

## **Not My Fault: The mystery of Hawaii's deep earthquakes**

Lori Dengler/For the Times-Standard  
Posted May 30, 2021

<https://www.times-standard.com/2021/05/30/lori-dengler-the-mystery-of-hawaiis-deep-earthquakes/>

Something unusual has been happening beneath Mauna Loa. No, not the slow rise of magma. Although that is also of interest. For the past six years, the world's largest volcano has been slowly inflating, a sure sign of magma heading to the surface. Mauna Loa is headed towards another eruption, but it is still likely months or years away.

Last week the Hawaii Volcano Observatory released a report about an ongoing swarm of earthquakes on the south coast of Hawaii near the small town of Pāhala (<https://www.usgs.gov/center-news/volcano-watch-new-research-sheds-light-recent-p-hala-earthquake-swarms>). Kilauea began a new eruption five months ago and, at first glance, that could be the cause. Except Pāhala is atop Mauna Loa, not Kilauea and the intensification of earthquake activity began in 2015. Even more puzzling, these earthquakes are much deeper than the quakes associated with surface eruptions.

When it comes to earthquakes, deep is a relative term. The USGS classifies earthquakes according to depth: less than 43 miles shallow, 43 to 186 intermediate, greater than 186 deep. The overwhelming majority of global quakes fall in the shallow category including almost all Hawaiian quakes. It is more useful to look at depth on a regional scale.

In California, more than 99% of the State's earthquakes are less than 18 miles in depth. The vast majority of earthquakes along the San Andreas fault system are less than 10 miles deep. A California earthquake at a depth of 15 or 20 miles is "deep" from a State perspective. And these so-called deep California earthquakes are almost all located north of Cape Mendocino. Some reach depths of over 50 miles and there is a deepening trend to the east away from the coast. The depth tells a story about the tectonics of California. These earthquakes are within the descending slab of the Southern Cascadia subduction zone.

What about Hawaii? There is no subduction zone or any plate boundary near the island chain. Earthquakes in Hawaii are notable as "intraplate" events, not related to stresses along a plate boundary. A hotspot, a plume of

warmer rock extending upwards from deep within the earth's mantle, is the cause of both Hawaii's seismicity and volcanism.

Aha, you might think, deeper Hawaii quakes are caused by the hotspot plume! Not directly. Hotspots are too warm for brittle fracture. But the hotspot can cause earthquakes in other ways. Volcanic activity driven by the hotspot is one type of seismic activity. As magma pushes its way upwards and outwards, the stress causes fracturing of adjacent rock. Earthquakes are also caused by the weight of all that lava output on the surface of the earth. Mauna Loa has been active for about a million years. The volcano has a volume of nearly 20,000 cubic miles, 500 times greater than Mt. Rainier. That is a load of at least 75 billion tons. Add in the weight of the Island's four other volcanoes, and the weight becomes even greater.

This weight is so large it causes the sea floor to sag, producing measurable deformation of the oceanic lithosphere (the crust and the uppermost mantle) that makes up the Pacific plate. Called isostatic deformation, bending makes faults, some near the surface and others at greater depth. Like California, relative depths of earthquakes in Hawaii tell a story. Most Hawaiian earthquakes in Hawaii are shallow, less than 18 miles beneath the surface. But unlike California, a much larger percentage (~7.6 %) of the Island's earthquakes are deeper.

The majority of Hawaii's deeper earthquakes are distributed broadly around the island, as you might expect if caused by the fairly uniform weight of the volcanoes. But the Pāhala swarm is different. Beginning in 2015, Hawaii Volcano Observatory (HVO) scientists began observing deeper earthquakes concentrated beneath the small town of Pāhala. The number of deep earthquakes in this small area has increased each year. In 2018, 176 magnitude 2 and larger earthquakes were detected; last year, the number was over 2000. We are on pace to exceed 3200 in 2021.

There has been debate at HVO on the origin of the Pāhala earthquakes. With isostatic deformation ruled out, attention turned to volcanic plumbing. Perhaps there was a deep conduit beneath Mauna Loa that supplied magma to Kilauea and the strong clustering was related to an unknown piping system. But this hypothesis is unsupported by any other evidence.

Taking a closer look this year, seismologists looked at the characteristics of these earthquakes. Unlike earthquake sequences related to a particular fault, the type of faulting

and fault orientations showed no clear pattern. Some were strike-slip, others showed dip-slip movement. Some were on steep fault planes and others were nearly horizontal. The variety of orientations and the concentration of the earthquake foci required a localized source.

The newest idea to emerge is that some of the magma generated by the hot spot plume is not traveling all the way upwards into a shallower magma chamber beneath Mauna Loa. Instead, there is a leak in the conduit and some of that magma is seeping out roughly 20 or so miles beneath Pāhala and stalling as it hits the cooler surrounding rock. The continued pressure from the seeping magma causes the localized increase in pressure and could explain why earthquake orientations are so varied.

This is a new idea and will require additional evidence to confirm. A bigger question is do these earthquakes pose a hazard? HVO scientists consider Pāhala unique; there is nothing similar in the fifty years of high-quality seismic data from the region and, without a precedent, it is difficult to make a forecast. The largest magnitude Pāhala quake to date was M4.2 in August of 2020. It was widely felt and caused a few items to topple over. My non-expert response? The sequence is likely to continue what it is currently doing a while longer, producing many small earthquakes, some large enough to be felt. And there is always a small but real chance that a much larger earthquake could occur – if not near Pāhala, on one of the many other faults beneath the island. For Hawaii, just like California, a strong earthquake could strike anywhere at any time so be prepared.

-----  
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](mailto: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."