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Not My Fault: Earthquakes can and will happen anywhere

Lori Dengler for the Times-Standard
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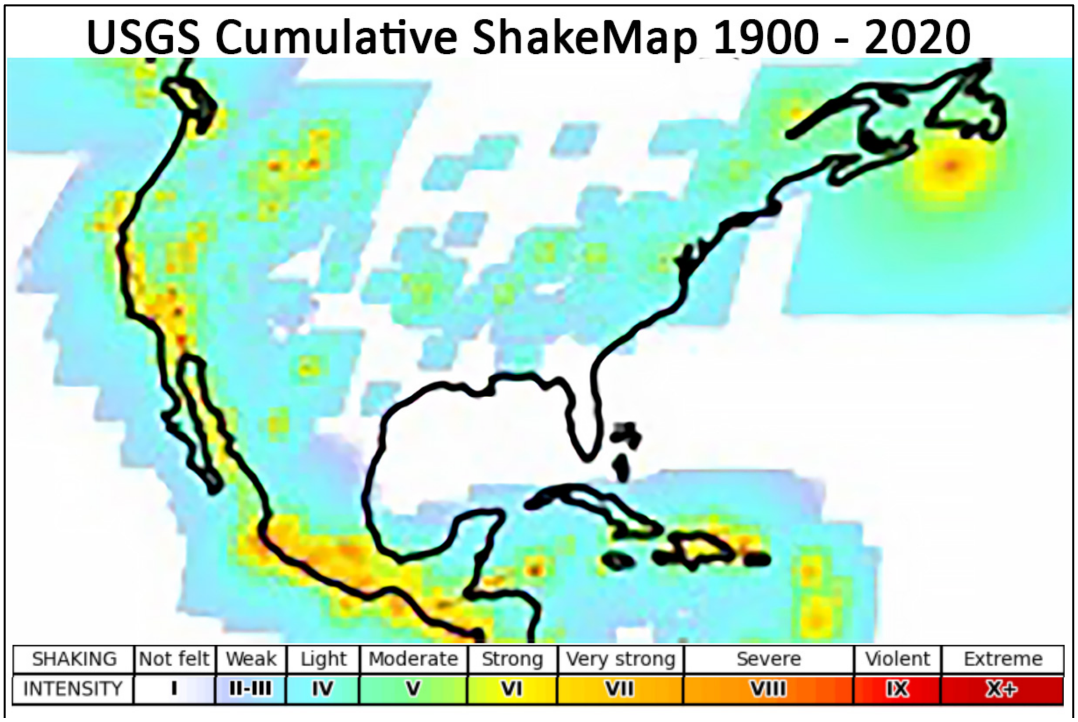

Annualized earthquake shaking based on actual and modeled USGS ShakeMaps 1900 to 2020 (Dave Wald, USGS).

New Jersey's magnitude 4.8 earthquake on April 5 continues to be front page news. At least 50 aftershocks have been recorded including a widely felt 2.6 last Wednesday. Teams of geologists, seismologists, and engineers are looking for the causative fault and impacts.

A friend of mine posted a quip from one blog, "… there is no active tectonic plate motion in the area today, but there was about 250 to 300 million years ago." The statement, from a reputable professor at SUNY Buffalo, ruffled my hackles a little. This wasn't because it was wrong, but, in my opinion, a little misleading. The unstated implication is that all earthquakes are caused by plate tectonics.

I lived through the plate tectonics revolution, and it was exciting to see how a once discounted idea became a bandwagon that we all jumped onto in the 1960s. The idea that our planet's surface was mobile goes back centuries. Sir Francis Bacon recognized how neatly the east coast of the Americas meshed with the west coasts of Europe and Africa in the early 17th century, and Alfred Wegner published tomes on Continental Drift with supporting evidence from fossils and geology beginning in 1912.

A quick search for "father of plate tectonics" will come up with Wegener's name. I give him kudos for recognizing continents could split and drift apart and slam into one another. But his proposed mechanism that the earth's solid crust could slide over the solid mantle was panned with good reason by geophysists. If a Nobel prize were offered in earth sciences (and it should be), I'd include Wegener but would add Harry Hess and J. Tuzu Wilson who supplied the mechanisms by which the outer part of the earth can move relative to the deep interior.

I was an undergrad at Berkeley at the time the Hess and Tuzo Wilson papers were published. I took a seminar in 1967 where we read these and other early plate tectonic papers and debated their validity. Not all of my professors jumped on board. The key point that finally swayed the naysayers was the discovery of a "soft" zone about 50 to 120 miles beneath the earth's surface many miles below the crust – mantle boundary. Called the aesthenosphere, this zone is a bit like cold molasses – it's basically solid but if stress is applied, can slowly flow.

Cooler and stiffer rock above the aesthenosphere can "slide" over the deeper rock. Called the lithosphere, this outer zone is broken into a number of slabs (plates) that can spread apart (like Iceland), slam together (like the Himalayas), and grind laterally past one another like the San Andreas.

Earthquakes, uplift and mountain building, and volcanic activity are concentrated in the boundary zones between plates. The highest erosion rates are likewise related to the steeper terrain in plate boundaries regions. Geologic evidence suggests the process goes back at least 3.5 billion years and shows an earth surface constantly changing with new plates formed, amassing together, and breaking apart, continually reshaping oceans and coastlines.

Fast forward a few decades and I am at Humboldt State University. I developed a general education class "Earthquake Country" in the 1980s. It was a bit of a battle to convince the curriculum committee that a class focused on earthquakes could teach the fundamentals of physical science to undergrads. One committee member commented that if we allowed an earthquake class to satisfy General Education requirements, a school in the Midwest might offer a tornado class. I answered Bingo and I bet students would flock to it.

Plate tectonics became a major part of the Earthquake Country course but after a few years I realized that many students were putting the cart before the horse. Why are there earthquakes? They would answer because of plate tectonics. No – earthquakes happen because of stress. Stress is concentrated at plate boundaries and earthquake are an important piece of evidence in the theory, but other processes cause stress as well.

I devised a class exercise. On the first day of the semester, students would choose an area like Alaska, Japan, or Indonesia, and a week of the semester when they thought a magnitude 5.5 or larger earthquake would occur. We would track the earthquakes through the term.

Term after term the results were similar. Roughly 90 to 95% of earthquakes were centered on or near plate boundaries. Convergent boundaries (subduction and collision zones) had the lions share at 75 to 80%, transform boundaries like the San Andreas sat at around 10%, and spreading centers 2 to 4%. So yes, most earthquakes are related to plate boundaries. But there was always 5 to 10% that were far from any boundary area.

We call these intraplate earthquakes. They are caused by stress triggering fault slip and produce the same types of seismic waves that other earthquakes do. But there is a difference. The bedrock geology in the interior of plates tends to be more cohesive – fewer active faults and fractures. The rock is also colder. The result is less attenuation or weakening of seismic energy. Wednesday's 2.6 was felt by some people in Washington DC and Rhode Island, 180 miles away.

Plate motion is not the only force acting on earth's surface. Volcanic activity, tidal forcing, temperature variations, melting of glaciers and ice caps, complex interaction of fluids and rock can all contribute to localized and regional stresses. Our planet is not uniform in composition and bears the scars of billions of years disassembling and reconstructing of its surface. Plate boundary zones that were active hundreds of millions of years ago imbed structural weaknesses that other stresses exploit today.

A few months ago, I asked a colleague of mine, Dave Wald at the U.S.G.S. if he could compile shaking frequency maps. Dave developed ShakeMap to depict ground motion data and he's recently modeled the expected shaking patterns of global earthquakes going back to 1900. Dave is usually a step ahead of me and sent me copies of the prototype maps his team has developed in the past few months.

Dave's maps show the expected level of shaking per year based on 120 years of data. It isn't a surprise that California shows up with stronger shaking patterns than most of the country. But over two-thirds of the US show at least light shaking. This was compiled before the recent New Jersey quake and doesn't include data from the major 19th century earthquakes in Missouri, Arkansas, and South Carolina.

Another result of those Earthquake Country surveys of long ago – students always expected their success rate to be about 5%. They actually succeed 35 to 45% of the time. Bottom line – we all live in Earthquake Country. And earthquakes happen more frequently than you might expect.

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/taxonomy/term/5 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 and to request print copies of preparedness magazine "Living on Shaky Ground."