

Not My Fault: Who has the most earthquakes? It depends on how you measure

Lori Dengler/For the Times-Standard
Posted November 29, 2020

What is the most seismically active spot in California? The answer depends on your perspective. If you are a regular reader of this column, you might say the North Coast and adjacent offshore area. That's a good answer when you look at size. We have fairly frequent M6s and 7s. About 46% of all earthquake energy released in the State over the past fifty years comes from our neck of the woods.

Folks in Southern California might wave their arms and say it's us of course. They are right if we defined "active" in terms of how many people feel earthquakes. A 4.5 near El Monte last September produced nearly 39,000 Did You Feel It reports. If the criteria were lives lost, it would be the San Francisco Bay Area. 1906 alone accounts for 85% of the total US earthquake and tsunami death toll in historic times.

What about just going by the numbers, regardless of size or impacts? Unless you are a close watcher of earthquake activity, I don't think you will guess this one. The area of California with the most earthquakes, sustained at a relatively steady rate for at least the past three decades is The Geysers geothermal area north of Santa Rosa. Over 200 earthquakes were recorded near The Geysers in the past week, 730 in the past month and nearly 10,000 in 2020 to date.

Why so little news coverage? Almost all of these earthquakes are very small in magnitude. And by small, I mean miniscule. Of the 730 earthquakes in the past month, only 23 were magnitude 2 or larger, the largest was a M3.2. The largest earthquake in The Geysers of the past year was a 4.1, and over the past 40 years, a 5.0. No historic earthquakes have caused any damage.

The earthquakes in The Geysers are unusual. They are not the typical mainshock – aftershock sequence where a large quake occurs followed by numerous smaller ones. They aren't swarms where a burst of nearly equal size earthquakes occurs over a period of days or weeks. The Geyser activity is sustained – 216 last week, 229 the week before and 237 the week before that.

The cause requires understanding the geologic setting and human activities. The Geysers is the world's largest electricity producing geothermal field. Steam drawn from more than 350 wells power 18 geothermal power plants that produces about 6500 Gigawatt hours of electricity a year. In 2018, renewable energy sources provided 32% of California's electric generation. 20% of that came from the Geysers, the single largest contributor to the renewable budget. A Calpine report in 2008 estimated The Geysers meets 60% of the total coastal electric power demand between Marin County and the Oregon border.

Energy production at The Geysers uses natural dry steam to drive turbines and convert the heat to electricity. The steam comes from a magma body about 4 miles beneath the surface. The Pomo, Wappo and Miwok peoples utilized the natural hot springs in the area for cooking, bathing and healing long before the entry of European peoples. In the mid 19th century spas and resort hotels were developed, a tradition that continues today in Calistoga. Electricity production began in 1921 when The Geysers Resort tapped the first geothermal well in the Western Hemisphere to power the hotel.

The Geysers steam field is fueled by a magma body that is part of the Clear Lake Volcanic Field. If you have driven through the Clear Lake area, you can't help but notice Mount Konocti, a cinder cone on the south shore of Clear Lake. One of my closest friends in graduate school at Berkeley was Julie Donnely-Nolan and her thesis project was to study Konocti and other volcanic centers to parse out volcanic history of the Clear Lake area. She and others ascertained that volcanic activity began about 2.1 million years ago and the most recent eruptive phase was 10,000 years before present. The area is considered quite capable of producing future eruptions.

The modern era of power generation at The Geysers began in 1960 with PG&E's first geothermal well. Calpine took over management in 1998. There are two features of The Geysers area that make it ideal for resource extraction. First, it produces steam and second, the steam is clean and contains almost no salts or contaminants.

The natural flow of steam from The Geysers began to decline by the late 1980s, reducing the power generation capacity. Calpine partnered with Lake County to use wastewater to recharge the field. In 2004, a 42-mile long pipeline from Santa Rosa provided additional fluids for the recharge effort. Treated effluent is injected into deep wells where it is heated to steam by the magma body in

the same way that natural ground water has fed the field for millennia.

There have always been earthquakes in the region. It is difficult to quantify the relation between geothermal activity and earthquakes prior to the commercial steam extraction era, as the seismic network wasn't sensitive enough to detect very small earthquakes. The process of withdrawing the steam and heat causes rock to contract and hence produce small quakes. I was certainly aware of Geysers seismicity as a grad student on the 1970s.

In the 1980s and 90s the seismic network was improved with the addition of borehole instruments and newer digital equipment. It is capable of recording earthquakes as small as 0.1. The impact of waste fluid injection shows up clearly in the seismic data records, and has more than doubled the seismicity rate. And although the number has increased, the magnitudes are still modest. Each year, on average only one or two quakes hit the low M4 range and most seismologists don't believe that heat extraction or waste fluid injection makes larger earthquakes beneath the geothermal area any more likely.

Note: more about The Geysers and the Clear Lake Volcanic Field at <https://www.usgs.gov/volcanoes/clear-lake-volcanic-field/geysers-geothermal-field>

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