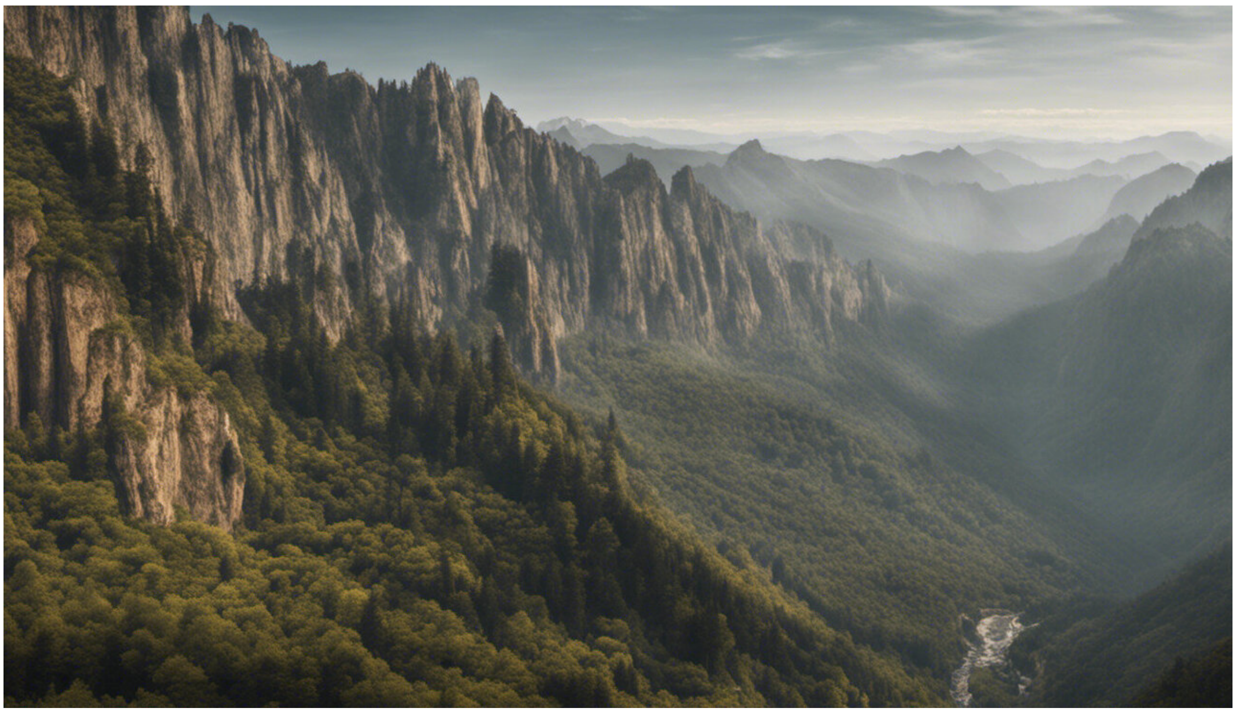
Seismic data yields deeper quake knowledge

October 7 2020



Credit: AI-generated image (disclaimer)

By examining data from large earthquakes, KAUST researchers have linked their magnitude, and the extent to which they cause aftershocks, to new depths in the Earth's crust: these are depths at which it was previously thought earthquakes could not occur.

"This research is critical to understanding how stress builds up in a fold," says Paul Martin Mai, who led the research. "If we observe an increase in seismogenic (earthquake generating) depth right after a large earthquake in a given fault system, then we know that the next large earthquake in that area may be stronger than we would have thought possible assuming fixed seismogenic depth."

Most earthquakes occur in the strongest layer of the Earth's crust, typically between 13 and 18 kilometers deep. Here, huge confining pressure from above acts to increase the brittle strength of rock to maximum effect such that more stress builds up before it fractures. Below this depth, heat from the Earth's core raises the temperature to degrees at which rock behaves plastically: deforming like a slow-moving liquid, instead of rupturing.

Until the mid-1980s, earthquakes were thought to not occur in this 'aseismic' lower zone. Subsequently, however, seismologists began recording aftershocks in this zone, following large earthquakes in the seismogenic zone above. During this transient increase in seismogenic depth, they surmised that rock in the aseismic zone was behaving like the toy Silly Putty, which will flow under normal conditions but ruptures under abnormal stress.

The team's hypothesis was that transient seismogenic deepening varies with earthquake magnitude. To test it, the researchers took data from 16 earthquake cycles in four fault zones, with each cycle spanning thousands of tremors leading up to and away from the main quake. The zones, in Alaska, Japan, California and Turkey, were chosen for the quality of their data-collecting seismometer networks. In each of the 16 cycles, the main quake was big enough to rupture the Earth's crust from the surface all the way down to the aseismic zone.

"I had the idea for this paper 10 years ago, but back then there were few data points," says research scientist Olaf Zielke. "Holding back until rich enough data sets became available has been a waiting game."

Now, the team has shown the connection between earthquake magnitude and degree of transient seismogenic deepening. Their finding should lead to a better understanding of earthquake physics, as well as improved seismic hazard assessments.

More information: Olaf Zielke et al. Magnitude-Dependent Transient Increase of Seismogenic Depth, *Seismological Research Letters* (2020). DOI: 10.1785/0220190392

Provided by King Abdullah University of Science and Technology