Tabletop fault model reveals why some quakes result in faster shaking

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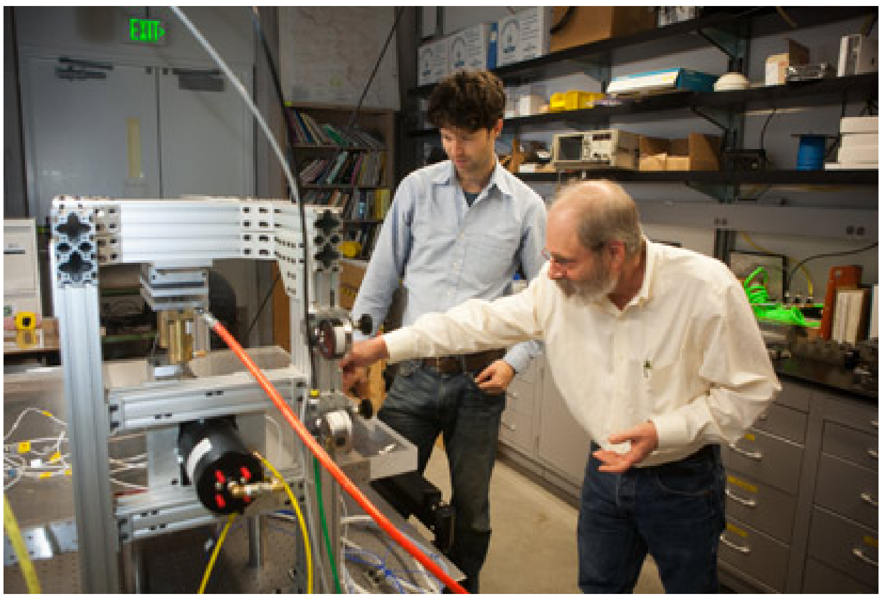

Gregory McLaskey (L) and Steven Glaser examine a tabletop model of a fault at UC Berkeley. Credit: Preston Davis photo

The more time it takes for an earthquake fault to heal, the faster the shake it will produce when it finally ruptures, according to a new study by engineers at the University of California, Berkeley, who conducted their work using a tabletop model of a quake fault.

"The high frequency waves of an earthquake—the kind that produces the rapid jolts—are not well understood because they are more difficult to measure and more difficult to model," said study lead author Gregory

McLaskey, a former UC Berkeley Ph.D. student in civil and environmental engineering. "But those high frequency waves are what matter most when it comes to bringing down buildings, roads and bridges, so it's important for us to understand them."

While the study, to be published in the Nov. 1 issue of the journal *Nature* and funded by the National Science Foundation, does nothing to bring scientists closer to predicting when the next big one will hit, the findings could help engineers better assess the vulnerabilities of buildings, bridges and other structures when a fault does rupture.

"The experiment in our lab allows us to consider how long a fault has healed and more accurately predict the type of shaking that would occur when it ruptures," said Steven Glaser, UC Berkeley professor of civil and environmental engineering and principal investigator of the study. "That's important in improving building designs and developing plans to mitigate for possible damage."

To create a fault model, the researchers placed a Plexiglas slider block against a larger base plate and equipped the system with sensors. The design allowed the researchers to isolate the physical and mechanical factors, such as friction, that influence how the ground will shake when a fault ruptures.

It would be impossible to do such a detailed study on faults that lie several miles below the surface of the ground, the authors said. And current instruments are generally unable to accurately measure waves at frequencies higher than approximately 100 Hertz because they get absorbed by the earth.

"There are many people studying the properties of friction in the lab, and there are many others studying the ground motion of earthquakes in the field by measuring the waves generated when a fault ruptures," said

McLaskey. "What this study does for the first time is link those two phenomena. It's the first clear comparison between real earthquakes and lab quakes."

Noting that fault surfaces are not smooth, the researchers roughened the surface of the Plexiglas used in the lab's model.

"It's like putting two mountain ranges together, and only the tallest peaks are touching," said McLaskey, who is now a postdoctoral researcher with the U.S. Geological Survey in Menlo Park.

As the sides "heal" and press together, the researchers found that individual contact points slip and transfer the resulting energy to other contact points.

"As the pressing continues and more contacts slip, the stress is transferred to other contact points in a chain reaction until even the strongest contacts fail, releasing the stored energy as an earthquake," said Glaser. "The longer the fault healed before rupture, the more rapidly the surface vibrated."

"It is elegant work," said seismologist John Vidale, a professor at the University of Washington who was not associated with the study. "The point that more healed faults can be more destructive is dismaying. It may not be enough to locate faults to assess danger, but rather knowing their history, which is often unknowable, that is key to fully assessing their threat."

Glaser and McLaskey teamed up with Amanda Thomas, a UC Berkeley graduate student in earth and planetary sciences, and Robert Nadeau, a research scientist at the Berkeley Seismological Laboratory, to confirm that their lab scenarios played out in the field. The researchers used records of repeating earthquakes along the San Andreas fault that

Nadeau developed and maintained. The data were from Parkfield, Calif., an area which has experienced a series of magnitude 6.0 earthquakes two to three decades apart over the past 150 years.

Thomas and McLaskey explored the records of very small, otherwise identically repeating earthquakes at Parkfield to show that the quakes produced shaking patterns that changed depending on the time span since the last event, just as predicted by the lab experiments.

In the years after a magnitude 6.0 earthquake hit Parkfield in 2004, the small repeating earthquakes recurred more frequently on the same fault patches.

"Immediately after the 2004 Parkfield earthquake, many nearby earthquakes that normally recurred months or years apart instead repeated once every few days before decaying back to their normal rates," said Thomas. "Measurements of the ground motion generated from each of the small earthquakes confirmed that the shaking is faster when the time from the last rupture increases. This provided an excellent opportunity to verify that ground motions observed on natural faults are similar to those observed in the laboratory, suggesting that a common underlying mechanism—fault healing—may be responsible for both."

Understanding how forcefully the ground will move when an earthquake hits has been one of the biggest challenges in earthquake science.

"What makes this study special is the combination of lab work and observations in the field," added Roland Burgmann, a UC Berkeley professor of earth and planetary sciences who reviewed the study but did not participate in the research. "This study tells us something fundamental about how earthquake faults evolve. And the study suggests that, in fact, the lab setting is able to capture some of those processes correctly."

Glaser said the next steps in his lab involve measuring the seismic energy that comes from the movement of the individual contact points in the model fault to more precisely map the distribution of stress and how it changes in the run-up to a laboratory earthquake event.

Provided by University of California - Berkeley

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