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Not My Fault: The megathrust earthquake cycle

Lori Dengler/For the Times-Standard
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The Seismological Society of America is the world's largest organization dedicated to the study of earthquakes and their impacts on humans. The Society's highest honor is the Henry F. Reid Award recognizes the work that has done the most to the transform the discipline. This year's recipient is George Plafker for his studies of great subduction zone earthquakes.

I mentioned Dr. Plafker in my last column as a pioneer of post earthquake/tsunami reconnaissance. His contribution was much larger than that. By the time I became aware of the emerging Cascadia earthquake story in the 1980s, the general framework of megathrust earthquakes was understood. That understanding was in large part due to the work of George Plafker. The Reid award is an opportunity to look at how both Reid and Plafker contributed to understanding megathrust earthquakes, including our own Cascadia subduction zone.

Henry Fielding Reid was the first American professor of geophysics. Trained as a mathematician and physicist, the John's Hopkins professor became interested in earthquakes after the great 1906 San Andreas earthquake and was invited to contribute to the State's comprehensive earthquake report. Reid's contribution was describing how the land area around the fault had changed from before the earthquake to after. He examined surveys taken in the half century before the earthquake and noticed subtle changes in the location of landmarks, reflecting the accumulation of what he identified as "elastic strain," as forces pushed the land in opposite directions along the fault. Eventually the strain exceeded the strength of the rock, causing the earthquake and sudden offset between with the rocks snapping into a new undeformed state. Reid's work put to rest the controversy of what came first – the seismic waves or the fault - and became known as the Elastic Rebound Theory of earthquakes and is still the basic framework of the earthquake source to this day.

Fast forward to the 1960s. May 22, 1960, an earthquake ruptures hundreds of miles near the southern Chile coast producing a tsunami that affects the entire Pacific Ocean. A little less than four years later, a similar-sized earthquake strikes the Prince William Sound area of Alaska producing a tsunami that ravages Alaska and the west coast of North America. At the time, it was clear these were very large quakes, registering 8.6 and 8.5 on the Surface Wave magnitude scale, the variant of the Richter scale that was in use at the time. But only after theresearch of two more Reid award winners Aki and Kanamori (whose work would replace the Richter scale with seismic moment and moment magnitude) would the true size of these earthquakes become clear. When recalculated in the 70s, 1964 Alaska was upped to 9.2 and 1960 Chile became a whopping 9.5, the largest magnitude earthquake ever recorded on a seismograph.

Both of these earthquakes occurred before plate tectonics, the grand unifying theory of how the outer part of the earth works, was well known or accepted. In the sixties, many earth scientists believed great earthquakes occurred on vertical faults, like the 1906 quake. A very prominent seismologist published a paper about the Alaska earthquake in 1965 explaining that a vertical fault between 10 and 125 miles deep was the culprit. George Plafker would soon prove him wrong.

George was a quiet, meticulous USGS field geologist who had spent summers since 1953 mapping Alaska geology. He had little experience with earthquakes before 1964, but immediately recognized it was significant and convinced the USGS to send a group to study it. While the others worked on the damage in the Anchorage area, George took every available means of transportation to survey the bigger picture. He caught military helicopters and flew in bush planes to remote villages and islands. He spent commandeered a converted tugboat and measured ground level changes. Some areas had risen as much as 30 feet while other areas, formerly above sea level, were now submerged. He compiled a map contouring the patterns of deformation and was able to demonstrate no vertical fault could have produced what he observed. A few years later, he headed to Chile and mapped similar patterns of vertical changes caused by the 1960 earthquake.

In 1972, he published the results on his Alaska and Chile studies in a paper that is still cited today. In a sense, it turned Reid's Alaska Rebound theory on its side and along a fault that wasn't vertical, but sloped gently like a ramp. Instead of stresses moving horizontally, the force was compressional with a great offshore slab of the earth's surface diving beneath the continent. This mechanism not only explained the distinctive pattern of

uplift and subsidence, it also explained why both these earthquakes produced major tsunamis.

Plafker's work became the framework of what we now call the megathrust earthquake cycle – hundreds of years of slow deformation, squeezing and uplifting the overriding plate until, in a few tens of seconds, the fault ruptures and the land rebounds, resetting the scene for the cycle to occur all over again. The Cascadia region from coastal Northern California to Vancouver Island, Canada is somewhere in that cycle right now and sometime in the next years to many tens of years, a version of what happened in Chile and Alaska will happen here. We have George Plafker to thank for helping to make the picture clear.

Lori Dengler is an emeritus professor of geology at Humboldt State University, an expert in tsunami and earthquake. Questions or comments about earthquakes or this column can be sent to Kamome@humboldt.edu or (707) 826-6019.

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