New insights: How soil production processes respond to erosion

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A team comprised of Roman DiBiase, a recent SESE doctoral student of SESE, and professors Arjun Heimsath and Kelin Whipple, conducted research in the San Gabriel Mountains, a region in southern California. Their research provides new insights into how soil production processes respond to erosion. Credit: Courtesy of Roman DiBiase

In many ways, soil is fundamental to life. Flora and fauna depend on its presence for their survival as much as they depend on water and air. In order to sustain its soil content, an ecosystem needs to maintain a balance between rates of soil erosion and soil production. Factors such as tectonic plate movement or climate change can tip this balance, and learning how such changes affect soil cover is crucial to our understanding of how the Earth's surface works.

In a series of studies appearing in the journals *Nature Geoscience*, *Earth Surface Processes and Landforms*, and *Earth and Planetary Science Letters*, researchers at Arizona State University are providing new insights into how soil production processes respond to erosion in mountainous regions.

The studies utilized an ideal natural laboratory in the San Gabriel Mountains, a region in southern California, where previous work quantified a large range of erosion rates.

In the study released Feb. 5 in Nature Geoscience, Arjun Heimsath, associate professor in the School of Earth and Space Exploration (SESE) in ASU's College of Liberal Arts and Sciences, and co-authors measured soil production rates across the large gradient in erosion rates. Previous models suggested that once soil production rates reach a certain rate, they remain constant even if background erosion rates continue increasing. After making their measurements, the team recorded soil production rates that far exceeded this model's upper limit of soil production; contrary to previously held popular belief, the team found that soil production rates can keep up with very rapid erosion rates.

"One reason why this data is so exciting is because the previous way that we and other people viewed the world – the previous conceptual framework – was that there was an upper limit of soil production," said Heimsath. "There was thought to be a maximum possible rate of soil production and anything above that was not possible. We've found that the landscape is responding to this higher erosion rate by producing soil more rapidly, and that makes us rethink the way that we have believed the Earth's surface is responding to changes."

In a second study, in press in Earth Surface Processes and Landforms, led by Roman DiBiase, a recent doctoral student of SESE professors Whipple and Heimsath, the team developed a new method for determining where bedrock emerges in a landscape. Stitching together a series of high-resolution photographs and magnifying the composite image to compare with high-resolution topographic data and field observations, the researchers developed a method to accurately predict rock exposure from remotely sensed data. They used this technique to examine the details of the landscape's progression from soil to exposed rock in DiBiase's study, and also applied the technique for use in Heimsath's paper.

A third study, soon to appear in Earth and Planetary Science Letters, examined the relationship between chemical weathering – how rainfall chemically erodes a landscape – and erosion rates. The study's lead author, Jean Dixon, previously a postdoctoral researcher with Heimsath, found that chemical weathering rates increased along with soil erosion rates up to a certain maximum limit, after which point chemical weathering rates decreased even as soil erosion rates continued to rise. This phenomenon was predicted in a previous model, but this study marks the first time field-based data and observations verified the model.

"Because of doing the studies in the exact same place, we now have the ability to know how soil production is related to chemical weathering," said Heimsath. "And that's the next step, to really put them together even more clearly."

One interesting question the research raises is whether soil production rates do not have an upper limit, or whether the upper limit is just far higher than previously thought.

The team is also interested in pinpointing the mechanisms that explain their observations – how the landscape manages to keep up its rate of soil production with such rapid erosion rates. One hypothesis is that the biology of the landscape – the flora and fauna that are responsible for and dependent on much of the soil produced in mountainous regions – are working harder to maintain soil production rates to keep pace with erosion. Heimsath said that finding the answers to these questions will be the researchers' next endeavor.

"The presence of soil sustains our ecosystems," said Heimsath. "It sustains vegetation, and all the life that exists in mountainous regions. Understanding what sets the upper limit of soil cover is really important to understanding what can sustain life in some of these landscapes."

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Provided by Arizona State University

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