Taking the Pulse of Parkfield

After their second significant alert on the San Andreas fault, researchers are encouraged that they are in touch with the source of the next Parkfield earthquake

Parkfield, California

IN the early days of last February, the earth shifted ever so slightly beneath Middle Mountain, an oversized hill just up the road from this isolated town in central California's cattle country. Seemingly dwarfed by the great San Andreas fault that cuts through the mountain and most of California, that feeble disturbance has nonetheless helped reassure researchers attempting to predict the next moderate earthquake at Parkfield.


R. A. Kerr

Middle Mountain, where it should all begin.

The timing and location of February's microearthquakes, fault movements, and crustal deformation suggest, but do not prove, that the monitoring network on and near the surface probes more than 9 kilometers down to the starting point of moderate Parkfield earthquakes. The most recent in a string of five magnitude 5.5 quakes occurred there in 1966 and the next is due within a few years. There is also guarded optimism that the fault will give some warning of its imminent failure.

The shifting on the fault that prompted the C-level or intermediate alert was, by human standards, exceedingly subtle. During the early morning of 1 February the water level in a well on Middle Mountain dropped 10 centimeters, indicating that the rock there dilated by 0.2 part in 1 million as the stress on it changed. At about the same time the east side of the fault crept 0.22 millimeter southward past the west side, as measured at the surface of Middle Mountain. Shortly thereafter, a magnitude 2.0 shock struck 5 kilometers above the starting point, or hypocenter, of moderate Parkfield earthquakes.

The C-level alert came early that evening when a magnitude 2.7 shock, which apparently went unnoticed by area residents, ruptured a patch of the fault 4 kilometers south of the hypocenter and at the same 9.5-kilometer depth as the hypocenter. Aside from a small creep event and two small earthquakes, that was the end of Parkfield's second C-level alert. There have been no B- or A-level alerts.

"I think [these events] are very encouraging," says William Bakun of the U.S. Geological Survey (USGS) in Menlo Park, chief scientist of the Parkfield Prediction Experiment. "They are the kind of thing we had in mind when we designed the system." Unlike last June's apparent fault slippage, during which unusual activity was recorded at scattered sites along much of the 25-kilometer Parkfield fault segment, February's seismicity was concentrated in or above the deeply buried few kilometers of fault around the hypocenter, the trigger for the rest of the section.

Even more encouraging was the deformation detected under Middle Mountain. It preceded the sequence's two largest earthquakes, which fell nearest the expected hypocenter. Some theories and laboratory experiments have suggested that rock on the fault should deform at an accelerating rate before the fault fails, but observations at varying distances from a half dozen moderate earthquakes had failed to detect any such precursory deformation. Those who had planned the Parkfield experiment were not at all certain that the dense network of instruments now in place would detect even a moderate earthquake's precursory deformation. "The question is, was the order of deformation followed by earthquakes a matter of chance," says Bakun. "The very close spatial coincidence suggests that it was not. That is very encouraging, but we need data on more events in order to be confident."

The fault behavior prompting the alert also supports a suggestion made recently by Catherine Poley and her colleagues at the USGS in Menlo Park. They noted that the patch of fault lying 7 to 15 kilometers beneath Middle Mountain experiences a remarkable sort of seismicity. Within this patch are the largest shocks in the Parkfield area, the deepest microearthquakes, clusters of repeated earthquakes, an exceptionally high proportion of relatively small shocks, and a cluster of earthquakes near the expected hypocenter where magnitude 3 shocks repeat with clocklike regularity every 39 to 40 months and relieve a relatively large amount of stress each time. The decrease in seismicity on the San Andreas fault induced by the nearby Coalinga earthquake of 1983 was particularly evident within this patch, where earthquakes larger than magnitude 1.6 and overlying fault creep ceased entirely for 15 months.

The USGS group suggests that the unusual behavior of the fault at Middle Mountain, highlighted most recently by the alert, may reflect physical properties peculiar to fault patches where larger earthquakes begin. It may be a strong point on the fault, called an asperity, where stress concentrates, or it may be a weak point, called a barrier, where fault motion is resisted.

Whatever the case, the group concludes that the Middle Mountain fault patch seems to be particularly sensitive to stress changes, suggesting that it is the most likely place along the fault to find any precursory deformation. It is so unusual seismically, they add, that the initiation points of future earthquakes elsewhere might be identified solely by their current microseismicity without knowledge of earlier destructive earthquakes. If the rest of the San Andreas works the way the short Parkfield section does, researchers might be able to find and monitor San Andreas initiation sites that have not broken since 1906 in the north and since 1857 or earlier in the south. ■

RICHARD A. KERR