Times-Standard
Times-Standard / Humboldt Beacon

Not My Fault: Measuring earthquake size is not so straightforward

Lori Dengler/For the Times-Standard
Posted August 22, 2021
https://www.times-standard.com/2021/08/22/lori-dengler-measuring-earthquake-size-not-so-straightforward/

Janet asked after last week's column, "People report the Richter intensity of earthquakes and depth but not the length in time. I lived in San Mateo during the '89 quake. It seemed to last an eternity, and if I had lasted longer, the damages would have been even worse. So why no report how long the earthquake lasts?"

Thank you, Janet. First, what is Richter magnitude? Scientific agencies haven't reported Richter magnitude for decades. Yet some media still misuse the term. Yes, we still use Richter's magnitude concept and number range roughly as he defined it. But the way it is measured and what it means is vastly different now than the original definition back in 1935.

Charles Richter is mainly remembered for the first earthquake magnitude scale although he made many other important contributions to seismology. Caltech installed a network of Wood-Anderson seismographs in Southern California in the 1920s and Richter began studying instrumental seismicity in 1928. These instruments were the standard for regional studies, and we had two operating at Humboldt from 1948 to 1992.

Before Richter, earthquakes were measured by intensity, qualitative scales based on damage and human perception of shaking strength. People of that time likely knew the Rossi-Forel scale used to map shaking strength in the 1906 San Francisco earthquake or the Mercalli scale that was modified and adapted as a standard by the USGS in the 20th century.

With its new seismic network, Caltech wanted to publish earthquake catalogs and needed something more quantitative than intensity. Richter was influenced by Kiyoo Wadati in Japan who suggested ground displacement as a be a measure of earthquake size. Richter measured the largest seismic signal recorded on the Wood-Anderson instruments and, by adding/subtracting a factor based on distance away, converted it into a unitless number by taking the logarithm of the value.

Richter borrowed the term "magnitude" from astronomy for his new parameter, although in reverse. In astronomy, the brighter a star appears, the lower the magnitude. Richter calibrated the scale so that earthquakes would fall between zero and 10. After his 1935 publication, the idea was accepted by other seismologists and quickly became the global standard. When I entered grad school in 1969, we mainly used two magnitudes, Richter magnitude for regional earthquakes and Surface wave magnitude (same idea but using different seismographs) for earthquakes from far away.

Janet's question implies shaking length has nothing to do with magnitude determination. When it comes to Richter and Surface wave magnitudes, she's right. You measure the biggest signal. It is assumed that the signal will get bigger and bigger as the size of the source increases. The great earthquakes of the 1960s showed the limitation of this methodology. The Surface wave magnitude for Chile (1960) was 8.5 and Alaska (1964) 8.4, nearly the same as 1906 San Francisco's 8.3. Yet the Chile earthquake lasted at least 5 minutes and ruptured a fault area of 40,000 square miles, far larger than San Francisco's 40 seconds of shaking and 2,000 square mile rupture.

We now know that seismic amplitude saturates around magnitude 7. Instead, the signal gets longer for bigger quakes. This makes physical sense. Bigger earthquakes last longer because the rupture takes more time. In 1979, Tom Hanks and Hiroo Kanamori, proposed the moment magnitude scale. Moment magnitude is based on the size of the entire fault rupture and uses most of the seismic signal.

Moment magnitude is calibrated to roughly agree with Richter's original scale – moderate quakes have values in the M4-5 range and major quakes are M7 and above. But recalculation makes a difference for big quakes. On the moment magnitude scale, 1964 Alaska weighs in at 9.2 and 1960 Chile, a whopping 9.5; !906 San Francisco is demoted to 7.9. Moment magnitude is now the standard for almost all moderate to large earthquakes.

Earthquake duration is part of the magnitude number as it is defined today. A M5 earthquake will only last 10 or so seconds and a M8 about a minute. The USGS latest earthquake page includes duration info for some larger quakes. Go to quake.usgs.gov and click the latest earthquake map. For major earthquakes like the recent Alaska 8.2 or Haiti 7.0, you will find a link on the left menu to Finite Fault with a map of the fault rupture area and, at the bottom, a graph of rupture duration. The 8.2 lasted

nearly two minutes; the duration for Haiti was about 25 seconds.

Duration doesn't tell the whole story. The nature of the rupture and how fast it occurs also affects damage potential. Many fault ruptures propagate at the speed of sound, creating high frequency vibrations that you will feel and will shake structures strongly. But some ruptures proceed more slowly and produce little high frequency energy. The moment magnitude may still be large but the impact on the built environment small and people might not feel much shaking.

There is still much confusion about magnitude. As in Richter's original definition, today's magnitude doesn't tell you anything about damage or shaking strength. Rather it is a measure of the potential to do damage based on its location. The July 28th M8.2 in Alaska and the August 12th M8.1 in the southern Atlantic each produced about 30 times more energy and lasted two to three times longer than the August 14th M7.2 in Haiti. Yet the 8s caused no damage and the Haiti death toll now stands at nearly 2,200.

Thank you, Janet. More questions welcomed – see below on how to contact me.

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://kamome.humboldt.edu/resources and may be reused for educational purposes. Leave a message at (707) 826-6019 or email rctwg@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."