Predicting Parkfield

Geologists and seismologists have dreamed of monitoring the birth and death of an earthquake. If a fault near Parkfield, Calif., does what it's supposed to, they'll get their chance.

By JOANNE SILBERNER

Identify the next number in the following sequence: 1881, 1901, 1922, 1934, 1966, ... If you discarded 1934 as an anomaly, imagined 1944 in its place, saw a pattern of increases of 20 to 22 and filled in 1988, you're in agreement with the U.S. Geological Survey (USGS).

The numbers are years in which earthquakes of magnitude 5.5 or greater occurred on a segment of the San Andreas fault near the small town of Parkfield, Calif. The fault marks the meeting point of two slowly moving plates of the earth's outer crust, the Pacific plate and the North American plate, which are traveling in opposite directions. Occasionally they shudder past each other and an earthquake ensues.

Based on the relative regularity of the Parkfield quakes and what is known about the geology and seismicity of the area, the USGS in 1985 made its first-ever earthquake prediction: that there would be an earthquake of magnitude 5.5 to 6.0 in the Parkfield area by 1993 (SN: 4/13/85, p.228).

On a field trip to Parkfield following last month's Seismological Society of America meeting in Santa Barbara, scientists showed off hardware capable of measuring major and minor earthquake waves, changes in topography, movement across the fault and strains on the earth.

The instruments are there to measure the earliest rumblings of an earthquake, something never before fully quantified. The USGS has twice issued short-term alerts for aftershocks following a series of earthquakes, but the Parkfield prediction is the first long-term one and represents the first opportunity to have instruments in place before an earthquake happens.

The ability to forecast earthquakes accurately has so far eluded geologists and seismologists. "At this point we basically don't predict earthquakes," says Lucile Jones of USGS in Pasadena, Calif., one of the scientists responsible for the Parkfield prediction. Several changes thought to possibly presage an earthquake have been investigated, including the release of radon or hydrogen from soil and a change in the water table. But they haven't really panned out, she says.

The problem is that without knowing when and where an earthquake is going to occur, it is difficult to have instruments there to monitor the events that precede it. Says Jones, "We're reactive scientists; we generally have to wait for the earthquake and then respond. Here we have a chance to go in beforehand.... It's our best chance of catching one."

... And other California quakes

The Parkfield prediction specifies a place, magnitude and rough time for an earthquake. But there is no firm schedule of any sort for the millions of Californians who live near other sections of the San Andreas fault.

Lucile Jones of the U.S. Geological Survey in Pasadena, Calif., and Allan G. Lindh of USGS in Menlo Park, Calif., have developed short-term probability estimates that may prove useful for emergency planners in the San Andreas fault area. The estimates, which they presented at last month's Seismological Society of America meeting in Santa Barbara, Calif., give the likelihood of a small earthquake being followed in a few days by a large one.

They studied the seismic wave history of California since 1932 and found that overall, 6 percent of the shocks over magnitude 3 were followed by another quake at the same site. But this number varies depending on the magnitude of the initial quake, the geology of the region and the nature of the quake itself.

Jones and Lindh assumed that the next 50 years are likely to be seismically similar to the last 50 years. They also assumed that quakes that begin at the end of a segment are about twice as dangerous as midsegment quakes. "There's a little guesswork in all of this," Jones says.

Among their conclusions: A quake on the San Andreas fault segment through Point Arena has less than 0.1 percent chance of being followed by something worse. A quake in the Palm Springs area is more likely to be a problem. The magnitude 5.9 North Palm Springs quake in 1986 had a 10 percent chance of being a foreshock; when news of the quake reached USGS offices, says Jones, "We were all biting our nails."

The Indio segment, which stretches from the Cajon Pass between the San Bernardino and San Gabriel mountains to the Salton Sea, is also at high risk. A magnitude 6 quake at either end of the segment bears a 10 percent likelihood of being followed within three days by a quake 10 or 100 times bigger.

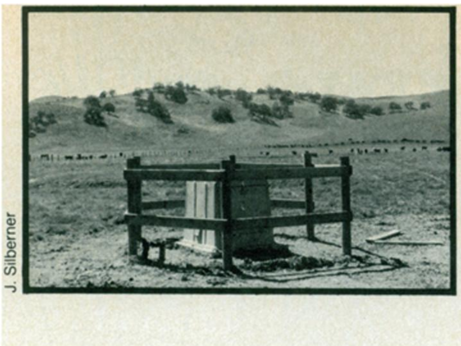
While the numbers aren't very exact, at least they're something to go on, says Jones. "If [emergency planners are] going to do anything," she says, "they're going to have to decide beforehand." While she says it would be inappropriate to evacuate Los Angeles on a 10 percent chance ("You'd kill more people in the traffic jam"), a small shock in a likely location might induce nearby communities to stockpile water, pull their fire engines out of firehouses and alert emergency personnel.

"Think of what you'd be willing to do 10 times so you'd have it once in an earthquake," Jones says. "Companies might decide not to handle toxic chemicals during that time."

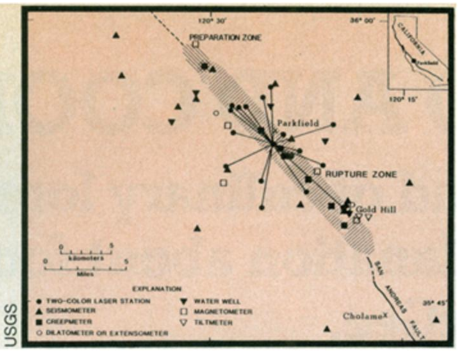
Richard Andrews of the California Governor's Office of Emergency Services in Los Angeles says that being able to make a 10 percent risk estimation "is potentially very valuable." His office is evaluating Jones's and Lindh's work to determine whether it should be adopted in planning guidelines.

Notwithstanding all the technical methods of earthquake prediction under development, one scientist at the meeting observed that there is already an accurate predictor — the scheduling of seismology meetings. In the last decade and a half, he noted with a grin, at least three significant quakes have occurred somewhere in the world while such gatherings were being held.

— *J. Silberner*



J. Silberner



USGS

Within the box at left is a strong-motion detector designed to measure the speed and strength of ground motion during earthquakes. At right, a map of the Parkfield area shows the density of seismic instrumentation as of about six months ago. The lines on the map connect a two-color laser with receiving stations; small changes in the time laser light takes to travel to each point reflect changes in the points' locations, and thus in land movement. Since this diagram was made, $2 million in state and federal money has been spent to essentially double the number of measuring devices.

Which is where Parkfield comes in. Not only has the fault had quakes on a regular, short-term time scale, but the quakes have been remarkably similar in magnitude and nature. Seismological readings of the 1922, 1934 and 1966 quakes made in the Netherlands and analyzed by William H. Bakun of USGS in Menlo Park and Thomas V. McEvilly of the University of California at Berkeley showed that the earthquakes were essentially identical. Given the regularity, the USGS made its prediction, which has been accepted by the State of California and the federal National Earthquake Prediction Evaluation Council.

The advance warning has given scientists a chance to get ready for this one and wire the area with instruments that detect seismic and geologic changes. A glance across the spring-green valleys and rolling hills around Parkfield reveals that the area is seeded with monitoring equipment. Look in one direction and you see sunlight glinting off a solar array set up to power instruments. Atop a nearby hill, a transmitter that beams data up to a satellite and back down to the USGS in Menlo Park can be seen.

Scattered across the land are seismometers capable of measuring upward as well as sideways movement of the earth, and wires spread across the fault to detect and quantify movement of the two plates past each other. There are bore holes containing devices that measure the ground strain; this equipment is sensitive enough to pick up pressure changes induced by the moon's pull on earth. And there are instruments for measuring water-table fluctuation and magnetic field changes.

In the town of Parkfield sits a "thumper," a truck capable of producing small seismic waves. Soviet scientists as well as Chinese scientists have reported that the way rock carries seismic waves changes just before an earthquake; the thumper will give U.S. researchers a chance to evaluate the contention.

In addition, a series of devices have been set up to monitor topographic changes. One, a dual laser just south of Parkfield, is used to measure distance changes from the instrument to 17 nearby detectors. And there are precisely set markers, between which distances and levels are periodically checked.

The Parkfield instruments are also intended to provide the best measurements of the changes that occur *after* an earthquake. Historically, the changes in surface structures from previous quakes are estimated by looking at such things as fence-line offsets or streambed changes. But while these provide visual evidence of plate movement, they're not precisely quantifiable.

The laser instruments, on the other hand, are capable of detecting land movement on the order of half a millimeter — the width of a pencil line.

Parkfield's earthquake is not expected to do much damage — the town has only 34 people. ("They must not be counting geologists," jokes one geologist.) The surrounding area is also sparsely populated, and the few buildings are single-story structures.

Says Art Sylvester of the University of California at Santa Barbara (UCSB), one of the organizers of the meeting, "It's a pretty ideal place for this 'test' earthquake to happen in. Not many people live there, and the place is fully instrumented."

If the earthquake happens on time, it will prove the scientists right, and provide a wealth of data. But, says Jones, it will be far from the final word on earthquakes, or even San Andreas quakes. The geology, fault structure and stresses differ from place to place along fault lines, and what is learned at Parkfield will not necessarily translate to other segments of the San Andreas fault.

"If nothing happens before the Parkfield earthquake — if every instrument is flat — it's going to be very discouraging, but it doesn't say no earthquake will be preceded by anomalies," Jones says. "And if it does have anomalies, that doesn't say we will have the same anomalies somewhere else. That's the problem of earthquake prediction — you can't just reduce it to physics."

Notes Bakun of the USGS, "If it happens and we don't see anything beforehand, we'll have to rethink our strategies." Chinese scientists who have picked up seismic changes before large quakes there have failed to find anything before earthquakes of Parkfield's expected magnitude. "A failure may mean that a moderate quake doesn't generate much in the way of precursors."

Peter Malin of USGS says data collected before, during and after the quake could allow scientists to figure out how this quake starts and stops, something that is not known for quakes in general.

Meanwhile, scientists on the project are always on call — "like obstetricians," says Allan G. Lindh of the USGS in Menlo Park, Calif. "The earthquake is waiting to happen," he says. "What we don't know is how it decides when to happen."

And with all this planning, what if the quake doesn't occur until the next century? "The model will be thrown out and we'll be thrown out," jokes Lindh. □