

# Lessons and Questions Emerge From Armenian Quake

By RICHARD MONASTERSKY

A team of U.S. engineering and earthquake experts returned from Armenia earlier this month, bringing with them some answers and important new questions about the extraordinarily destructive shocks that hit the region in early December, killing more than 24,000 people. According to their findings, this tragic event offers some unique lessons that could reduce death tolls from future earthquakes, not only in Armenia but around the globe.

Although many factors, including freezing temperatures, combined to make this event particularly deadly, team members agree that building inadequacies are the principal reason why the strong, but not huge, quake killed so many people. Engineers who examined the damage and rescue workers who cut through the wreckage searching for trapped people blame both design deficiencies and flawed construction practices for the collapsed buildings.

The main shock, which registered a magnitude of 6.9, struck just north of the city of Spitak on Dec. 7, at 11:41 a.m. local time. Four minutes later, a magnitude 5.8 aftershock occurred. Since then, swarms of aftershocks as large as magnitude 5.0 have continued to emanate from a zone centered around Spitak, a leveled city that formerly held about 16,000 people.

The rubble of reinforced concrete in cities around Spitak testifies that many of the newer nine-story buildings in this quake-prone region could not survive the one-two punch of the main shock and strong aftershock, while some older, shorter buildings fared better. Although the Soviets had adapted their standard building designs for use in this seismic area, they "are indicating that the earthquake was bigger than they had designed for," says Loring Wyllie, a co-leader of the team and a structural engineer who specializes in seismic-resistant building designs with H.J. Degenkolb Associates in San Francisco.

Wyllie says regulations for the area required that buildings be constructed to survive tremors that would register 7 or 8 points on the 12-point Soviet scale. The Dec. 7 event hit 10 points. In spite of the quake's severity, many damaged buildings did stand, and examinations of these structures will help engineers determine which kinds of buildings can best survive strong shaking, Wyllie says.

Historical records reveal that significant earthquakes have long struck this

section of eastern Armenia. The area's most recent large tremors occurred during the mid-1920s and registered about magnitude 6, which corresponds to ap-



proximately 8 points on the Soviet scale, says John Filson of the U.S. Geological Survey in Reston, Va., a co-leader of the study team. Last month's quake was about 10 times stronger than these historic and seemingly characteristic temblors. Because of the region's prior record and the limited length of nearby faults, the Dec. 7 jolt was probably the largest earthquake this area could produce, Filson adds. "They got hit by about the worst case you could imagine," he told SCIENCE NEWS.

The region fits into a broad seismic zone stretching from Turkey to the Arabian Sea near India. Here, the Arabian land mass is slowly smashing into the Eurasian plate, a process pushing up the Caucasus Mountains in the north.

The geologic structure that created last month's disaster is a fairly small thrust fault running northwest-southeast, apparently right under Spitak, says Robert Sharp, a geologist with the U.S. Geological Survey in Menlo Park, Calif., who traveled to Armenia with the team. Unlike vertical faults such as the San Andreas, thrust faults dip into the ground at an angle. During the earthquake, the Spitak section to the northeast of the fault rode up over the southwest side, meaning the city sat on the overhanging edge of the thrust sheet. "Geologically, that has to be a very dangerous position for a city," Sharp says.

Estimates for the main shock's epicenter have shifted as scientists sift through more of the incoming seismic information, although experts believe this center was quite close to the surface. Measurements of the aftershock swarm will help outline the region of the fault that ruptured, and geologists have located a 1.5-meter-high, 8-kilometer-long

scarp just southeast of Spitak that shows where fault movement broke the surface.

Of the nearby big cities, the quake damaged Leninakan, with a population of 290,000, far more than Kirovakan, which held about 170,000. However, Kirovakan sits closer to the presumed epicenter than Leninakan, creating a puzzle that seismologists hope to solve with data taken by the 20 seismographs they brought to Armenia. Some buried geologic structures underneath Leninakan, such as soft rock, may have amplified the shaking during the quake, Filson says.

For earth scientists, the quake emphasized the deadly potential of seemingly unimpressive faults. "This fault, as you might judge its importance based on outcrops, appeared to be a minor geologic structure," says Sharp. Filson suggests that even in the well-studied earthquake country of California, obscure but possibly hazardous faults have

not received enough attention from scientists and public officials.

The December disaster exacted an extraordinary toll on human life. "This was one of the most deadly earthquakes we've ever seen," says Fred Krimgold from the Virginia Polytechnic Institute and State University's Washington-Alexandria Center, who went to Armenia immediately after the quake with a U.S. search-and-rescue team and again with the post-disaster study team. "Typically the ratio of injury to mortality is something on the order of three or four to one. In the case of this earthquake, it's the reverse."

While the quake and its aftermath injured 15,000 people, 24,000 bodies have been recovered during the last month, says Krimgold. Early estimates placed total fatalities at more than 60,000 people, but revised reports lower the death toll to about 25,000.

Krimgold attributes the high death rates to the way buildings fell apart. Many structures had floors made of concrete planks about 3 feet wide — a design that collapsed into compact rubble piles, leaving little open space where trapped people might survive.

Krimgold says search-and-rescue teams will learn important details about these buildings and the deadly power of earthquakes in cold areas, where time becomes even more critical than usual in rescue operations. "From our experiences in [earthquakes in] Mexico City and El Salvador and isolated building-collapse situations in the United States, we had what we thought was the book on search and rescue. I think what we learned in Armenia was that we only have chapter one." □