What Is Worse Than "The Big One"?

A great earthquake on the San Andreas may be inevitable, but a quake 1/30 as powerful within the Los Angeles basin could wreak greater damage

THE first thought in the minds of many residents of the city of Whittier when the first shock hit them was "Is this the big one?" the San Andreas' once-in-150-years great shaker? It might as well have been for Whittier, which is 20 kilometers east of downtown Los Angeles. The ground shook harder there this month than it will when the big one does strike the distant San Andreas, which lies 50 kilometers on the other side of the mountains. And this was only a moderate, magnitude 6.1 shock. Earthquakes of magnitude 7 and larger, 30 times more powerful, could rupture faults beneath the feet of Angelenos at any time. The loss of life and destruction could exceed that caused by the big one.

The Los Angeles region has more than one earthquake to fear because, although the North American and Pacific plates grind by each other along the San Andreas and generate earthquakes in the process, the boundary between the two plates is not that neat and clean. San Andreas–like faults split off the main fault or parallel it for hundreds of kilometers. Where the San Andreas makes a jog to the left just north of the Los Angeles basin, the side-by-side motion of these faults translates into the thrusting of one block on top of another, the mountainous Transverse Ranges being one product of this thrust faulting.

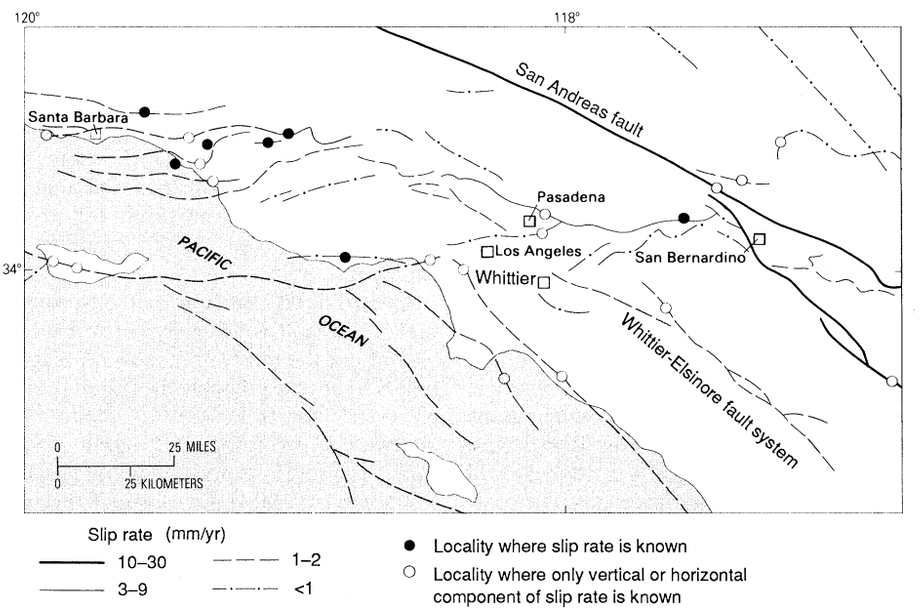
The end result is a maze of 95 identified faults that have slipped during the past million years and 41 damaging earthquakes since 1800. It is not clear to seismologists that the forty-first, which is properly called the Whittier Narrows earthquake, even fell on one of these known faults. It struck a few kilometers beyond the identified tip of the Whittier fault, which is part of the Elsinore fault system that parallels the San Andreas for 200 kilometers to the Mexican border.

According to Lucile Jones of the U.S. Geological Survey (USGS) in Pasadena, the rupture broke a section of fault that lies within 25° of the horizontal by thrusting one face of the fault over the other in a north-south direction. Because the rest of the faults in the system are at least in part San Andreas–like, Jones is guessing that this rupture was on a terminal splay of the Whittier-Elsinore system. It may be at the base of a growing fold of sediment overlying a shallowly thrusting fault in the basement rock. "If someone had asked if there was ever going to be an earthquake there," says Jones, "I would have said no."

This unexpected failure of an unseen few kilometers of fault has caused more than $125 million worth of damage, at least 3 deaths, more than 100 injuires requiring hospitalization, and an immeasurable amount of social disruption. The shaking of the ground responsible for all this reached a level of roughly VIII on the Modified Mercali Intensity (MMI) scale, according to seismic engineers. The MMI scale is based on the effects on different types of structures and runs from I—"not felt except by a very few"—to XII—"damage total." Damage during an MMI VIII event is described as "slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures."

That description seems to fit the Whittier earthquake. As a spokeswoman for the city of Whittier put it, the crumbled business district "looks like downtown Beirut." Twenty buildings there were condemned and more than 2000 homes were damaged. As earthquake engineers would have guessed, the main shock and its aftershocks picked out the old and weak structures for damage.

Shaking knocked older homes off their post foundations and dropped them half a meter to the ground, which was a bigger jolt than the earthquake could give them. Some older, unreinforced masonry buildings fell into a million pieces. "What Whittier tells us is what we've known all along," says engineer John Wiggins of Redondo Beach. "The old stuff is not going to perform as well as the new." Unfortunately, there is plenty of



The fault-riddled Los Angeles region. *The less than perfect meeting of two tectonic plates has created a network of faults. Because earthquake hazard bears some relation to the rate at which the sides of a fault slip past each other, most attention has been focused on the San Andreas with its 35 millimeters of slip per year. The Elsinore fault system as shown here slips at only 1 to 2 millimeters per year and might experience a major earthquake every few hundred years. Recent work by Thomas Rockwell of San Diego State University suggests that slip on the Elsinore may be closer to 5 millimeters per year.* [*Modified from Ziony (1985)*]

the old stuff still around. Los Angeles alone has more than 7000 old masonry buildings, only 1000 of which have been reinforced under a 1981 ordinance that requires that all be strengthened or demolished by 1992.

When the big one comes to test these and more modern structures, Whittier's damage may serve as some guide to the prospects for the Los Angeles region. Not that there is more than order of magnitude agreement among engineers about the amount of damage expected. A major source of uncertainty is the intensity of shaking that a repeat of the great, magnitude 8 earthquake of 1857 would produce. However, there is a consensus that Whittier will not be shaken as hard as it just was. The MMI might be around VII but not VIII. Most of the rest of the urbanized Los Angeles region would experience the same moderate shaking, thanks in part to the unusually efficient attenuation of seismic waves by the crust between the San Andreas and Los Angeles. In addition, it seems that a magnitude 8.3 earthquake cannot shake the ground near the fault any harder than a magnitude 6.5 event can.

But great earthquakes still deserve their reputation. Instead of the 5 or 6 seconds of strong shaking felt during the Whittier earthquake, a repeat of the great 1857 event would produce at least 30 seconds of strong shaking. For structures, that could mean progressive weakening and failure, much the way repeated bending of a coat hanger eventually breaks it. And MMIs of VII or greater would cover 57,000 square kilometers.

Another difference would be the great earthquake's far greater preponderance of low-frequency, long-period shaking capable of swaying taller buildings. Engineers are confident that the carefully designed high-rises of Los Angeles will come through in good shape, but they are less sanguine about 10- to 15-story midrises of the 1950s and 1960s whose concrete may not have been reinforced sufficiently. And then there are the imaginatively designed modern buildings that have open ground floors, multiple towers, split levels, or other configurations that create weak points or concentrate stress.

Just when the next great earthquake will test the region remains uncertain. The common wisdom is that there is a better than 40% probability that the big one will strike within the next 30 years.

Such a great earthquake would by any measure have a devastating effect on the Los Angeles region. A 1980 federal report places the damage to buildings and contents alone at $25 billion (1980 dollars). There would be 52,000 long-term homeless. Depending on the time of day that it struck, 12,000 to 50,000 persons would be hospitalized and 3,000 to 12,500 would be killed. It would be the worst natural disaster in U.S. history. Not since the havoc wreaked by the Civil War has the nation suffered such a disaster, according to the report. City, state, and federal "response to such an earthquake would become disorganized and largely ineffective."

UPI/Bettmann Newsphotos

Brick can be bad. *A single-story, turn-of-the-century brick building in Pasadena did not fare well during the Whittier earthquake. Such unreinforced masonry structures are prone to collapse during even moderate shaking.*

Things could be worse. If, for example, a magnitude 7.5 rupture, which would be about 1/20 as powerful, broke the Newport-Inglewood fault zone that slices in from the sea between the airport and downtown Los Angeles, the disaster would be multiplied manyfold. Building damage could hit $62 billion, and the homeless might number 192,000 and the injured 18,000 to 84,000. The death toll could range from 4,400 to 21,000, according to the report.

An earthquake that large on the Newport-Inglewood fault is generally deemed possible but not the most likely event. A magnitude 6.5 shock is probably the largest probable event, but that would be destructive nonetheless, according to a recent USGS study. Ten to 15 seconds of strong shaking would reach an MMI intensity of VII across 50 kilometers of the Los Angeles basin from Anaheim on the south to Santa Monica on the north. That would be destructive but not particularly unusual. All of the urbanized area of the basin has been shaken at intensities of VII or more at least once during the past 180 years, and more than half of that area has been shaken like that three times or more.

The best defense that Los Angeles has may be time. Earthquake prediction, which might save lives and improve emergency response, is still in its infancy and in any case focuses on the San Andreas, by far the best understood of southern California's fault systems. It is known to slip at a rate of 35 millimeters per year and has produced major earthquakes every century or two during the past few thousand years. Because earthquake hazard is in part proportional to slip rate, any one section of fault off the San Andreas system—which may slip at only 1 to 2 millimeters per year at most—will rupture every few hundred to every few thousand years. With that little experience with a fault, seismologists have little idea where to look for the next quake. Sediment can hide potentially active faults, and some faults, as near Whittier, need never break the surface.

Remedial strengthening of buildings in the City of Los Angeles is progressing, but such efforts are slow or absent elsewhere in the region. On the bright side, mandated reinforcement and normal attrition of susceptible structures could be well along before the big one hits sometime in the coming decades. And of course, an occasional reminder like the Whittier earthquake would only accelerate society's adjustment to the inevitable shaking that southern California must endure. ■ RICHARD A. KERR

ADDITIONAL READING

An Assessment of the Consequences and Preparations for a Catastrophic California Earthquake: Findings and Actions Taken (Federal Emergency Management Agency, Washington, DC, 1980).

J. I. Ziony, Ed., *Evaluating Earthquake Hazards in the Los Angeles Region—An Earth-Science Perspective* (U.S. Government Printing Office, Washington, DC, 1985).