New research shows rivers cut deep notches in the Alps' broad glacial valleys

December 5 2010

A train crosses a river gorge in the Swiss Alps that drops steeply from the floor of the broad glacial valley above it. Credit: Oliver Korup

For years, geologists have argued about the processes that formed steep inner gorges in the broad glacial valleys of the Swiss Alps.

The U-shaped valleys were created by slow-moving glaciers that behaved something like road graders, eroding the bedrock over hundreds or thousands of years. When the glaciers receded, rivers carved V-shaped notches, or inner gorges, into the floors of the glacial valleys. But scientists disagreed about whether those notches were erased by subsequent glaciers and then formed all over again as the second round of glaciers receded.

New research led by a University of Washington scientist indicates that the notches endure, at least in part, from one glacial episode to the next. The glaciers appear to fill the gorges with ice and rock, protecting them from being scoured away as the glaciers move.

When the glaciers receded, the resulting rivers returned to the gorges and easily cleared out the debris deposited there, said David Montgomery, a UW professor of Earth and space sciences.

"The alpine inner gorges appear to lay low and endure glacial attack. They are topographic survivors," Montgomery said.

"The answer is not so simple that the glaciers always win. The river valleys can hide under the glaciers and when the glaciers melt the rivers can go back to work."

Montgomery is lead author of a paper describing the research, published online Dec. 5 in *Nature Geoscience*. Co-author is Oliver Korup of the University of Potsdam in Germany, who did the work while with the Swiss Federal Research Institutes in Davos, Switzerland.

The researchers used topographic data taken from laser-based (LIDAR) measurements to determine that, if the gorges were erased with each glacial episode, the rivers would have had to erode the bedrock from one-third to three-quarters of an inch per year since the last glacial period to get gorges as deep as they are today.

"That is screamingly fast. It's really too fast for the processes," Montgomery said. Such erosion rates would exceed those in all areas of the world except the most tectonically active regions, the researchers said, and they would have to maintain those rates for 1,000 years.

Montgomery and Korup found other telltale evidence, sediment from

much higher elevations and older than the last glacial deposits, at the bottom of the river gorges. That material likely was pushed into the gorges as glaciers moved down the valleys, indicating the gorges formed before the last glaciers.

"That means the glaciers aren't cutting down the bedrock as fast as the rivers do. If the glaciers were keeping up, each time they'd be able to erase the notch left by the river," Montgomery said.

"They're locked in this dance, working together to tear the mountains down."

The work raises questions about how common the preservation of gorges might be in other mountainous regions of the world.

"It shows that inner gorges can persist, and so the question is, 'How typical is that?' I don't think every inner gorge in the world survives multiple glaciations like that, but the Swiss Alps are a classic case. That's where mountain glaciation was first discovered."

Provided by University of Washington