Times-Standard
Times-Standard / Humboldt Beacon

Not My Fault: The truth about aftershocks

Lori Dengler/For the Times-Standard
Posted February 21, 2021

Last week a colleague asked me, "When is an earthquake not considered an aftershock any more?" A Facebook comment was more blunt, "An aftershock ten years later? No way." The remarks were in response last week's M7.1 earthquake seismologists proclaimed an aftershock of the 2011 M9.1 earthquake.

I had thought the same thing as soon as I saw the February 13th earthquake location, and it was nice to see the experts agree with me. But from comments and questions, it's clear that many people don't believe it. How can seismologists distinguish between an aftershock and an independent earthquake?

All aftershocks are earthquakes and are caused by rupture along a fault and the release of seismic waves that you can feel if close enough. Aftershocks are quite capable of causing major damage and deaths when large enough to affect populated areas and some have even caused more destruction that the mainshock. The only thing "lesser" about an aftershock is its magnitude compared to the largest earthquake in a sequence.

It's all about relationships in time and space. All large earthquakes are followed by smaller earthquakes (aftershocks). Some earthquakes are preceded by smaller earthquakes called foreshocks. All foreshocks, mainshocks and aftershocks are a response to stress. Earth materials tend to clumpiness – when rocks reach the breaking point, slip occurs in a sequence. Sometimes it's one big earthquake followed by smaller ones. Sometimes it's a few smaller ones followed by a bigger one and then more smaller ones. The 2011 Japan earthquake is an example of an earthquake with both foreshocks and aftershocks.

The March 11, 2011 Great East Japan earthquake was centered in the Tohoku region off the east coast of Japan's most populated island of Honshu. Offshore, the Japan trench marks the edge of the subduction zone where the Pacific plate descends beneath the North American plate. Gravitational pull causes stress to accumulate and deform the rock. When strain exceeds rock strength, earthquakes occur.

Earthquakes are common in the Tohoku region. In the decades before 2011, an average of 35 earthquake of magnitude 4.5 or larger were detected in this area every year. The region has experienced much larger earthquakes in the more distant past, including at least four in the low M8 range in the past two centuries. Prior to 2011, Japanese seismologists had estimated that earthquakes in the mid M7 range recurred on the order of every 35 years.

At first glance, it might seem like the high level of seismicity makes it difficult to parse out what is an aftershock and what is a new earthquake unrelated to previous ones. To make the distinction, understanding how the 2011 rupture occurred is helpful.

Geoscientists use many tools to determine fault size in a particular earthquake. Japan is the most highly instrumented country in the world and its dense network of seismographs, GPS stations, and other instruments reveals not only the area that ruptured, but how much slip occurred.

It's a little mind boggling to realize just how big that earthquake was. Epicenter maps are a poor way to depict the size of big earthquakes. The dot on the map only represents the surface point above where the rupture began. In 2011, that point was off the coast of Miyagi Prefecture, about 60 miles east of Ishinomaki at a depth of 18 miles beneath the surface. This point was only the beginning. Over the next two minutes, the crack proceeded to grow outward along a roughly planar surface to the west and coastal communities, to the north and south and even as far as the trench 100 miles to the east. As the crack grew, it continued producing new seismic waves. When the rupture finally stopped, rocks along a rupture surface more that 300 miles long and 150 miles wide had been displaced relative to one another.

Here's where it gets complicated. The slip wasn't uniform. Some patches on that fault surface slid as much as 150 feet, the largest slip ever measured in an earthquake. Other patches slipped much less – only 10 to 15 feet. When the rupture finally stopped, equilibrium had by no means been restored. Aftershocks are nature's way of balancing out the unevenness in that slip distribution. They are concentrated in areas with slip irregularities.

Two things about aftershocks: they are contained within and adjacent to the region ruptured by the main earthquake and their numbers decrease in time. There

were over 2000 earthquakes of magnitude 4.5 and larger in the Tohoku rupture zone area in the year following the M9.1. This number dropped to 373 in 2012, and has generally decreased each year since then. Last year, the number had dropped to 78. But note that 78 is still more than twice as large as the background before 2011.

It may take another five years for the Tohoku region to finally sort itself out and return to the pre-2011 level of activity. There is no time limit to an aftershock. It's a statistical definition - as long as the number of quakes in the area is above normal background and the trend is downward, we call it an aftershock. The 2004 Andaman-Sumatra quake was the same magnitude but the aftershock window didn't last this long.

Just because we call February 13 earthquake an aftershock, doesn't diminish the capacity to cause damage. The earthquake was felt strongly in the coastal areas of Fukushima and Miyagi Prefectures, felt by many in Tokyo, and by some as far away as Hokkaido and Osaka. Calling it an aftershock in no way diminishes its capacity to cause damage. Media stories report 185 injuries, including 12 requiring hospitalization, many items knocked from shelves, minor damage to structures and widespread power outages. When you feel an earthquake, it makes no difference if it is an aftershock or not. Just be sure to protect yourself and Drop, Cover and Hold On.

Lori Dengler is an emeritus professor of geology at Humboldt State University, an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times-Standard's. All Not My Fault columns are archived online at https://www2.humboldt.edu/kamome/resources and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column, or to request a free copy of the North Coast preparedness magazine "Living on Shaky Ground."
https://www.times-standard.com/2021/02/21/not-my-fault-the-truth-about-aftershocks/