Listening to rocks helps researchers better understand earthquakes

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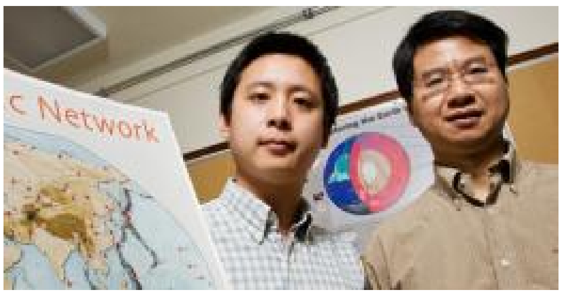

Using a technique called “ambient noise correlation,” Illinois seismologist Xiaodong Song, right, and graduate student Zhen J. Xu have observed significant changes in the behavior of parts of Earth’s crust that were disturbed by three major earthquakes. Photo by L. Brian Stauffer

(PhysOrg.com) -- When Apollo punished King Midas by giving him donkey ears, only the king and his barber knew. Unable to keep a secret, the barber dug a hole, whispered into it, "King Midas has donkey ears," and filled the hole. But plants sprouted from the hole, and with each passing breeze, shared the king's secret.

Earth, as it turns out, has other secrets to divulge. From the pounding of the surf and the rumbling of thunder, to the gentle rustling of leaves, Earth is not a quiet planet. The key is knowing how to listen to the ever-present ambient noise.
University of Illinois seismologist Xiaodong Song and graduate student Zhen J. Xu have become good listeners, especially to the sounds beneath

our feet.

Using a technique called "ambient noise correlation," Xu and Song have observed significant changes in the behavior of parts of Earth's crust that were disturbed by three major earthquakes.

"The observations are important for understanding the aftermath of a major earthquake at depth," Song said, "and for understanding how the rock recovers from it and begins again to accumulate stress and strain for future earthquakes."

The pair report their findings in a paper accepted for publication in the Proceedings of the National Academy of Sciences, and posted on the journal's Web site.

Researchers have used ambient noise to image Earth's interior and to monitor changes in seismic velocity near active volcanoes.

Xu and Song used the technique to examine how surface waves (extracted from ambient noise) between seismic stations change with time, because of earthquake-induced changes in the surrounding rock.

Xu and Song were not measuring the time it took for earthquake waves to travel from the epicenter to a seismic station. Rather, they were measuring the time it took for surface waves to travel from one station to another. Because the distance between stations is fixed, the technique allowed researchers to detect very tiny changes in seismic velocity.

"The observations allow us to see not just what happened at the surface, but what happened at depth, and how it affects not just the rupture area, but also the surrounding area," Xu said.

In their study, the researchers examined the three largest and most recent earthquakes in Sumatra, Indonesia. The earthquakes took place on Dec. 26, 2004; March 28, 2005; and Sept. 12, 2007.

The earthquakes occurred along the Sumatra subduction zone, where a portion of the Indian tectonic plate dives beneath the Eurasian plate. Fault rupture lengths ranged from 450 kilometers for the 2007 earthquake to 1,200 kilometers for the 2004 earthquake.

"We observed a clear change in surface wave velocity over a large area after each of the earthquakes," Xu said.

In one set of measurements, for example, a surface wave traveling between two particular seismic stations normally required 600 seconds to complete the journey. Following the 2005 earthquake, this time shifted by 1.44 seconds, which is a significant change. But, in all cases, the seismic velocities returned to normal levels within two to three months, indicating that elastic properties in the surrounding rock had recovered.

The most plausible explanation for the time shifts, the researchers write, is increased stress and relaxation in Earth's upper crust in the immediate vicinity of the rupture, as well as in the broad area near the fault zone. Using ambient noise correlation, the researchers can observe changes in stress several hundreds of kilometers from the source region.

The researchers also observed an unusual time shift that took place a month before the 2004 earthquake. More data is needed, however, to draw a conclusion and to determine whether it was a precursory signal to a major earthquake.

To that end, Xu and Song are studying last year's devastating earthquake in Wenchuan county in southwest China. An abundance of data was recorded at nearly 300 seismic stations in the source region by seismologists in China. The analysis of respective time shifts will help the researchers better understand how the fault and surrounding behaved before and after the earthquake.

"We need to densify our monitoring network," Song said. "With this natural source that's on all the time, and enough paths between different seismic stations, we can see not only changes in time, but also changes in space. So we can have a spatial and temporal image of what's going on both before and after a major earthquake."

Source: University of Illinois at Urbana-Champaign (news : web)