help military officials better position troops for relief efforts.

Quakes result when the Earth's tectonic plates slip suddenly on a geological fault, or break in the crust. That slip releases pent up kinetic energy that travels to the surface in waves. Several million quakes rock the planet annually, the U.S. Geological Survey reports. But only a handful of those tremors reach the destructive magnitudes that cause widespread damage and claim lives.

A number of countries are investing resources to develop systems to detect the small mechanical waves that often precede earthquakes by a few seconds. But there are other signs of an imminent tremor. Casual observers have noted seeing lights in the sky for hours or days prior to quakes. Some have noticed animals behaving oddly while others have measured changes in telecommunications signals and anomalies of infrared light on the ground. These phenomena long have been dismissed as hallucinations or coincidences, but researchers have correlated them to subsequent Earth-shaking episodes.



Sensors are installed in Tacna, Peru, to detect signals that precede an earthquake. QUAKEFINDER

The cause of these seemingly unrelated occurrences has been traced to a single culprit: the rocks lying deep within the Earth's crust. As tectonic plates move, they place enormous pressure on rocks at the faults. Rocks are normally thought to be insulators. But when stressed they release particles called positive-hole charge carriers that travel tens of miles through the crust to the surface.

Friedemann Freund, a San Jose State University physics professor who is conducting rock-stressing experiments at NASA's Ames Research Center, has measured electrical currents flowing out of pressurized stones ranging in size from millimeter fragments to boulders weighing several tons. "The idea that rocks are insulators is no longer valid," he says. "If you have square kilometers of area, you can pump thousands of amperes through the Earth's crust."

That electrical current flowing miles below the crust changes the magnetic field at the surface. The positive holes collecting there ionize the air, which causes perturbations in the ionosphere, the uppermost part of the Earth's atmosphere. Those atmospheric changes can be tracked using satellites and radar systems called ionosondes.

To monitor changes on the ground, a team of scientists led by Tom Bleier, chief technology officer of QuakeFinder LLC, is deploying sensors throughout California, Taiwan and several countries in South America. The suites include induction magnetometers, air conductivity detectors, GPS and geophones, which are electronic receivers that pick up seismic vibrations.

"We're looking for a very small ripple on top of the Earth's magnetic field," says Bleier. The "ripple" is in the 1 pico-tesla range, a million times smaller than the planet's magnetic field of 30,000 nano-teslas.

In 2007, a 5.4-magnitude earthquake struck Alum Rock, Calif. Two weeks prior to the event, one of Bleier's sensors on the Calaveras Fault picked up unipolar pulsations, or signal spikes that bear resemblance to a heart beat pattern. The magnetometer measured a deflection of 20 nano-teslas. "It looked like there was a burst of energy in the ground as the rock was starting to fracture," says Bleier.

In May, the team observed similar readings from a sensor in Peru beginning two weeks before a 6.2-magnitude quake struck the city of Tacna near the Chilean border. Though it was a subduction zone event — caused by one plate sliding underneath the other instead of slipping by one another as in the California quake — it gave off the same signals. "Alum Rock and Tacna, Peru, were pivotal," Bleier says. "They showed there is a common signal we should be able to detect in multiple sensors."

The team has developed an algorithm to search for those unipolar magnetic pulses. If they see those signals, the researchers can consult the air conductivity detector for indications of ion saturation in the area about a day or two before an earthquake hits.

So far, Bleier has installed 65 sensors throughout California with funding from NASA and a satellite engineering company called Stellar Solutions. He wants to monitor the entire state by setting out a total of 200 sensors, and ultimately tie them together with data from space-based sensors.

"We think we can get maybe four, five or six independent indicators tripping off at the same time to help us not have false alarms," he says.

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