After Loma Prieta, Uncertainty Remains

The forecasting of last fall's Loma Prieta earthquake has re-emphasized the vagaries of quake prediction

IT SEEMED LIKE AN UNQUALIFIED SUCCESS at first. In 1988 the U.S. Geological Survey's Working Group on California Earthquake Probabilities predicted that the most likely place for a large earthquake in northern California during the next 30 years was on the San Andreas fault just north of Santa Cruz. In 1989 a magnitude 7.1 shock struck there. Forecast fulfilled and methodology bolstered, or so it seemed.

In hindsight, however, the Loma Prieta success was far from unqualified. James Savage, one of USGS's own geophysicists (and a well respected one at that), has been critical of claims by some scientists and journalists that the working group's forecast had panned out.

"I didn't find that claim to be very impressive," says Savage, who works in the Menlo Park office of the USGS. "I think you can show they didn't hit it," at least with any statistical confidence, he adds. And that, he contends, raises broader questions about how the USGS handles uncertainty in its earthquake forecasts. Since the Loma Prieta quake, Savage has been taking his employer to task—in talks and a manuscript submitted for publication—for not being more explicit about the uncertainties inherent in earthquake prediction.

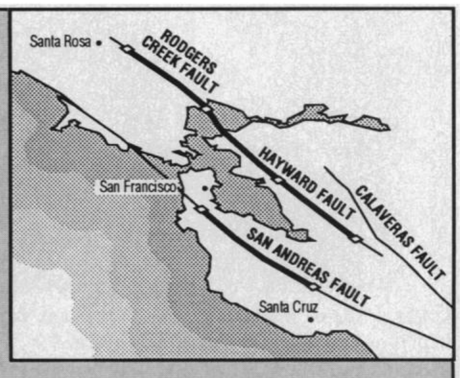
Take the Loma Prieta forecast. In 1988 the USGS group looked at how much the fault segment just north of Santa Cruz had slipped during the great San Francisco earthquake of 1906 and how fast strain had been accumulating since then. From that they a forecast a 30% probability of a magnitude 6.5 shock striking that segment during the next 30 years.

But soon after Loma Prieta hit, it became clear that the quake had missed the mark by 15 kilometers, that it had involved twice as much slip as predicted, and that the slip was not only horizontal but also vertical. Consequently, in its 1990 reevaluation of Bay Area forecasts, the group conceded that it cannot be sure the quake was the one they had foreseen. And even if it was, its timing was off. The working group had estimated that the median time after 1906 for the earthquake to recur was 126 years. This one happened 84 years later—too soon to be statistically equivalent to the estimated recurrence time.

What troubles Savage about all this is not only the allocation of credit where he feels it wasn't due; he feels strongly that the working group's initial forecast and its new revised forecasts (see box) sound too definite. The USGS group "should include a better estimate of their uncertainties," he says. "They should put their 90% confidence limits right up front, not in an appendix," where it is routinely ignored. He points out that many researchers attach uncertainties to their published probability forecasts. In the case of Loma Prieta, Savage calculates, the uncertainty of the 30% probability might have been expressed as a range of probabilities or a confidence interval of 1% to 83%.

In its defense, the USGS report does acknowledge the uncertainties in a couple of ways. One is a reliability designation ranging from A to E, with A the highest reliability. Loma Prieta's forecast got an E. The other is the group's judgment that probabilities differing by less than 10%—say, 20%

Worse News for the Bay Area



In a few weeks, San Francisco Bay Area residents will encounter bad news in a most unusual Sunday supplement. Almost 3 million magazine-style flyers, to be inserted in all the major newspapers, will spell out the area's earthquake hazard in depressing detail. The authors, including researchers from the U.S. Geological Survey, say that prospects for major quakes look even worse than before, athough questions have been raised about the reliability of forecasts for individual faults (see story). Then, to calm the resulting jitters, the supplement also includes ways residents can reduce their risk. Here is a preview of the USGS-projections.

- The chance of one or more large earthquakes striking the Bay Area in the next 30 years is about 67%, up from the 50% estimate of 2 years ago.
- About half of that increase results from the first estimate of the likelihood of a rupture of the Rodgers Creek Fault. Rodgers Creek, a continuation of the Hayward fault about 60 kilometers north of the Golden Gate Bridge, was long known to be active. But researchers had too little information on its past behavior to even guess about its future. Based on prehistoric activity revealed by new excavations across the fault, the USGS group has calculated that there is a 22% chance that Rodgers Creek will unleash a magnitude 7 earthquake within the next 30 years.
- The rest of the jump in risk can be traced to a number of changes that have insignificant effects on individual fault segments but, taken together, significantly increase the hazard for the Bay Area. The stress passed up the San Andreas fault by last fall's Loma Prieta earthquake may have hastened the next quake on the San Francisco Peninsula by a decade or two. And stress is being loaded on some fault segments slightly more rapidly than previously believed.
- The working group also noted other evidence that a large earthquake is in the offing. One sign is an apparent return to the higher rates of seismic activity that preceded the great 1906 San Francisco earthquake. Perhaps even more disconcerting is that twice in the 19th century a large quake on one side of the Bay, like last year's Loma Prieta, was followed by a big one on the other side within a couple of years.

Ending on a particularly somber note, the group concludes that other faults too poorly understood to be included among their forecasts probably threaten the Bay Area. The ominous estimate of a 67% chance of a large quake within the next three decades is probably an understatement. ■ R.A.K.

and 29%—are not significantly different.

But that is still not quantitative enough for Savage. Given the relatively huge confidence intervals he calculates for most forecasts, he sees no point in ranking risks any more specifically than being low, intermediate (10 to 90% probability), or high. Even the subjective letter system suggests more certainty than there is, he argues.

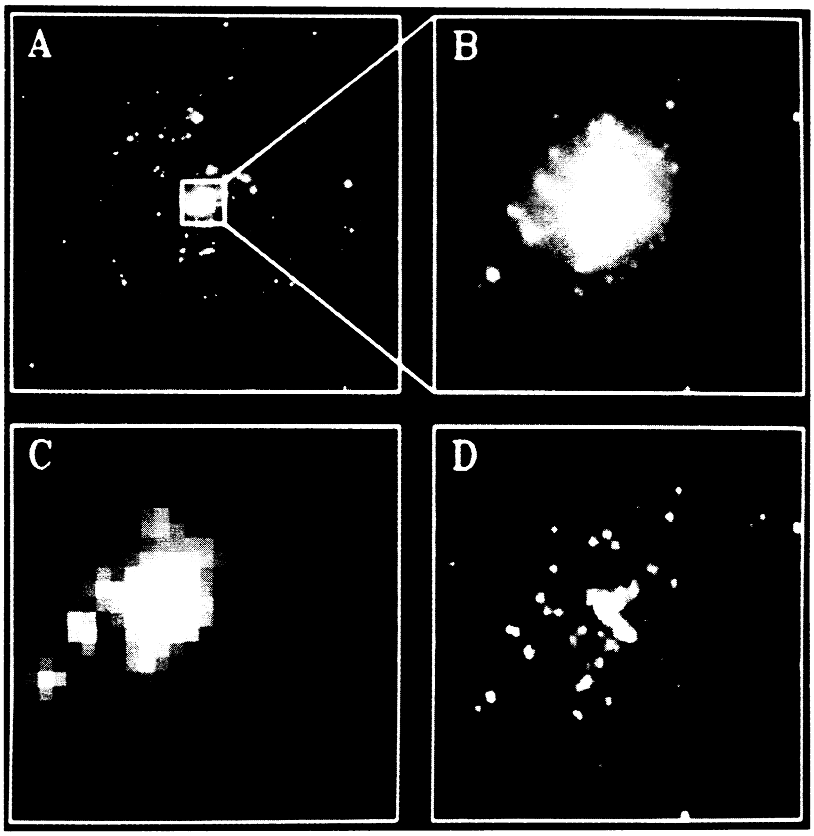
Although Savage has been waging something of a one-man campaign in his appeal for greater rigor, he does have some support among his colleagues. "I have the intuitive feeling that seismologists and geologists can't tell the difference between probabilities of 10% and 40%," agrees John Filson, himself a seismologist at the Survey's Reston, Virginia, headquarters. But Filson, like the USGS group, considers Savage's argument to be academic when it comes to public safety. In that arena, Filson says, "What's important is telling the difference between 0.1% and 10%. I think we can do that."

For the moment, at least, the USGS forecasters seem unlikely to change their practices, despite Savage's criticisms. Even statisticians do not agree on the advisability of placing uncertainties on probabilities, says James Dieterich of the Menlo Park office, who is chairman of the group. And anyone wanting more quantitative measures of uncertainty can find them by digging into the calculations in the report, he says.

While the debate continues on earthquake forecasting, the field's next test may be unfolding on the Parkfield segment of the San Andreas in central California. In 1985 the National Earthquake Prediction Evaluation Council endorsed a prediction that there was a 95% chance that that segment would break in January 1988 ± 5 years in a magnitude 5.5 to 6 shock. Parkfield (population 34) soon became the center of a dense—and expensive—instrument network intended to record and possibly make a short-term prediction of that quake.

More than 2 years past the midpoint of the target range, researchers are still watching and waiting. They could be there a while longer, says Savage. He notes that the reassuring 95% probability was premised on an unproven assumption—that the regular 22-year cycle of Parkfield quakes was back on schedule after one struck 10 years early in 1934. Drop that assumption and the probability falls to 67%, as was pointed out in 1985 by the scientists who first made the prediction. Savage's calculation comes out as a 60 ± 20% chance by 1993. With that kind of uncertainty, the wait at Parkfield could last far beyond January 1993, stretching researchers' patience as well as their budgets.

■ RICHARD A. KERR



Hot Young Stars

Having given astronomers some nasty shocks of late, the Hubble Space Telescope changed its act last week and produced a surpise of the nice kind. NASA astronomers were running routine engineering tests on the telescope when they got top-quality pictures (above) of a stellar nursery in the nearby galaxy called the Large Magellanic Cloud. The images are better than any made on the ground, proving that the $1.6 billion observatory can yield new science even before a rescue mission is mounted.

"The mood's really improved around here," says astronomer Richard L. White of the Space Telescope Science Institute in Baltimore. "There's something real—there's something we can look at and be pleased about."

Taken on 3 August by the Wide Field/Planetary Camera, the pictures show (in false color) an unusual cluster of young stars in the nebula called 30 Doradus, 160,000 light-years from Earth. Panel A shows the initial image of the entire cluster. Panel B is an enlargement of the central portion, showing a smaller cluster designated R136, consisting of very hot and massive young stars. Although the telescope's optical aberration causes each star image to be bathed in fuzz, the images do have bright "cores" no more than 0.1 arc second wide. The Hubble's improved resolution allowed astronomers to see many more stars than in comparable ground-based images, such as the one in Panel C, a photo of the same region where they couldn't discern details less than 0.6 arc second wide. Panel D is a computer-processed version of B, showing how the halos caused by the Hubble's flawed mirror can be reduced.

These images are enlightening stellar science. Astronomers can easily count 60 stars in R136, and they think that hundreds probably exist there. That's in sharp contrast to the view of a decade ago, when it was thought that the light was coming from a single star. In the new Hubble images astronomers can even make out some of the brightest stars at the center of the cluster, which may be 100 times as massive as the sun. And they're already planning follow-up studies to image fainter stars and to use spectroscopy on the brightest ones.

"This now demonstrates HST's ability to conduct crucial and important studies, even with the existing spherical aberration," says Charles Pellerin, director of NASA's Astrophysics Division. Adds Pellerin: "We will continue to study this region over the next few months, and the best is yet to come."

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