Project will monitor tremor activity beneath southern San Andreas Fault

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The Berkeley Seismological Laboratory will begin early next year to install earthquake detectors on the southern San Andreas Fault near the town of Cholame to study mysterious tremors discovered beneath the area.

Tremors are extremely faint and periodic rumblings originating 20-40 kilometers below ground – far beneath the zone where earthquakes occur – that appear to be associated with slipping rocks deep in the earth.

University of California, Berkeley, seismologists discovered the tremors in 2004 just south of the heavily instrumented Parkfield area of the fault, and subsequent studies suggest that changes in tremor activity may precede earthquakes. Tremors also have been detected in active earthquake zones in Japan and Washington state.

"The discovery of tremors deep in the roots of active plate boundary fault zones is arguably the most important discovery in earthquake science in decades," said Roland Bürgmann, principal investigator for the TremorScope project and professor and chair of UC Berkeley's Department of Earth and Planetary Science. "This is the first project in which a permanent instrument network has been specifically designed with tremor in mind."

The project is funded by a $1.2 million grant from the Gordon and Betty Moore Foundation.

"TremorScope will also help our studies of microearthquakes and, in general, help us understand how the southern San Andreas Fault works and how it prepares for the next large Southern California earthquake," said co-investigator Barbara Romanowicz, director of the Berkeley Seismological Laboratory and professor of earth and planetary science.

The Cholame tremors occur at a critical juncture of the San Andreas Fault, where the creeping and fairly benign middle section of the fault meets the locked southern section. Historically, numerous large quakes have originated in the Parkfield/Cholame area, propagating southward and causing extensive damage. The last major quake on the southern San Andreas Fault was the 1857 Fort Tejon earthquake, which started at Cholame and ruptured south with a total magnitude of 7.8.

While tremor studies may tell geologists what is happening deep under the southern locked portion of the San Andreas Fault, they also may open the door to earthquake prediction in the way that tremor activity in volcanic areas now warns of coming eruptions.

"Since the tremors are really sensitive to small stress changes, changes in tremor activity may be the flag or signal that people have been looking for as a precursor to an earthquake," said co-investigator Robert Nadeau, a UC Berkeley research seismologist who discovered the tremors.

TremorScope extends a large network of earthquake sensors already in place around the Parkfield segment of the San Andreas Fault, about 32 kilometers northwest of Cholame. In 1986, those instruments were first installed in 200- to 300-meter-deep boreholes by the U.S. Geological Survey and the state of California in anticipation of an earthquake predicted to occur in the late 1980s, but which came only in 2004. Nadeau noted changes in tremor activity before the 2004 earthquake, but the relationship between the tremor activity and the quake was inconclusive.

The array of 13 borehole detectors in the Parkfield High Resolution Seismic Network was supplemented in 2000 by instruments placed at the bottom of a 3 kilometer-deep borehole drilled diagonally through the fault by the SAFOD (San Andreas Fault Observatory at Depth) team, funded by the National Science Foundation.

The new detectors, to be installed in four boreholes and at four surface stations, include accelerometers, broadband instruments and geophones designed to have optimal sensitivity to capture the full tremor and earthquake signals. Roughly encircling Cholame at a radius of about 20 kilometers, the broadband seismometers will allow triangulation of tremors to pinpoint their precise location and map the underground tremor activity. Nadeau is already using the location of tremor activity to tomographically map the rocks underlying the Parkfield and Cholame area of the San Andreas Fault.

"In the past, we relied on earthquake waves for tomography, but in this part of the San Andreas Fault there are no earthquakes, so there is no real seismic energy passing through that allows you to get a good picture of the fault," Nadeau said. "Now, we are actually using waves from tremors themselves to do tomography, and we are starting to see some interesting patterns."

The new instruments will also allow seismologists to study shallower microquakes in the Cholame area. Nadeau noted that deep underground tremors seem to be connected with microquakes in the fracture zone, which extends to about 15 kilometers underground.

"What happens up where the earthquakes are happening is also doing something down deep where these tremors are taking place," he said. "Understanding the connection between deep tremors and shallow earthquakes is a major goal of our current research."

Before these so-called "non-volcanic" tremors were discovered, Bürgmann said, faults were thought to slip seismically only in the brittle fracture zone, either in small increments over long periods of time, or catastrophically in one big earthquake. Deeper rock was thought to be too hot and pliable to break, but instead, would creep without quakes.

The tremors may originate in small brittle regions that stick and break, while the bulk of the deeper rock creeps more fluidly, he said. Whatever the mechanism, study of tremors should turn up new information about how earthquakes are triggered.

"Tremors are markedly different in character from 'normal' earthquakes, and are now allowing scientists to obtain entirely new insights into the dynamics of fault processes at plate boundaries at otherwise inaccessible depths and directly beneath where earthquakes occur," Burgmann said.

Provided by University of California - Berkeley

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