# Finding a Secret Map to Erosion (w/ Video)

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(PhysOrg.com) -- On the northeast coast of New Zealand's North Island, the Waipaoa River drains into the dazzling sea. Upriver, things are not so pretty. More than a century of land clearing for farming has created some of the most dramatic erosion in the world: raw amphitheatres and gullies dump tons of fine-grained mud into headwater streams, choking wildlife with silt and flooding vineyards downriver.

For land managers attempting to restore the Waipaoa Basin -- or eroding landscapes anywhere -- finding the source of sediment moving downstream is critical. Restoration is expensive and must be targeted. But, for decades, scientists have had difficulty tracking sediment moving through river systems. Carried for miles, it's hard to know how much of the sediment is pollution from poor land management -- and where, exactly, all that sand and mud is coming from.

Now, University of Vermont geology professor Paul Bierman and his graduate student Luke Reusser have developed a new rapid method for pinpointing sediment sources and tracking it downstream. Their results4 were published in the January edition of the journal *Geology*.

## Beryllium talks

Their technique begins with a smash-up high in the atmosphere. There, cosmic radiation slams into nitrogen and oxygen, sometimes ejecting a heavy form of the metallic element beryllium. This heavy isotope, beryllium-10, gets caught in rain and falls to earth where it sticks in the top few feet of the soil.

If the land it falls on is eroding slowly, beryllium-10 builds up over years. But if it is eroding quickly, little or no beryllium has time to accumulate.

Bierman and Reusser have been able to measure the amount of this "cosmogenic" beryllium stuck to the outside of grains of sand -- and uncover a kind of secret map to eroding landscapes.

Reusser started by collecting sediment samples in the Waipaoa's steep headwaters and worked his way down the main channel of the river until it emptied into the ocean. In these samples, he and Bierman were able to measure a rising number of beryllium-10 atoms as they went downstream. "What that change represents is an initial input of sediment from a huge gully or landside complex that has no beryllium-10," says Bierman. In other words, from a place that is eroding extremely fast. But then, as the sediment-filled waters flow downhill, the beryllium level rises, reflecting inputs from more-slowly eroding side-channels.

"People in New Zealand have been trying very hard to find a way to re-stabilize the hill slopes and try to mitigate some of these problems with sediment," Reusser says. "Now we can come in and, in a very accurate manner, characterize what portions of the drainage basins are problematic and which ones aren't so problematic for land managers to target and try to restore."

His results indicate that the gullied northern regions of the Waipaoa produce sediment twenty times faster than eastern or western sections.

## Cosmic revolution

"About 20 years ago nobody had a clue in many parts of the world how quickly landscapes were changing," Bierman says, standing in the humming crispness of UVM's Cosmogenic Nuclide Extraction

Laboratory5 that he leads. "For a long time -- since radio carbon dating came in -- we've had ways of dating things below the surface, but very few ways of dating rock and soil right at Earth's surface. So we've been hamstrung as a discipline from understanding how quickly landscapes change and erode over human and intermediate time scales." (To a geologist, "intermediate," means thousands -- instead of millions -- of years.)

But over the last two decades, the measurement of isotopes produced by cosmic rays, like beryllium-10, has revolutionized the study of geologic processes happening at earth's surface, giving scientists a new ruler for measuring the age of many landforms and the rate at which they change.

Since 1994, with ongoing support from the National Science Foundation, Bierman's laboratory has been helping to lead this revolution. He and his students have been analyzing cosmic-ray-produced isotopes of aluminum, chlorine and beryllium -- after counting atoms, "literally one by one!" Bierman says, at the Lawrence Livermore National Laboratory6 in California -- and starting to draw a worldwide map of erosion rates and recent changes to landscapes.

But some places -- like the Waipaoa Basin -- are still blank spots on this map.

"We're looking forward to filling it in," says Bierman.

## Beyond quartz

Before Bierman and Reusser's new technique, the beryllium-10 geologists studied was restricted to one variety. It forms when quartz grains on the ground are hit by cosmic rays, dislodging beryllium within their crystal structure. Not surprisingly, this kind of beryllium-10 can be studied only in places with plenty of quartz, evenly distributed across the landscape.

But the Waipaoa, like many fast-eroding landscapes, is dominated by calcareous mud and siltstone, not quartz. And, though erosion is severe there, it's not evenly distributed.

Bierman and Reusser's new approach adds meteoric beryllium-10 -- that forms in the air and rains down everywhere -- to existing isotope techniques.

"This will allow geoscientists to more easily measure rates of erosion around the world -- and the pollution coming with it," Bierman says, "from New Zealand to the Chesapeake Bay to Lake Champlain."

Provided by University of Vermont

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