Los Angeles faces a dangerous quake debt

With memories of last January's devastating earthquake fresh in their minds, Los Angeles residents may not feel geologically lucky. But they should, suggest results of three new studies.

Judging by the known faults lacing the crust beneath the city, geologist James F. Dolan and his colleagues conclude that Los Angeles has been dodging seismic bullets ever since its birth. Although stress has accumulated steadily under the metropolitan region, the city has suffered no large earthquakes and only two moderate ones in the last 2 centuries, they report in the Jan. 13 SCIENCE. In other words, Los Angeles has accrued a quake debt that must eventually come due.

"The basic conclusion is that Los Angeles is likely to face either more numerous or larger earthquakes in the future," says Dolan, a researcher with the Southern California Earthquake Center in Los Angeles.

Two other new studies reach a similar conclusion about the city's quake risk.

Many past hazard assessments for southern California have focused on the threat of great, magnitude 8.0 quakes from the San Andreas Fault, which runs within some 50 kilometers of Los Angeles. But the magnitude 6.7 Northridge quake on Jan. 17, 1994, drew attention to faults directly under the city. Causing more than $15 billion in damage, Northridge demonstrated that moderate quakes beneath a heavily populated region can cause at least as much damage as a great San Andreas quake. The moment magnitude 6.8 killer tremor near the Japanese city of Kobe this week offered a similar lesson.

The energy for earthquakes in Los Angeles, and for quakes in much of California, comes from an ongoing, grinding collision between the Pacific and North American plates. The movement slowly compresses the Los Angeles basin in a north-south direction, straining the crust until it finally breaks along faults.

Dolan and his colleagues analyzed the quake risk Los Angeles faces by assessing the six major fault systems known in the area. From the fault dimensions, they calculated the size of potential earthquakes. To estimate the frequency of such quakes, they looked at the geologic slip rates — how quickly rock on one side of a fault has slid past rock on the other side over the millennia.

According to their calculations, Los Angeles has stored enough strain energy in the last 2 centuries for 17 Northridge-size earthquakes. Yet only two earthquakes of this size have occurred, in 1971 and 1994. That leaves enough energy for 15 magnitude 6.7 jolts sitting beneath the city. Many of these delinquent quakes could come in a cluster of shocks close together in time, a phenomenon seen in other parts of the world.

"Given the level of damage from the Northridge earthquake, such a sequence would certainly strain the ability of the region (and the nation) to absorb the resultant losses," the scientists say.

Dolan's team has another, perhaps even more disturbing, scenario. Los Angeles could avoid numerous moderate-size earthquakes only if it occasionally suffers much more destructive shocks. Indeed, the scientists conclude that the faults within the basin could produce quakes of magnitude 7.2 to 7.6.

But even these disasters are overdue. Quakes that large should occur every 140 years or so to relieve the accumulating strain, yet none has struck in at least 210 years. Dolan and his colleagues remain unsure whether the future holds numerous moderate-size earthquakes, a few much larger shocks, or a mixture. In any case, the rate of seismic activity will far exceed that in the past.

"Los Angeles appears to have been settled in a quiet period in terms of earthquakes, and that can't last forever. At some point, we're going to have to relieve all the strain that's built up over that period," Dolan says.

In another paper in the Jan. 13 SCIENCE, Susan E. Hough of the U.S. Geological Survey in Pasadena, Calif., reached a similar conclusion. Without looking at individual faults, Hough analyzed how many earthquakes it would take to narrow the entire Los Angeles basin by 0.9 to 1.2 centimeters per year — the rate of compression measured by satellites and by geologic methods.

She finds that too few earthquakes have occurred to release the accumulated strain. Even if magnitude 7.5 shocks only occur every 245 to 325 years, the city still should have witnessed magnitude 6.6 shocks every 46 years, a rate much higher than that observed.

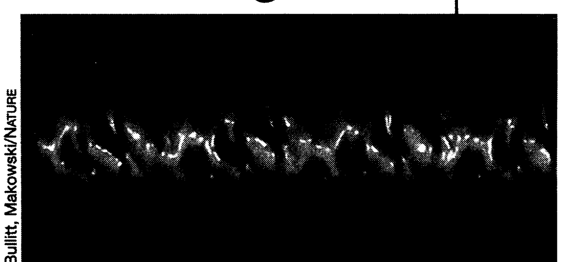
Taking a more general approach, a group of geoscientists assessed the risk across all of southern California in a report for the Southern California Earthquake Center. The group's primary conclusions, released Jan. 20, agree with Dolan and Hough's finding of an earthquake deficit in Los Angeles.

In fact, the deficit extends across much of southern California, according to report coauthor David D. Jackson of the University of California, Los Angeles. He and his coworkers calculate an 80 to 90 percent chance of a magnitude 7.0 or larger quake striking some part of southern California within the next 30 years.

— *R. Monastersky*

Helical protein helps *E. coli* hang on

Escherichia coli *has proved a versatile bacterium. It appears as various strains, each adapted to where it lives. In the urinary tract, for example, where streams of liquid wash other bacterial invaders away, one strain of* E. coli *clings to its host with dozens of hairlike appendages called adhesive pili. Now, scientists appear to have found the secret of the pili's tenacity: a helical structure that can unravel under stress (right).*



Bullitt, Makowski/NATURE

Each pilus, about a micrometer long and 6.8 nanometers thick, consists of 1,000 units of a protein called PapA. Biophysicists Esther Bullitt of the Boston University School of Medicine and Lee Makowski of Florida State University deduced the three-dimensional structure of pili by photographing them with an electron microscope, then reconstructing the images on a computer.

As they report in the Jan. 12 NATURE, *PapA winds tightly into coils that connect to form a closed helix. Three other proteins bind the helix to a sugar on the membrane of an epithelial cell in the urinary tract lining, thus anchoring the* E. coli.

The researchers then turned to how this helical structure might help E. coli *resist being flushed away. They noticed in micrographs that some of the pili appeared bent and that fine threads connected these partial breaks. The threads, they reasoned, are lengths of PapA in which linked coils had pulled apart. By measuring unraveled pili, the researchers found that these structures unwind to about five times their coiled length.*

Pili, suggest Bullitt and Makowski, help the bacterium hold fast to its host cell, even through blasts of urine. "If the pili were like a pencil," explains Bullitt, "they would just snap off." Instead, they can stretch slightly and bounce back. Or they can stretch even more, until the bonds between some PapA coils break and the closed helix opens.

More than mere curiosity led the duo to untangle pili structure. They believe their findings may help researchers develop new drugs to treat urinary tract infections — the cause of 6 million visits to doctors' offices each year. For example, scientists might find a molecule that would block the sites on PapA that hold coils of the protein together. — J. Kaiser

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