Research inside hill slopes could help wildfire and drought prediction

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Jackson School Assistant Professor Daniella Rempe directing the drillers on a ridgetop borehole. Credit: Michelle Pedrazas/ UT Jackson School of Geosciences

A first-of-its-kind study led by The University of Texas at Austin has found that rock weathering and water storage appear to follow a similar pattern across undulating landscapes where hills rise and fall for miles.

The findings are important because they suggest that these patterns could improve predictions of wildfire and landslide risk and how droughts will affect the landscape, since weathering and water storage influence how water and nutrients flow throughout landscapes.

"There's a lot of momentum to do this work right now," said study co-author Daniella Rempe, an assistant professor at the UT Jackson School of Geosciences Department of Geological Sciences. "This kind of data, across large scales, is what is needed to inform next-generation models of land-surface processes."

The research was led by Michelle Pedrazas, who conducted the work while earning a master's degree at the Jackson School. It was published in the *Journal of Geophysical Research: Earth Surface*.

Despite the importance of what's happening inside hills, most computer models for simulating landscape behavior don't go deeper than the soil due to a lack of data that can scale to large areas, Rempe said.

This study helps fill that knowledge gap, being the first to methodically sample the interiors of a sequence of hill slopes. The research focused on investigating the "critical zone," the near surface layer that includes trees, soils, weathered rock and fractures.

"This study helps to unravel a mystery in the critical zone research community, the linkage between bedrock weathering, topography and storage of water in mountainous watersheds," said Eric Pierce, the director of the Environmental Sciences Division at Oak Ridge National Laboratory who was not involved with the study.

The research site is in Northern California and is part of a national network of Critical Zone Observatories. The scientists drilled 35 boreholes across a series of hill slopes and their valleys to collect subsurface samples and other data. They also collected a core sample at the peak of each hill slope that captured the entire height of the hill—a distance that varied from 34 to 57 feet (10.5 to 17.5 meters).

The samples revealed deeper weathering and fracturing in hilltops and thinner weathering in valleys, in addition to weathering that penetrates deeper into shorter hill slopes than taller ones.

This finding is important because it suggests that computer models could use this scaling trend to model the extent of weathering in similar undulating terrain.

Where water is stored in the weathered rocks of hill slopes is an important question, especially during the arid summers experienced in the field area. Research led by Rempe in 2018 revealed that trees tap into water stored as "rock moisture" in the fractures and pores of critical zone rocks during droughts.

This study also revealed rock moisture in the critical zone—but only within the first 20 feet of weathered rock.

Learning more about how hill slopes store their water can help researchers determine what areas are most at risk of becoming wildfire hazards. Pedrazas said that the wildfire connection was clear when they collected the field data in 2018. Wildfires blazing in other parts of California turned the sun red and filled the sky with smoke. The setting underscored the fact that knowing what's happening at the surface is closely connected to what's happening within the hills.

"We were really seeing the potential impact of our research, [the importance of] where is the water, and when are trees really going to dry up, and what risk that is for society," Pedrazas said.

More information: Michelle A. Pedrazas et al, The relationship between topography, bedrock weathering, and water storage across a sequence of ridges and valleys, *Journal of Geophysical Research: Earth Surface* (2021). DOI: 10.1029/2020JF005848

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