Snowmelt causes seismic swarm near California's Long Valley Caldera

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Looking southwest across Convict Lake, Mono County, California, toward Laurel Mountain and the upturned meta-sedimentary strata under which some of the seasonal swarms occur. Credit: Emily Montgomery-Brown

A spring surge of meltwater, seeping through vertically tilted layers of rock, caused a seismic swarm near California's Long Valley Caldera in 2017, according to research presented at the 2019 SSA Annual Meeting.

The unusual event prompted U.S. Geological Survey researcher Emily Montgomery-Brown and her colleagues to look back through 33 years of seismic and water records for the region. They found that rates of shallow seismicity were about 37 times higher during very wet periods versus dry periods.

Although scientists have linked earthquakes to heavy rainfall or heavy runoff before this, the evidence connecting the two has been relatively weak or ambiguous, says Montgomery-Brown. In the Long Valley Caldera case, she says, "we're seeing phenomenal correlation between the seismicity and the stream discharge, and we are seeing about 37 times the number of earthquakes during the wet season as during the dry season."

As the meltwater recharged the groundwater in the drought-stricken area, it changed the pore pressure in the rocks lying one to three kilometers below the ground surface, triggering the small earthquakes of the 2017 swarm.

The shallow nature of the earthquakes, along with their unusual propagation, helped Montgomery-Brown and her colleagues determine that they were caused by seeping water and not volcanic processes related to Long Valley Caldera.

In locating the earthquakes, Montgomery-Brown's USGS colleague Dave Shelly found that the quakes "were actually propagating deeper, down from the surface," she says. In other swarms around volcanic areas, such as Yellowstone National Park, the earthquakes tend to start in a deeper seismic zone, about six to eight kilometers deep, and often move upward toward the surface.

Detailed geologic maps of the swarm area, to the south of Long Valley Caldera, show steeply dipping, nearly vertical rock layers that act like a fast conduit for meltwater. The runoff may not be reactivating a particular fault, Montgomery-Brown says, but instead may be infiltrating these rock layers and triggering small earthquakes there.

The researchers didn't see the same strong correlation between meltwater runoff and seismic rates in other areas around Long Valley Caldera. "It's only in these areas where we see the highly dipping strata," she says.

As far as she and her colleagues can tell, these shallow earthquakes stay shallow, and do not propagate deep enough to trigger activity on deeper faults in the area.

Montgomery-Brown has been studying seismic signals and monitoring ground deformation at Long Valley Caldera to keep track of volcanic activity and the movement of magma and gas beneath the caldera. Deformation caused by heavy snowfall (and then snowmelt) in the mountains creates seasonal signals in her data. "Usually I'm trying to get rid of that signal so I can see the actual volcanic deformation that is happening."

When the 2017 earthquake swarm—one of the biggest in a long time in the area— occurred on the edge of the caldera, she and her colleagues had been discussing whether it was caused by volcanic activity. "People were starting to feel the earthquakes, and we were wondering if we needed to issue some kind of statement regarding how the volcano was behaving."

But as she was giving a new manager a tour of a router closet at their offices, she ended up talking with Mammoth Community Water District managers who share the office space. As they talked about the spring runoff flooding, "it just kind of clicked in our understanding" how the runoff and the swarm might be linked, she says.

Provided by Seismological Society of America