Chemical weathering controls erosion rates in rivers

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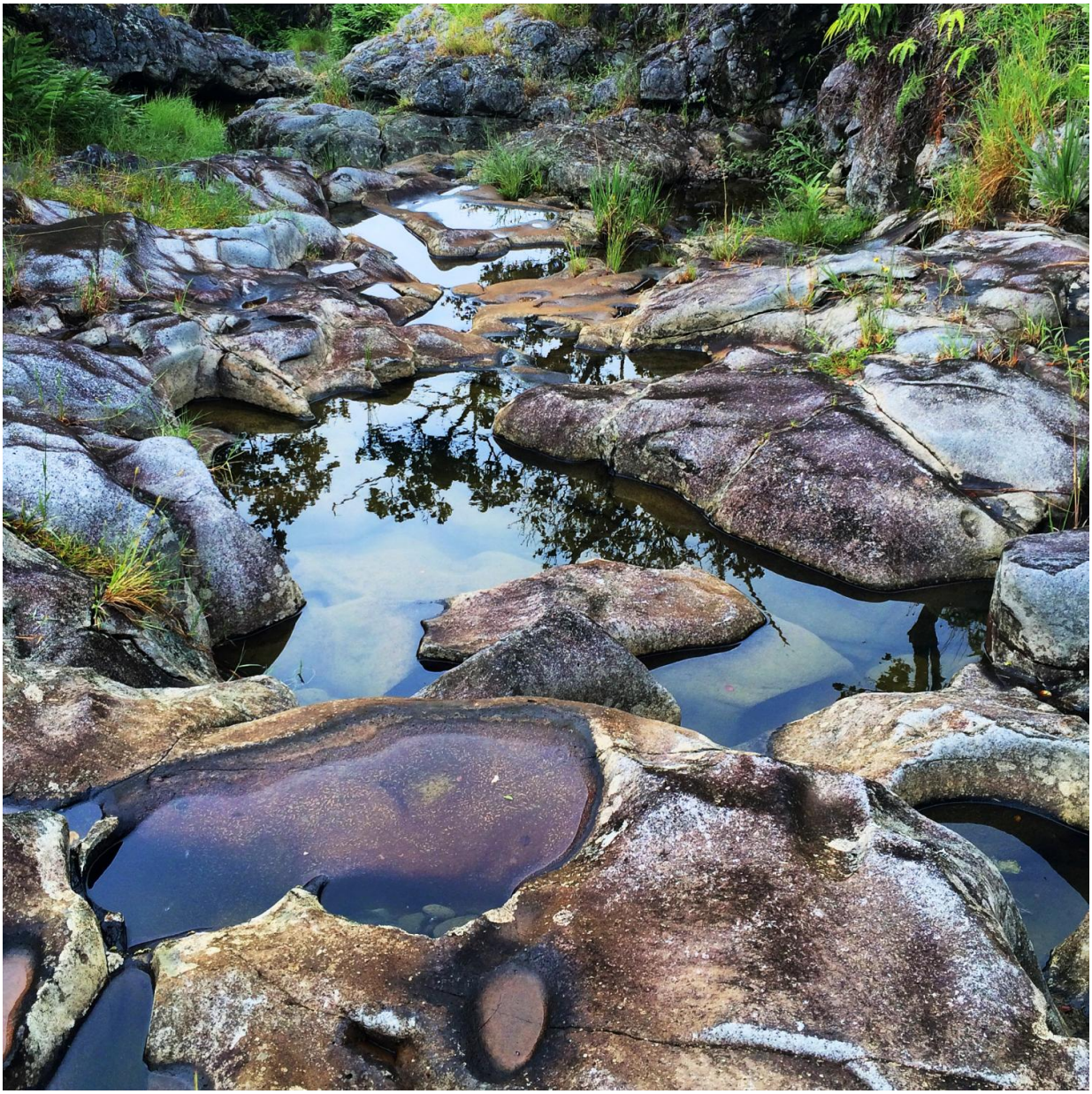

A bedrock-floored streambed after a recent flow event in Kohala Peninsula. Credit: Brendan Murphy

Chemical weathering can control how susceptible bedrock in river beds is to erosion, according to new research. In addition to explaining how climate can influence landscape erosion rates, the results also may improve scientists' ability to interpret and predict feedbacks between erosion, plate tectonics and Earth's climate.

The research, led by The University of Texas at Austin, was published in *Nature* on April 14, 2016.

"Our research presents a specific, process-based mechanism to explain how and why river erosion depends on climate, and also perhaps why previous studies have found conflicting sensitivities to climate in different landscapes," said Brendan Murphy, a Ph.D. student at The University of Texas Jackson School of Geosciences who led the research.

Murphy conducted the research with Joel Johnson, a professor in the Jackson School's Department of Geological Sciences, Nicole Gasparini of Tulane University and Leonard Sklar of San Francisco State University.

Chemical weathering occurs when minerals in rock react with water. These chemical reactions physically weaken rock by altering its structure. Rocks in streambeds then become more susceptible to erosion by physical processes, such as impacts by sediment carried in flowing water.

It has been established that chemical weathering influences rock

strength, Murphy said. But scientists have lacked data on the extent to which chemical weathering influences river erosion. To explore the issue, the team travelled to the Big Island of Hawaii, where the bedrock is made entirely of volcanic basalt, to collect data on chemical weathering, rock strength, and erosion rates in streams across wet and dry regions of the island.

A core of basalt sampled from the stream bed of Puanui Gulch on the dry-side of Kohala Peninsula. Credit: Kory Kirchner

"Hawaii is a simple, natural laboratory for studying how climate controls river erosion because it has uniform lithology and a very extreme precipitation gradient," Murphy said. "We went to investigate if the local

precipitation rate was changing the rock strength in the rivers and then looked for a mechanism to explain it."

They measured the strength of the rock using a Schmidt hammer, a device that measures surface hardness in the field, and also analyzed the chemistry and density of rock samples back in the lab to determine the influence of chemical weathering.

Consistent with their hypothesis, they found that bedrock was more chemically weathered and physically weaker where local precipitation rates were greater. More significant, Murphy said, was their finding that locations of high precipitation could maintain high erosion rates despite continuously exposing "fresh rock" - rock that was previously below the eroded surface and is not chemically altered.

Lead author Brendan Murphy (left) and his Ph.D. adviser Joel Johnson (right) hiking to river sources on the dry-side of Kohala Peninsula. Credit: Kory Kirchner

Fresh bedrock weathers rapidly when exposed at the surface, which weakens rock and allows it to be efficiently eroded by the river, the researchers found.

"This presents a positive feedback allowing river streambeds to maintain high weathering rates, weaker rock, and high erosion rates," Murphy said.

Based on their findings, the researchers modified a numerical model that describes how rivers cut into a landscape, Johnson said, finding that chemical weathering data drastically improved their ability to predict patterns of river incision.

"Once we included the climate effect demonstrating that the chemical weathering is weakening the bedrock and making it more erodible, we can do a much better job of matching the pattern and rates of incision that occur across this landscape." Johnson said.

Even though researchers examined only a single rock type, Murphy said that the mechanism linking chemical weathering to rock strength and erosion should apply to all types of rock. Understanding the relationship between erosion and chemical weathering can help tease out the role climate has on sculpting landscapes and influencing global cycles, Murphy said.

"The ability to better understand how landscapes erode is important,

because bedrock erosion affects chemical weathering, which is a major component of the global carbon cycle and can influence global climate by the removal of carbon dioxide from the atmosphere," Murphy said. "The ability to model landscape evolution and how climate plays into it is important for tying these larger global cycles together."

More information: Brendan P. Murphy et al. Chemical weathering as a mechanism for the climatic control of bedrock river incision, *Nature* (2016). DOI: 10.1038/nature17449

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