Tectonic stress feedback loop explains U-shaped glacial valleys

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In the shadow of the Matterhorn, the broad form of the Matter Valley—like so many throughout the Alps—is interrupted by a deep U-shaped glacial trough. Carved into a landscape reflecting millennia of tectonic uplift and river erosion, growing evidence suggests the 100-meter-deep (328-foot-deep) U-shaped groove was produced shortly after a shift toward major cycles of Alpine glaciation almost a million years ago. Subsequent glaciations may have therefore had little effect on the landscape.

The Matter Valley and other Alpine valleys' U-shaped incisions were carved by glaciers, but the power of ice alone is not enough to explain the location or apparent timing of the troughs' formation. If glacial forces were the sole driver, the valleys would be three times as wide, and would grow consistently deeper during each period of glaciation.

In previous research, Leith et al. proposed a new mechanism to explain characteristic fracturing in bedrock beneath glaciers, and in the present study, they find that this may have driven a one-off period of amplified glacial erosion in the Matter Valley. In the authors' model, bedrock stresses left over from mountain formation are focused beneath the surface at the center of V-shaped valleys. Early periods of glacial erosion carved through the upper bedrock layers, exposing the stressed rock. Thinning glaciers allowed the stressed bedrock to fracture, and broken rock was easily carried away by flowing ice. As the valleys deepened, stresses were further focused at the valley floor, creating more fractured bedrock and making it easier for the glaciers to dig in. Their model

suggests that bedrock stresses were relieved once the valley glacier retreated, and that subsequent periods of glaciation may not have encountered similar conditions.

The authors' model shows how glacial erosion promotes the formation of U-shaped valleys of a particular size and with a particular frequency, results which align with their observations in the Matter Valley.

More information: Subglacial extensional fracture development and implications for Alpine valley evolution, *Journal of Geophysical Research-Earth Surface*, DOI: 10.1002/2012JF002691, 2013 onlinelibrary.wiley.com/doi/10 … 012JF002691/abstract

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