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Scientists mimic Earth's response to quake in lab

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Predicting earthquakes with certain degree of accuracy is next to impossible with what scientists currently know. But earnest efforts are being made to understand the precursors of a high-magnitude tremor and how the earth's crust would respond to it so that human lives and properties can be saved.

In one such valuable study, a team of Indian researchers and their counterparts in Switzerland and France have demonstrated that the large bursts in ground acceleration of real earthquakes can be reproduced using soft materials in a laboratory scale experiment.

The researchers led by Ajay K Sood, physicist at the Indian Institute of Science (IISc) Bengaluru, found that under constant stress these soft materials reorganise in a manner very similar to how earth's crust gets restructured during earthquakes.

The study to which scientists from Bengaluru-based Raman Research Institute (RRI) and ETH Zurich also contributed appeared in the journal *Nature Communications* on Tuesday.

The team studied thin sheets of two types of soft materials — a tightly packed gel of soap-like molecules and a glass made from clay nano-particles — sheared between two steel plates. When force was continuously applied on the material, the internal reorganisation of the material generated burst-like patterns over time that resembled that appeared on seismograph during earthquakes.

“When you apply a certain stress, the material is trying to adjust. Its shear rate is fluctuating. This fluctuation is similar to what is seen during earthquakes,” Sood, who is DST Year of Science Chair Professor at IISc's Department of Physics, said.

Earthquakes typically occur due to friction between pieces of the Earth’s surface called tectonic plates, releasing a sudden burst of energy that causes severe damage to the environment and human lives. Scientists still don’t know how to predict when an earthquake will strike next, or how strong it will be.

To simulate earthquakes in the lab, researchers usually apply force to rocks or ceramic materials, and study how they deform and crack under stress. But because these are solids, it can be difficult to study changes that happen inside the materials before they split open.

“The main disadvantage with these previous experiments is that no one can probe the domain structure directly,” said Sayantan Majumdar, Associate Professor at RRI and one of the authors. “We cannot see what is going on inside the material.”

A different approach

In the current study, the researchers used soft materials instead and observed how they reacted under stress. Using an optical microscope and camera, they were able to look closely at how the inside of the material changed over time.

They found that the rate at which the material reorganised itself showed burst-like patterns persisting over thousands of seconds, resembling seismic foreshocks and aftershocks. These events usually happen over hundreds of kilometres during earthquakes. “We were able to observe this phenomenon at about 10 micron scale length. That is a huge advantage,” said Pradip Bera, first author and a PhD student at IISc's physics department.

The researchers also found that these patterns obeyed laws that govern earthquake dynamics. One of these, called the Gutenberg-Richter law, describes the strength of earthquakes. Another, called the Omori law, describes how the frequency of aftershocks reduces over time.

Values for mathematical parameters defined by these laws, when calculated for the soft materials, were found to be very close to those that have been reported for real earthquakes. The time gaps between spikes were also found to closely match real-life patterns. "Our data exactly fits what is seen on earthquakes," said Sood.

The researchers hope that further studies on such materials will eventually help identify microscopic precursors of earthquakes. "We have shown that the materials we used are excellent model systems. We hope that in future by using machine learning on the signals of our experiments we may have a way to see the signatures of a shock. This is only a hypothesis at this stage and needs to be worked upon in collaboration with experts in Artificial Intelligence," Sood told *BusinessLine*.