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Graffiti for science: Qualitative detection of erosional patterns through bedrock erosion painting

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Bedrock erosion is a crucial constraint on stream channel incision, and hence whole landscape evolution, in steep mountainous terrain and tectonically active regions. Several interacting processes lead to bedrock erosion in stream channels, with hydraulic shear detachment, plucking, and abrasion due to sediment impacts generally being the most efficient. Bedrock topography, together with the sediment tools and cover effects, regulate the rate and spatial pattern of in situ surface change. Measurements of natural bedrock erosion rates are valuable for understanding the underlying process physics, as well as for modelling landscape evolution and designing engineered structures. However, quantifying spatially distributed bedrock erosion rates in natural settings is challenging and few such measurements exist.

We studied spatial bedrock erosion in a 30m-long bedrock gorge in the Gornera, a glacial meltwater stream above Zermatt. This stream is flushed episodically with sediment-laden streamflow due to hydropower operations upstream, with negligible discharge in the gorge in between these flushing events. We coated several bedrock surface patches with environmentally safe, and water-insoluble outdoor paint to document the spatial pattern of surface abrasion, or to be more precise, to document its driving forces. During four consecutive years, the change of the painted areas was recorded repeatedly with photographs before the painting was renewed. These photographs visually documented the spatial patterns of vertical erosion (channel incision), of lateral erosion (channel widening) and of downstream-directed erosion (channel clearance). The observed qualitative patterns were verified through comparison to quantitative change detection analyses based on annual high-resolution terrestrial laser scanning surveys of the bedrock surfaces.

Comparison of repeated photographs indicated a temporal cover effect and a general height limit of the tools effect above the streambed during flushing events. Further, the photographs clearly show the erosional development of a UFCS (upstream-facing convex surface) feature with an upstream-facing surface full of impact marks, a sharp crest-line, and an adjacent downstream-facing surface preserved from sediment impacts. This pilot study documents that bedrock erosion painting provides an easy, cost-efficient and clear qualitative method for detecting the spatial distribution of bedrock erosion and inferring its controlling factors. Our results show that the susceptibility of a painted surface to abrasion is controlled by its position in the channel and its spatial orientation relative to the sediment-laden flow. Erosion painting is a scientifically useful form of graffiti that could be widely applied in both natural and laboratory settings, providing insight into patterns and processes of erosion.