EARTH SCIENCE

Ominous Pattern Looms in California Earthquakes

Prophecies of doom have a long tradition in southern California, but after last month's magnitude 7.4 Landers earthquake, it isn't just the astrologers and cranks who are preoccupied with thoughts of the really Big One. "I don't know when it's going to happen," says Allan Lindh of the U.S. Geological Survey (USGS) in Menlo Park, "but I'm not the only seismologist in California who's worried now. In our hearts, we fear that it's really going to happen, that it's not just an idle possibility."

Seismologists may have been saying something like that for years, but the Landers temblor and its smaller companion, the Big Bear shock, have them really worried. For one thing, the recent quakes in the Mojave Desert, 150 kilometers east of Los Angeles, are only the latest and largest events in a pattern of seismic activity over the past 6 years that, to seismologists, suggest bigger things to come. Second, it is now clear that the Mojave quakes had direct effects on a nearby segment of the San Andreas Fault. And not just any segment—it's one of those considered a likely spot for the next big earthquake in California. Lucile Jones of the USGS in Pasadena puts it bluntly: By shifting stresses in the crust, the quakes have "made it easier to have an earthquake" on the San Andreas. "On the intermediate term—months to years—it is obvious there is an increased hazard," she continues, and "nothing guarantees it won't happen tomorrow."

The part of the San Andreas at the focus of all this concern, called the Coachella Valley segment, has always been one of the most worrisome along the entire fault. Indeed, the first comprehensive evaluation of earthquake hazard in California, released in 1988 by a working group of the USGS, rated it the most dangerous of all. The geologic record of this segment, which runs southward from near Palm Springs 100 kilometers to the eastern shore of the Salton Sea, shows that it experienced repeated earthquakes, at intervals of 200 to 300 years, until about 300 years ago. Since then, it has been eerily quiet, steadily accumulating strain that must eventually be released. The USGS working group gave it a 40% probability of producing a magnitude 7.5 quake by 2018 that would rip as far north as Palm Springs.

But even as the working group was debating the threat of the Coachella Valley segment back in 1988, additional evidence of the threat was piling up. For 100 years or more, only one sizable quake had struck anywhere near the southern San Andreas: a magnitude 5.8 event just off the Coachella Valley segment in 1948. But in the late 1980s, as Lindh recounts it, earthquake after earthquake began striking near either end of the locked segment—one near the northern end in 1986, two off the southern end in 1987, and then, last April, the magnitude 6.1 Joshua Tree quake near the northern end. The June 28 quakes added to the pattern, both falling near the northern end of the segment. To seismologists, this pattern of earthquakes bracketing a locked segment is worrisome. There's no hard and fast rule, notes Lindh, but in the past the pattern has sometimes foreshadowed a rupture of the segment itself.

And it's not only the general pattern that is disquieting, says Jones. The faults ruptured by the Landers, Big Bear, and Joshua Tree events form a rough triangle with the San Andreas as its base. The net effect of the movement along the faults has been to pull the triangle of crust away from the San Andreas, easing the stress that squeezes the sides of that fault together and keeps it from slipping, says Jones. At the same time, the movements have increased the stress along the fault that would drive an earthquake. And these stress changes are beginning to have their way with the San Andreas, as evidenced by a recent spate of small earthquakes where the newly active faults intersect the San Andreas. Says Lindh: "At this point, I'm hard pressed to see what more the earth need [do to] tell us that something is going to happen."

Still, as William Ellsworth of the USGS in Menlo Park notes, "the interpretation of seismic patterns is an inexact science." The outcome might not live up to the menacing buildup. All the pre-June activity may have simply been leading up to the Landers quake, and the San Andreas might not rupture for decades. Or perhaps, following a pattern seen in the past, the Landers earthquake will be echoed by a similar event on a distant fault, and the nearby San Andreas will hold fast.

But most researchers are now focusing on the San Andreas, wondering what it has in store. A magnitude 7.5 on the Coachella Valley segment alone would not be the Big One of Hollywood fame, but a rupture there might not stop with one segment. If the rupture broke into the next segment northward, the magnitude would rise to 7.8, and the temblor would rip by the edge of heavily developed San Bernardino. Rupture of the third segment in line—considered nearly as dangerous as the Coachella Valley segment—would make for a truly great earthquake of magnitude 8 that would continue past Los Angeles itself. Asked what part of the San Andreas worries her most, Jones has a simple answer: "I'm worried about the whole thing."

–Richard A. Kerr

AP/WIDE WORLD

SOURCE: USGS ILLUSTRATION: SUSAN NOWOSLAWSKI

California commuting. The earth slipped as much as 6 meters in the Landers quake, and it joins an ominous pattern of earlier quakes *(right)* that suggests worse to come. (Rupture zones of 1992 quakes are shown in orange.)