

What happened?

Scientists presented a puzzle

By ROBERT REINHOLD
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SANTA CRUZ MOUNTAINS — The California earthquake has presented scientists with a puzzle, one that has left some of them wondering whether probability estimates of future quakes are too low.

Given the magnitude of last Tuesday's temblor, 6.9 on the Richter scale of ground motion, geologists who have swarmed over this ridge near the epicenter above the San Andreas fault were puzzled last week to find that the quake did not cause clear ruptures along the fault lines, but instead produced a crazy-quilt of cracks and fissures on the surface.

Surface ruptures offer a major clue to earthquake activity, especially to quakes that occurred in prehistoric times. Scientists have relied on them to assess the earthquake history of the region and estimate the probability of future ones.

Prof. Kerry E. Sieh of the California Institute of Technology said Monday that he was "flabbergasted" by the absence of surface ruptures. He said it had always been assumed that quakes of 6.5 magnitude or larger would break the surface.

There is no reason to raise estimates of the probability for larger quakes of the magnitude that hit San Francisco in 1906, or that are believed likely in the Los Angeles area in the next 30 years, he said,



Shmuel Thaler/Sentinel

Geologists like Jim Berland have been spending hours in the trenches, investigating Tuesday's earthquake.

but "this will cause us to be more cautious about the potential for moderate sized quakes."

Other scientists said, however, that the area near Santa Cruz has behaved this way before and that the lack of surface evidence of last week's quake might simply be the result of local geological eccentricities.

The great earthquake of 1906 that virtually destroyed San Francisco left a clearly defined rupture along most of the fault, said Lane R. Johnson, acting direc-

tor of the seismographic station of the University of California at Berkeley. "But in the Santa Cruz Mountains there was something like what we see now."

He said scientists would re-examine their earthquake probability estimates "but I would be surprised if they changed much."

Given the size of last Tuesday's temblor, geologists who have swarmed over this ridge near the epicenter above the San Andreas fault were puzzled to find that the fault did not cause clear ruptures at

the surface along the fault lines below.

But now they are further confused by preliminary tests of the vast network of small and large cracks that did open on roads, driveways and hillsides. These tests tend to show that the ground here moved, surprisingly, in the opposite direction from the quake six miles below the surface.

"This complex zone of cracking is unlike anything in the past," said Thomas L. Holzer, chief of the branch of engineering

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seismology and geology for the U.S. Geological Survey in Menlo Park. "It is very unusual for a quake of this size not to come close to the surface."

As a result, Holzer said, geologists have begun to doubt their ability to make reliable estimates for future major quakes and to recognize active faults. It is in large part by digging trenches along fault lines and studying the underground geological record that geologists reconstruct the earthquake histories on which the probabilities are based.

In an area like this one, the record would be confusing.

"Had this been on a fault that ruptured every 20,000 years and we trenched it, we probably would not have recognized it as an active fault," Holzer said, stressing that final analyses would not be complete for months.

The area under the most intense scrutiny is a five-mile swath on

either side of Summit Road, along the crest of the Santa Cruz Mountains about 10 miles west of the epicenter. There was little cracking in the brushy area above the epicenter.

But there was enormous damage here at the crest, where homes collapsed in huge heaps, where most people still lack power and where the roads and driveways are rent by wide cracks. The most dramatic crack is the one that has opened in front of the pink home of John and Freda Tranbarger, a retired couple.

The crack is seven feet deep and three feet wide at points, and extends about 1,700 feet on either side of Summit Road, leaving a big fissure and bump, or "scarp," on the road that has been patched over temporarily.

The geologists, with tape measures, compasses, stakes and nails, are trying to map the area and to identify which cracks were due directly to the quake and which were caused by secondary

events, mainly landslides.

They are fighting a driving chill rain that began Monday and property owners who do not want their land mapped for fear their homes will be condemned as a result.

The mapping is being done mainly by scientists from the geological survey like Malcolm Clark but also by some volunteers like Burt Hardin of William Cotton and Associates of Los Gatos. They are looking along the fault "traces," the surface features that follow the fault below.

They hope to find a consistent pattern from such factors as the direction and length of movement of the two sides of a crack, and the inclination below the surface at each rupture.

In particular, they look for dislocation in painted parking lot and road stripes, fences and other normally straight lines. They also try to match, pebble by pebble, the broken edges of cracks, like a jigsaw puzzle. Arrays of evenly

spaced nails are driven into the ground to check for further movement.

The quake resulted from what is known as a "strike slip" movement, in which one of the two adjoining tectonic plates that form the fault slides past the other deep under the surface. In this case, according to the seismic readings, the plate closer to the Pacific Ocean moved toward the northwest, known as right lateral movement, and thrust up over the eastern plate a bit.

Thus, scientists expected to see similar right lateral movement on the surface. But in fact, most of the measurements so far have found slow left lateral movement.

They are now trying to figure out what caused this anomaly. One possibility, said Holzer, is that there were "flaws" in the upper crust that were readjusted by the quake, with blocks moving left even as the underlying movement was rightward.