Earthquake 'memory' could spur aftershocks

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Using a novel device that simulates earthquakes in a laboratory setting, a Los Alamos researcher and his colleagues have shown that seismic waves—the sounds radiated from earthquakes—can induce earthquake aftershocks, often long after a quake has subsided.

The research provides insight into how earthquakes may be triggered and how they recur.

In a letter appearing today in *Nature*, Los Alamos researcher Paul Johnson and colleagues Heather Savage, Mike Knuth, Joan Gomberg, and Chris Marone show how wave energy can be stored in certain types of granular materials—like the type found along certain fault lines across the globe—and how this stored energy can suddenly be released as an earthquake when hit by relatively small seismic waves far beyond the traditional "aftershock zone" of a main quake.

Perhaps most surprising, researchers have found that the release of energy can occur minutes, hours, or even days after the sound waves pass; the cause of the delay remains a tantalizing mystery.

Earthquakes happen when the Earth's crust slips along cracks, known as faults. Major faults can be found at the junction of independently moving masses of crust and mantle, known as tectonic plates.

Each earthquake releases seismic waves—vibrations at the cusp, or below the range of human hearing—that travel through the Earth. These waves can trigger aftershocks in a zone several to tens of miles away from the radiating main earthquake, known as a “mainshock.” Most aftershocks usually occur within hours to days after the mainshock.

Researchers often have assumed that seismic waves beyond the immediate aftershock zone were too weak to trigger aftershocks. However, Gomberg and others have proven that seismic activity sometimes increases at least thousands of miles away after an earthquake.

“At these farther distances, earthquake triggering doesn’t happen all the time,” said Johnson. “The question always was why? What was going on in certain regions that lead to triggering? The challenge was whether we could go into the laboratory and mimic the conditions that go on inside the Earth and find out.”

The answer to the challenge lay at Pennsylvania State University, where Marone had developed an apparatus that mimics earthquakes by pressing plates atop a layer of tiny glass beads. When enough energy is applied to the plates, they slip, like tectonic plates above the mantle.

Johnson wondered whether sound waves could induce earthquakes in such a system. His colleagues originally believed sound would have no effect.

Much to their surprise, the earthquake machine revealed that when sound waves were applied for a short period just before the quake, they could induce smaller quakes, or, in some instances, delay the occurrence of the next major one. The sound waves seemed to affect earthquake behavior for as many as 10 earthquake events after they were applied.

More surprising still, the team found that the granular beads could store a “memory” even after the system had undergone a quake and the beads had rearranged themselves.

“The memory part is the most puzzling,” Johnson said, “because during an earthquake there is so much energy being released and the event is so violent that you have to wonder, why doesn’t the system reset itself?”

The research has helped confirm that earthquakes are periodic events and that sound can disrupt them.

But catastrophic events in other granular media—such as avalanches or the sudden collapse of sand dunes—could help provide clues into the physics of earthquakes, and could help Johnson and his colleagues begin to unravel the mystery of stored memory in granular systems.

“What we’ve created in the laboratory has provided the basis for an understanding of dynamic triggering of earthquakes, something that has mystified people for years,” said Johnson.

Source: Los Alamos National Laboratory

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