Hopes Fade for Earthquake Prediction

Japanese seismologists are not alone in looking for warning signs of the next Big One. Researchers around the world have seen signs of imminent temblors in everything from the behavior of animals to cloud patterns. In the United States, optimism over quake prediction peaked in the 1960s and 1970s as researchers developed new detection equipment designed to measure everything from changes in the shape of the land to electric signals in the ground. But so far, none of the signals has proved reliable. Nevertheless, small-scale efforts continue to monitor the following signals for hints of upcoming quakes.

Foreshocks: In 1975, Chinese researchers accurately predicted the devastating Haicheng quake based on an increasing tide of small quakes in the region. The forewarning allowed them to evacuate much of the region before the 7.3-magnitude quake, saving thousands if not tens of thousands of lives. But such crescendos are more the exception than the rule, says Max Wyss, a seismologist at the University of Alaska in Fairbanks. "Some earthquakes have foreshocks and others do not," he says, making pattern detection an unreliable gauge at best.

Bulges and creeps: In addition to measuring motion, researchers also look for changes in the shape of the ground's surface and slow slipping along known faults. In 1966, such creeping along the San Andreas fault was noticed just before a magnitude 6 quake in Parkfield, California, which has a record of earthquakes every couple of decades. And anecdotal accounts from Japan report changes in the shape of the ground prior to the 8.1 Tonankai earthquake in 1944. The problem with measuring shape changes, however, is that rainfall, drying, and natural slumping continually change the shape of the landscape, says John Langbein, chief scientist at the U.S. Geological Survey's (USGS's) Parkfield Earthquake Prediction Experiment.

Electric resistivity: Geologists have long known that ground water, with an abundance of dissolved ions, is a good electrical conductor. They've also known that tectonic stress and strain can move water within rock and change its conductive properties. Researchers measure this changing behavior by simply burying two electrodes in the ground, applying a voltage, and measuring the resistivity—how much resistance the intervening earth puts up to the flow of current. Chinese researchers claim that changes in resistivity have preceded several quakes, including the 7.8-magnitude quake in Tangshen, China, in 1976. "But there are also non-tectonic factors that can affect resistivity," such as changes in rainfall and water pumping patterns, says Leonardo Seeber of Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York.

Magnetic fields: Underground water could also give rise to magnetic signals in advance of quakes. Since rock tends to absorb electrons from water, water often has a slight positive charge relative to surrounding rock. When fracturing and straining pump water through the rock, the slight charge imbalance between them may create an electric current. The current, in turn, could generate a corresponding magnetic signal, which could be measured at the surface using magnetometers. Magnetic fields can also change when magnetic minerals in the rock are squeezed prior to a large quake. While such magnetic signals have shown up clearly during earthquakes such as the 1992 Landers quake in California's Mojave Desert, "what we haven't seen is the precursory [signal]," says Malcolm Johnston, a USGS geophysicist in Menlo Park, California.

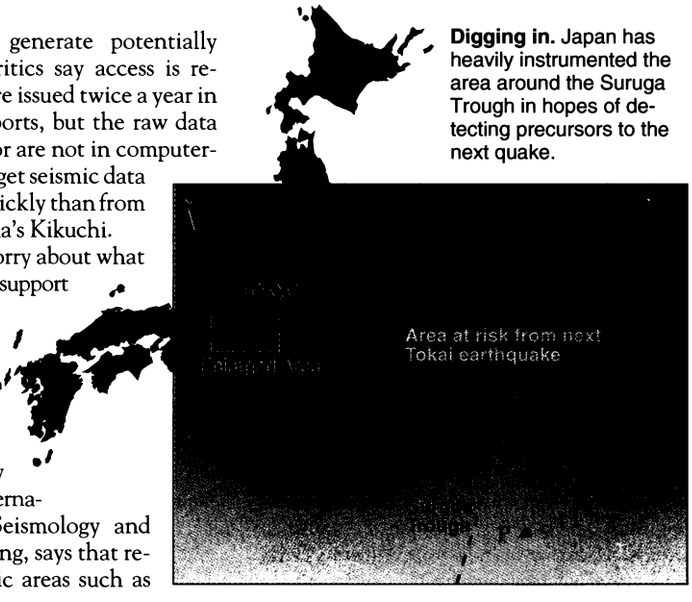
Ultra-low frequency electromagnetic waves (ULFs): A possible connection between these electromagnetic waves and earthquakes was suggested in 1989, when atmospheric scientist Antony Fraser-Smith of Stanford University measured ULFs 300 times stronger than normal 3 hours before the magnitude 7.1 Loma Prieta earthquake near Santa Cruz, California. Fraser-Smith and his colleagues believe ULFs, too, may result from fluid flow and the magnetic fields it may generate. But since Loma Prieta, Fraser-Smith points out, no ULF signals have been detected in advance of other earthquakes.

In the hope of sorting out the different predictors, USGS researchers have placed dozens of instruments near Parkfield to measure these different signals along the San Andreas fault. But because different types or sizes of quakes may be associated with different precursors (if any at all), few researchers expect the Parkfield experiment to point to a single clear warning sign. "If there were an easy way to predict [earthquakes], we would have figured it out long ago," says Langbein.

–Robert F. Service

prediction program, generate potentially valuable data. But critics say access is restricted: Summaries are issued twice a year in phone book–sized reports, but the raw data are often embargoed or are not in computer-usable form. "We can get seismic data from the U.S. more quickly than from Japan," says Yokohama's Kikuchi.

Other scientists worry about what has been sacrificed to support earthquake prediction. Although there are no central records of funding by discipline, Katsuhiko Ishibashi, a seismologist at the Ministry of Construction's International Institute of Seismology and Earthquake Engineering, says that research into more basic areas such as earthquake source physics, crustal dynamics, and seismotectonics is being neglected. "We are talking about projects being funded in terms of millions of yen [tens of thousands of dollars]," says Kikuchi, "while the prediction research projects get hundreds of millions of yen [millions of dollars]."



Digging in. Japan has heavily instrumented the area around the Suruga Trough in hopes of detecting precursors to the next quake.

Increasing public concern

The debate over the scope of the program and its chances of success has so far barely reached the general public. "I'm embarrassed to admit this, but until I took over this position I thought earthquake prediction was much more advanced," says Yukiko Hirakawa, an official with the Ministry of Education, Science and Culture (MESC) who recently moved into a position involving regular contact with the Geodetic Council. The council is an advisory body to MESC, but it drafts prediction research plans that get