

What triggers rockfalls? Yosemite study shows it's about the heat

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When rocks get hot, they do what people do: shed a few layers.

That cautionary advice comes from geologists who are measuring the seasonal expansion and contraction of granite cliffs in the Sierra Nevada - showing, in essence, how mountains become molehills.

And, if you happen to be underneath, flatten you.

"Cliffs move in and out, and detach," said Menlo Park-based U.S. Geological Survey scientist Brian Collins, who uses instrumentation to measure restless rocks at Twain Harte reservoir and Yosemite National Park.

"People look at landscape as static, that it will be there forever," he said. "But it's changing all the time." Think James Franco in "127 Hours" - caught between a [rock](#) and a painfully hard place.

Collins and U.S. Park Service geologist Greg Stock looked at the pattern of 925 past rockfalls in Yosemite with no known cause, and found about 15 percent occurred in the hottest hours of day, from noon to 6 p.m., between July and September. That's more than double the expected rate; if the rockfalls were random, only six percent would have happened during those hours.

Seasonal swings in temperature are also blamed for dangerous cracking in a restless and beautiful dome of granite adjacent to the concrete and

metal dam at Twain Harte Lake in the Sierra Nevada foothills, requiring \$900,000 in repairs, according to researcher Faye Lynn Moser of the University of North Carolina at Charlotte.

The Sierra Nevada is not the only place where granite domes are sloughing off layers. Other domes include such famed sites as Diamond Rock in South Africa, Rio de Janeiro's Corcovado Mountain and Stone Mountain, Georgia.

However, what's going on here is different than the rockfalls recently in southern Big Sur. California's Coast Range is made of soft sedimentary rock and soil, which becomes saturated and then slides after prolonged winter rains. In contrast, the granite of the Sierra is brittle igneous rock, which cracks when it expands and contracts.

How much do the slabs crack and move? Collins and Stock roped up and climbed a slab of unstable rock - 60 feet tall, 12 feet wide and 4 inches thick - in Yosemite's Royal Arches, behind the Majestic Hotel, formerly known as the Ahwahnee Hotel.

In the heat of a summer afternoon, the researchers found, an unstable slab in Yosemite bulges and moves off a cliff about 8 millimeters, almost one-third of an inch.

On cool nights, the slab reverses itself, shifting back about seven millimeters.

This means it moves 1 millimeter a year - and, over time, eventually breaks off and crashes into a giant pile of rubble. Their 2016 findings are published in the journal *Nature Geosciences*.

In human time, that might seem like no big deal. To be sure, it poses a far lesser risk than, say, climbing over guard rails to swim above Vernal

Falls or tailgating down Route 120's Priest Grade Road in a rush to get home.

But this process, called "exfoliation," is catastrophic if a boulder lands on your head.

"If I hear a big boom, I don't assume that it's far away," Collins said. "I look up to see where it's coming from."

Since the glaciers retreated around 15,000 years ago, rock fall has been the major force of change in the Sierra Nevada. While dramatic, rockfalls rarely kill; only about 15 people have died from rocks in Yosemite, for instance, over the past 150 years. The National Park Service has taken steps to reduce deaths still further, permanently closing the most vulnerable cabins in Curry Village.

The Collins-led team measures rock movement by climbing up into deep cracks and installing a long thin wire, which measures strain. (The wire vibrates at different frequencies as it loosens and tightens.) A device records data every five minutes - tracking movement as tiny as 0.001 centimeter.

New research led by UNC's Moser is now focused on a granite dome of Twain Harte Lake in the Sierra Nevada foothills, as well as 14 other nearby domes.

It has become a sensation with the geo-curious, who come in hopes of spotting what's called "active exfoliation" - bursting shards of rock.

A YouTube video circulated by a staffer of Condor Earth Technologies, which is studying the impact on the dam, documents the dome's gently widening cracks. Then the video turns as gothic as "The Blair Witch Project," with a shaky camera recording rocks that explode like hand

grenades.

Twain Harte officials were so worried about the restlessness - loud popping sounds and leakage of water - that they drained the lake in 2014 to strengthen and stabilize it. Last summer, they temporarily closed what's dubbed "The Rock," including the diving platform, and canceled special events.

Witnessing a lifeguard tower tilted up by rock, "my erudite and learned comment was 'Wow!'" wrote Garry Hayes, a geology teacher at Modesto Junior College and former president of the National Association of Geoscience Teachers, Far Western Section.

What's the cause? "Thermal cycling," rock deformation and cracking in response to sudden temperature shifts, based on Moser's data analysis.

While rock movement is most profound in heat, it happens all year long, Collins said. And other things - such as winter rain and snow, even tree roots or lightning strikes - may actually trigger the final collapse.

That's no reason to stay away from one of the most beautiful places on Earth, Collins said.

Sure, it's dangerous to linger for long on a talus slope, that pile of rubble that signifies weak rock above you. The safest place to stand is in a meadow, away from cliffs, he said.

But the geologic stresses and strains are what make the Sierra so special, he said. The hills seem alive.

"The reason we like to go is their beauty," he said, "and that beauty is the result of steep cliffs and rocks falling."

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