Pre-quake quirks: Searching for predictors

In the aftermath of the 7.1 magnitude Loma Prieta earthquake that rocked Northern California last Oct. 17, researchers realized that their standard quake-monitoring techniques had failed to provide any clear warnings of the impending temblor. Now, two research teams report finding unusual pre-quake crustal signals — electromagnetic bursts and elevated gas emissions — and suggest that those, when coupled with traditional early-warning technologies, may improve the reliability of quake predictions.

One report, published in the Sept. 27 NATURE, comes from Kozo Takahashi of the Communications Research Laboratory in Tokyo and Yukio Fujinawa of Japan's National Research Institute for Earth Science and Disaster Prevention in Tsukuba. The Japanese scientists found that anomalous electromagnetic changes preceded several quakes and an undersea volcanic eruption that shook the central eastern coast of Japan in July 1989.

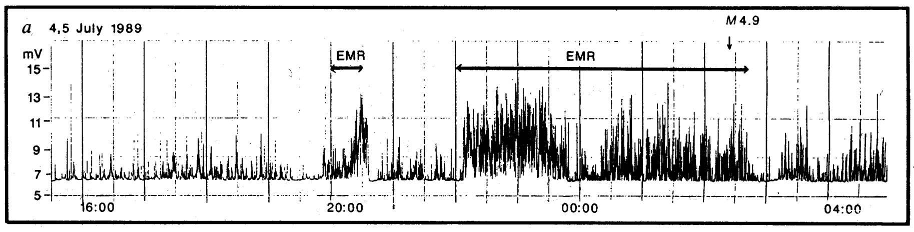
Takahashi and Fujinawa devised an electromagnetic radiation monitoring technique that effectively filters out urban and atmospheric background interference. The system measures the vertical electric field between two electrodes — a steel pipe in a 603-meter-deep borehole, and a 40-meter-wide ring of grounded wire encircling it.

On July 5, 1989, a magnitude 4.9 temblor struck off the coast of Ito, about 150 kilometers from the electrodes. Roughly six and again four hours before the quake, the monitoring system detected electromagnetic bursts in the extremely-low- and very-low-frequency ranges — between about 1 and 9 kilohertz. Sporadic bursts also occurred hours before a magnitude 5.5 quake four days later, and again the day before an undersea volcanic eruption on July 13.

Even larger pulses preceded a magnitude 6.5 quake last February, Takahashi says. He now hopes to pinpoint the source of such signals, which he believes result from the microfracturing of rock. "If we succeed in finding the location, size and magnitude of the electromagnetic source, it will be the best way to predict earthquakes," he told SCIENCE NEWS.

"I think we're beginning to home in on something here in electromagnetic measurements," says Stanford University's Antony C. Fraser-Smith. Just hours before the Oct. 17 California quake, his instruments recorded unusual magnetic signals in the 0.01 to 10 hertz ultra-low-frequency range near the epicenter-to-be. U.S. scientists have tended to ignore electromagnetic measurements for a long time, Fraser-Smith says. But after Loma Prieta, it's clear that supplementary tools are needed, he says. "We're going to have to look at a lot of unconventional things to predict earthquakes."

But Malcolm J. Johnston, a U.S. Geological Survey (USGS) geophysicist who has studied magnetic signals along the San Andreas fault since 1972, expresses reservations. "It's always possible to claim you have a precursor to an earthquake, but it's much harder to demonstrate your particular observation is related to a particular



Anomalous electromagnetic signals recorded before a magnitude 4.9 quake (arrow).

quake," he says. In the case of the Ito quakes, he notes, the electrodes were far from the epicenter.

Some scientists think anomalous soil-gas levels may also serve as quake predictors. A letter in the same Sept. 27 NATURE observes that 32 hours before the Oct. 17 quake, a soil-monitoring station on the San Andreas fault recorded a spike in helium levels at Stone Canyon, 60 km southeast of the epicenter. The concentration rose to 5,560 parts per billion (ppb), exceeding the normal range of 5,160 to 5,440 ppb, says G. Michael Reimer, a USGS geologist in Denver.

Reimer offers two possible explanations for the increase in helium, which comes from natural radioactive decay of uranium in rock. If crustal stress drops before a shock, rock pores could dilate, allowing more gas to escape. Or, pre-quake pressure waves could have released helium trapped in a buried pocket.

The Loma Prieta helium "burp" contradicts 10 years of data that show *decreases* in helium preceding San Andreas quakes of magnitude 4 or greater, Reimer says. Any of several factors could cause such drops, he says — such as stress changes that interrupt a constant flow of helium by decreasing rock permeability.

Though Reimer can't pinpoint the specific processes behind the helium fluctuations, he believes any unusual change in soil-gas levels may signal a future quake. "Gases really should play a part in earthquake prediction," he says.

Geochemist Donald M. Thomas of the University of Hawaii's Center for Study of Active Volcanoes in Oahu, is less certain. Thomas himself has observed a gradual rise and then a sudden fall in concentrations of radon before some Hawaiian temblors. But he warns, "Until you understand the process, it's going to be very difficult using gas geochemistry . . . to predict earthquakes." *— I. Chen*

Medical Nobels announced

Two Americans won the 1990 Nobel Prize in Physiology or Medicine this week for their pioneering work in life-saving organ- and cell-transplant techniques. Joseph E. Murray, a pathfinder in kidney transplants at Brigham and Women's Hospital in Boston, and bone-marrow specialist E. Donnall Thomas of the Fred Hutchinson Cancer Center in Seattle will share the prize, worth approximately $700,000.

For Murray and Thomas, the Nobel road ran counter to all prevailing medical wisdom and experience. Despite repeated surgical efforts since the turn of the century, virtually all organ transplants had ended in rejection. As recently as the late 1940s, many clinicians deemed the procedure a medical impossibility, with Nobel laureate Sir Peter Medawar averring that a mysterious biological force "forever will inhibit transplantation from one individual to another." But working first with animals and identical twins and finally with patients unrelated to their donors, the 1990 laureates helped define the poorly understood immunological mechanisms behind organ rejection and applied some of the first ways of overcoming them.

In 1954, Murray performed the first successful human kidney transplant — an operation now repeated with an 80-percent-success rate tens of thousands of times annually among victims of terminal kidney failure. He showed that total body irradiation reduces the risk of organ rejection, and obtained even better results using a newly developed immunosuppressive drug, azathioprine.

Similarly, the bone marrow transplants that each year save thousands of cancer patients' lives have their roots in Thomas' discovery that the drug methotrexate can diminish the "graft-versus-host" reaction that otherwise dooms such transplants to failure.

The Nobel Committee noted that the researchers' discoveries — especially impressive given the rudimentary state of immunological knowledge in the 1950s and 1960s — are in large part responsible for today's wide range of transplant successes on such organs as the heart, pancreas and liver. *— R. Weiss*