An Earthquake– On Schedule

For the first time, Caltech scientists have been able to predict the time and location of a sizable earthquake in California.

The quake occurred at 10:05 p.m. last January 30 near Yucaipa, about 16 miles east of the city of Riverside, and was felt widely throughout the east Los Angeles Basin. The event occurred at the expected site and within the expected time limit of about three months.

Only one factor of the prediction remained unfulfilled; the magnitude of the earthquake was 4.1 instead of the predicted 5.5, but the possibility of a larger event yet to come has not been ruled out.

The difference in the quake's predicted and actual magnitude may have been due to the fact that the Yucaipa event was a different kind of earthquake from the one used in developing the formula or model on which the prediction was based. If this is so, it will have significant implications on earthquake prediction research.

Research on earthquake prediction being pursued in this country, Japan, and Russia is based on the concept that strain increases in rocks prior to an earthquake, the strain causing the widening of microscopic cracks in the rocks. This reduces the speed of seismic waves moving through the rocks from distant quakes and explosions. The velocity is cut by as much as 20 percent. The widened cracks, which weaken the rocks, either gradually close or fill with water and the velocity of the seismic waves returns to normal.

When "normalcy" is reached, the rocks will rupture along a zone of weakness—a fault zone—triggering an earthquake. The longer the period of slow seismic waves, the greater the earthquake. This theory is called dilatancy from the idea of the rocks dilating as their cracks grow in size.

The dilatancy-diffusion model of quake prediction was developed by James Whitcomb, senior research fellow in geophysics, and his colleagues at Caltech. It is based on data from the 1971 San Fernando quake (of magnitude 6.4) and data reported for smaller quakes in Russia and New York. All of these quakes resulted from thrust-type faulting, in which land on one side of a fault thrusts itself under or over land on the other side.

The Yucaipa quake did not result from thrusting action but from either strike-slip fault movement or from movement on what geologists call a gravity, or normal, fault. Strike-slip faulting is where the rocks on one side of a fault slide horizontally past rocks on the other side. Gravity fault movement involves a dropping of land on one side of a fault in relation to the land on the other side.

The "unusual" behavior of the seismic velocities under Riverside was discovered in June of 1973 by Hiroo Kanamori, professor of geophysics at Caltech, by studying old seismic records of more than a dozen stations in the Caltech Seismological Laboratory network that blankets southern California. The wave velocities—averaging 20,000 to 30,000 miles an hour, with the higher speeds being at greater depths—remained constant at all stations except at Riverside.

Whitcomb determined that the wave velocity drop at Riverside began in the first part of 1972. The velocities were returning to normal last November, signifying an earthquake was imminent. The velocities had been slower for at least 13 months. That time span, based on the relationship developed at Caltech for thrust quakes of the San Fernando type, would predict a temblor of at least 5.5 magnitude. On the same basis, the time span for a magnitude 4 thrust event should be 26 days and for a magnitude 3 thrust event only 5 days.

Whitcomb observed that the velocity variations were most intense east of Riverside, implying that it was the most likely place for a quake. Portable seismic instruments were installed in the area so that when the quake did occur, a detailed record of it was obtained.

The Caltech study of the San Fernando quake demonstrated that the drop in wave velocity was due to a drop in the velocity of only one of the two earthquake waves—the P wave. That wave is a compressional wave that goes through the earth, while the S wave is a shear wave.

This important finding contradicted some earlier theories and supported a theory proposed by Amos Nur of Stanford University. The intensive study of the San Fernando quake led to development and confirmation of Caltech's present theoretical model for predicting earthquakes. □