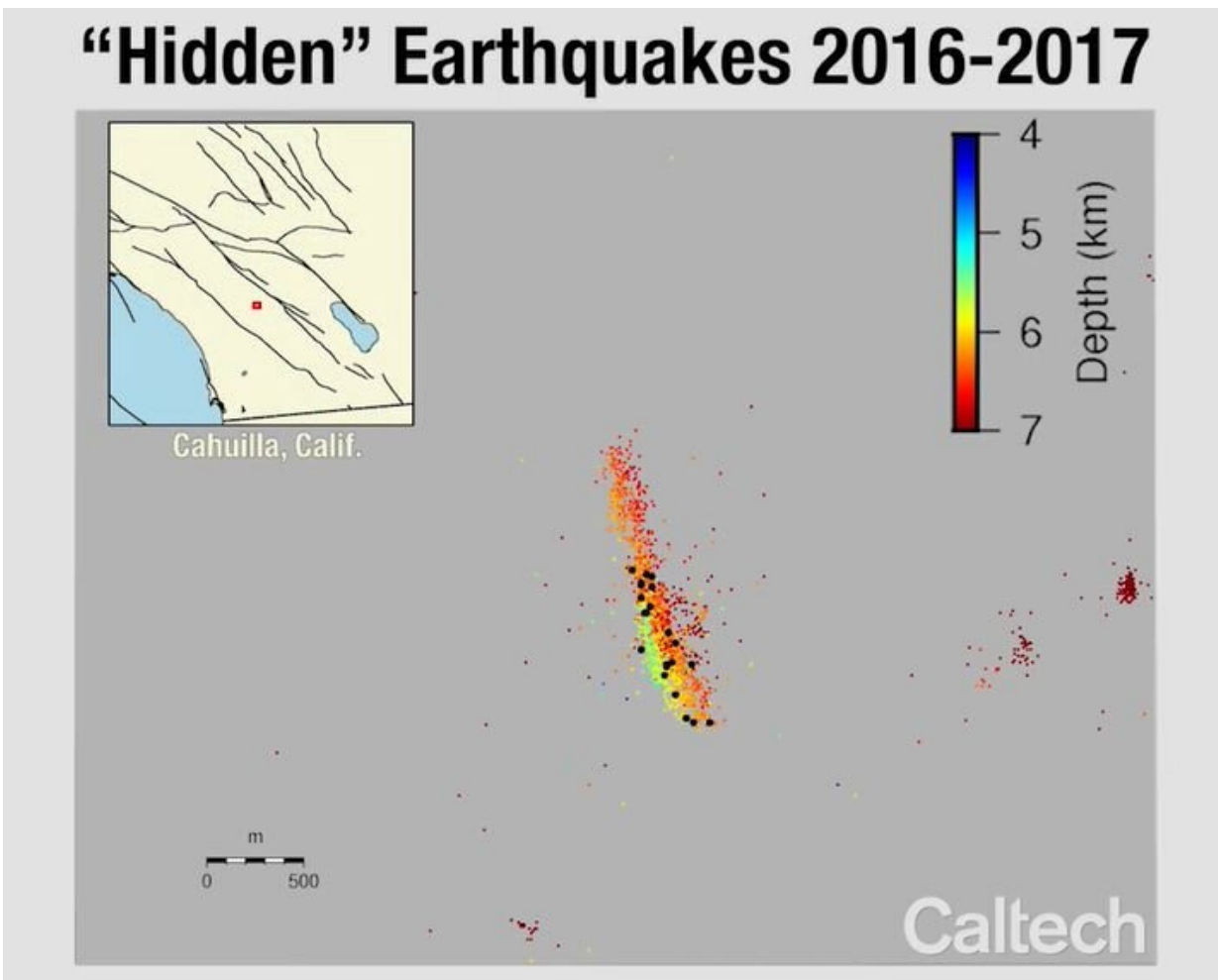


Scientists identify almost two million previously 'hidden' earthquakes

April 18 2019, by Robert Perkins



Poring through 10 years' worth of Southern California seismic data with the scientific equivalent of a fine-tooth comb, Caltech seismologists have identified nearly two million previously unidentified tiny earthquakes that occurred between 2008 and 2017.

Their efforts, published online by the journal *Science* on April 18, expand the earthquake catalog for that region and period of time by a factor of 10—growing it from about 180,000 recorded earthquakes to more than 1.81 million. The new data reveal that there are about 495 earthquakes daily across Southern California occurring at an average of roughly three minutes apart. Previous earthquake cataloging had suggested that approximately 30 minutes would elapse between seismic events.

This 10-fold increase in the number of recorded earthquakes represents the cataloging of tiny temblors, between negative magnitude 2.0 (-2.0) and 1.7, made possible by the broad application of a labor-intensive identification technique that is typically only employed on small scales. These quakes are so small that they can be difficult to spot amid the background noise that appears in seismic data, such as shaking from automobile traffic or building construction.

"It's not that we didn't know these small earthquakes were occurring. The problem is that they can be very difficult to spot amid all of the noise," says Zachary Ross, lead author of the study and postdoctoral scholar in geophysics, who will join the Caltech faculty in June as an assistant professor of geophysics. Ross collaborated with Egill Hauksson, research professor of geophysics at Caltech, as well as Daniel Trugman of Los Alamos National Laboratory and Peter Shearer of Scripps Institution of Oceanography at UC San Diego.

To overcome the low signal-to-noise ratio, the team turned to a technique known as "template matching," in which slightly larger and

more easily identifiable earthquakes are used as templates to illustrate what an earthquake's signal at a given location should, in general, look like. When a likely candidate with the matching waveform was identified, the researchers then scanned records from nearby seismometers to see whether the earthquake's signal had been recorded elsewhere and could be independently verified.

Template matching works best in regions with closely spaced seismometers, since events generally only cross-correlate well with other earthquakes within a radius of about 1 to 2 miles, according to the researchers. In addition, because the process is computationally intensive, it has been limited to much smaller data sets in the past. For the present work, the researchers relied on an array of 200 powerful graphics processing units (GPUs) that worked for weeks on end to scan the catalog, detect new earthquakes, and verify their findings.

However, the findings were worth the effort, Hauksson says. "Seismicity along one fault affects faults and quakes around it, and this newly fleshed-out picture of seismicity in Southern California will give us new insights into how that works," he says. The expanded [earthquake](#) catalog reveals previously undetected foreshocks that precede major earthquakes as well as the evolution of swarms of earthquakes. The richer data set will allow scientists to gain a clearer picture of how seismic events affect and move through the region, Ross says.

"The advance Zach Ross and colleagues has made fundamentally changes the way we detect earthquakes within a dense seismic network like the one Caltech operates with the USGS. Zach has opened a new window allowing us to see millions of previously unseen earthquakes and this changes our ability to characterize what happens before and after large earthquakes," said Michael Gurnis, Director of the Seismological Laboratory and John E. and Hazel S. Smits Professor of Geophysics

The paper is titled "Searching for Hidden Earthquakes in Southern California."

More information: Z.E. Ross et al., "Searching for hidden earthquakes in Southern California," *Science* (2019).

[science.sciencemag.org/cgi/doi ... 1126/science.aaw6888](https://science.sciencemag.org/cgi/doi/10.1126/science.aaw6888)

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