

## **Not My Fault: The difference between mainshocks, foreshocks, and aftershocks**

Lori Dengler/For the Times-Standard  
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Earthquakes almost never occur in isolation. The most common type of grouping is the mainshock – aftershock sequence. This is what is going on right now in the Gulf of Alaska. On January 23, a magnitude 7.9 earthquake occurred southeast of Kodiak Island. For those of us awake in those early morning hours, it gave us a bit of a start waiting to see if a tsunami alert would be issued for our area. Fortunately, it was the wrong type of faulting to cause a tsunami and we were able to peacefully go back to bed.

Since the M 7.9, over 1800 aftershocks have been recorded. Aftershocks are smaller earthquakes that occur after a large earthquake. They are nature's way of adjusting to the new stress regime caused by the fault slip from the main earthquake. The January 23quake ruptured a 125-mile long fault. The slip during the earthquake wasn't uniform. A section near the middle of that 125 mile-long zone moved as much as 30 feet during the earthquake. Other parts moved much less, and of course there was no slip at the ends. After the main slip, rock in the vicinity of the fault found itself in an entirely new stress regime. Areas that had slipped a lot were now in a lower stress area, zones that didn't move as much in the main quake now had a more push on them, and stress in surrounding rock may have increased or decreased depending on how the fault moved. Aftershocks are nature's way of resolving those stress differences. It may take weeks, months or even years for all parts of the area to adjust to the "new normal."

In the first week after the Alaska earthquake, over 1000 aftershocks were detected. Each succeeding week, the number declined – 305 the second week, 156 the third, 63 in week 4 and only 28 in the fifth and most recent week. Eventually, the number will return to whatever background value existed before the quake.

The larger the magnitude of the main earthquake, the longer and more vigorous the aftershock sequence. How to tell whether a quake is an aftershock or not? Statistics. Take for example, Japan. Japan is a seismically active area and all parts of the islands and adjacent offshore areas

experience some level of background activity. Between 2000 and 2010, about 35 earthquakes in the magnitude 4.5 or larger range were recorded each year off the NE coast of Japan's main island of Honshu. On March 11, a magnitude 9.1 earthquake ruptured a fault nearly 200 miles long and 100 miles wide. About 2100 aftershocks were recorded in the eight months after the earthquake. Like the pattern seen in the Alaska, the number of aftershocks has been declining since then, but the fault was so much larger and the slip so much greater, it has taken longer to adjust to the new background state. In 2017, 99 earthquakes were recorded in the area, still nearly three times the long term pre 2011 average. Just last Sunday, a M5.5 occurred offshore of Fukushima prefecture, right in the middle of the aftershock zone. It was strong enough to be felt throughout Japan's Tohoku region.

Not all sequences start with the biggest quake. In perhaps 10% of significant earthquakes, smaller earthquakes precede the main event hours, days or sometimes months beforehand. These smaller quakes occur on the same fault that produces the main rupture. The Japan earthquake was preceded by magnitude 7.3 foreshock two days before the main earthquake. At the time, there was nothing about the 7.3 that suggested a bigger quake was coming and the initial assessment was that it was going to be the main earthquake.

Sometimes aftershocks can be more damaging than the main earthquake. On September 3, 2010, a M 7.0 earthquake occurred on New Zealand's South Island, about 40 miles west of the city of Christchurch. It damaged some older buildings and caused a few injuries but no casualties. Nearly five months later, a magnitude 6.1 aftershock occurred. It devastated Christchurch killing 185 people and causing nearly three times the cost of the mainshock. The reason for the difference? The 6.1 aftershock was centered only 4 miles from the city.

Sequences are often more complex when they occur near the conjunction of several faults or tectonic regimes. The April 25, 1992 magnitude 7.2 mainshock was centered on a thrust fault in the triple junction area near Petrolia. Two very large "aftershocks" occurred in the early morning hours of the next day. I put "aftershock" in quotations because they were completely different kinds of earthquakes, on strike slip faults within the Gorda plate. The stresses and faults in the triple junction region are complex and when one fault moves, it is not unusual for the change in stress to trigger movement on adjacent faults.

To clear up any misconceptions, foreshocks, mainshocks, aftershocks, and triggered quakes are all earthquakes and are all quite capable of doing damage no matter what you call it. They all involve fault rupture, slip and the release of seismic waves. The larger the magnitude or the closer it is to you, the stronger it will feel. So the next time the ground starts shaking, don't be surprised if the shakes continue for some time afterwards. The actions you take now to secure your home and workplace will prepare you for the next sequence whether it includes one or dozens of temblors.

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