Times-Standard
Times-Standard / Humboldt Beacon

Not My Fault: Of beach balls, the San Andreas and Cascadia

Lori Dengler/For the Times-Standard
Posted June 20, 2021
https://www.times-standard.com/2021/06/20/lori-dengler-of-beach-balls-the-san-andreas-and-cascadia/

I became aware of the unusual tectonics of California's North Coast in 1968, my senior year at Berkeley. It was my first seismology class, and the topic was focal mechanisms. The professor was working on a paper using focal mechanisms to study Northern California earthquakes.

Focal mechanisms had Berkeley roots dating back to Perry Byerly, first director of the Berkeley Seismographic Stations. We called them beach balls for their round shape and pattern of light and dark zones. It's a simple idea but complicated to explain. As a fault ruptures, seismic waves are pushed in the direction the fault moves rock towards and a pulled in the direction the slip moves rock away from (see https://www.youtube.com/watch?v=MomVOkyDdLo for an animation).

As seismology students, we spent hours poring over paper records to determine if the first motion was a push (up) or pull (down). We made plots to show what quadrants the fault had slipped towards and away from. From the final product, we could tell if the earthquake slip had been horizontal as in strike-slip movement, compressive (thrust), or extensional (normal).

Why does it matter? Fault motions are a window into regional tectonics. We were given a draft of the North Coast paper (Bolt et al. BSSA Bulletin Vol. 58, 1968) as an illustration. The summary figure showed northwest-oriented strike-slip faults in the San Andreas fault system, east-west strike-slip movement along the Mendocino fault and normal faults (extension) on the Gorda ridge.

By 1968, plate tectonics was accepted, and the Bolt paper used focal mechanisms to put earthquakes into this new framework. But not all the results easily fit into this model. Earthquakes weren't just concentrated along the plate boundaries. Many North Coast quakes were within the Gorda plate as well.

The plate tectonic model in its simplest form says deformation (faults and earthquakes) concentrate along plate boundaries and the interior of plates are deformation free. But the Gorda plate offshore of Humboldt and Del Norte Counties was riddled with earthquakes.

Bolt and colleagues proposed an explanation. These intraplate earthquakes were strike-slip and, at first glance, the beach balls looked identical to earthquakes in the San Andreas system. It was an easy jump to propose that the San Andreas was in the process of penetrating into the fabric of the Gorda plate and would eventually break through and connect to fault systems further north.

My seismology class in 1968 accepted this interpretation with no questions. Ten years later as a new lecturer at Humboldt State College, it was still the basis of my understanding. Bob McPherson quickly corrected me. Bob, a recent Humboldt Geology graduate, ran the Tera Corporation seismic network as part of a study of the PG&E Nuclear facility at King Salmon. He would go on to write up the Tera data as my first master's student.

The authors of the 1968 paper had failed to consider an elementary property of focal mechanisms. Beach balls tell you the type of faulting. The non-science majors in my Earthquake Country GE classes could easily distinguish strike-slip, normal and thrust faults. But there are always TWO possible fault orientations. It's called a double couple mechanism. Bolt and colleagues chose the NW-SE fault plane, the one that was the same as San Andreas quakes. But all of these earthquakes could have been caused by a fault oriented 90° to the NE-SW and McPherson and the Tera crew were convinced this was the case.

Bolt was persuaded on November 8, 1980, when a M7.2 earthquake offshore of Trinidad ripped an 85-mile-long fault in the Gorda plate. The focal mechanism showed strike-slip movement either to the NW or SE. How to tell the difference? The 7.2 temblor was followed by numerous aftershocks. Aftershocks concentrate along the causative fault and the 1980 sequence showed a clear SW trend.

More thorough examinations of historic North Coast quakes showed this was the rule rather than the exception and put to bed the San Andreas "breaking through" hypothesis. Seismologists would need to look elsewhere to explain the enigma of Gorda plate earthquakes.

This is my circuitous route to where I ended my column last week. How do plates die? The Cascadia subduction zone (CSZ) from Northern California to Southern British Colombia is the last gasp of a convergent margin that once extended along the entire North American and South American coasts. It's a good place to study that question.

For well over 100 million years, the subduction zone consumed the ancient Farallon plate. The ridge system that produced the Farallon probably looked a lot like the present day Mid-Atlantic ridge, jagged with lots of steps. Around 30 million years ago, one of those steps made contact with the subduction zone around the location of the Los Angeles basin. To the north and south, subduction continued and more and more of the ridge hit the subduction zone. The San Andreas transform was born of that contact and grew longer as more and more of the ridge was swallowed.

Today, the Juan de Fuca plate system is all that remains of the Farallon along the US and Canadian coasts and each year the remaining ridges move a little closer to the coast. In 15 or so million years, a blink of an eye geologically speaking, the last bit will be gone. And what happens then? The San Andreas will grow until it eventually connects to the Queen Charlotte fault system offshore of British Columbia and SE Alaska. In a way, Bolt was correct in the end result. The San Andreas will dominate in the long haul, just not in the way they had imagined.

In the interim, how much more kick does the Cascadia subduction zone still have? On a human timescale, plenty. Preparedness is the key. Recent research focus can help and that means a more targeted regional approach to hazards. Not all parts of the Cascadia margin are equal. Sounds like a theme for next week.

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."