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Bedrock Gorges Preserved Through Alpine Glaciations?

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Long running controversy surrounds the origin of Alpine gorges nested in formerly glaciated valleys. Classic examples of such composite valley cross sections in the Swiss Alps have traditionally been interpreted as either the result of post-glacial fluvial bedrock incision into glaciated surfaces or palimpsest landforms carved more gradually during successive glaciations. We analysed LiDAR-derived, high-resolution topographic data and show that in the eastern Swiss Alps fluvial erosion rates >10 mm/yr are required to attain the relief of continuous v-shaped inner gorges solely during post-glacial times. Commensurately high glacial erosion rates would be required to eradicate such rapidly incised bedrock channels during glacial cycles. While post-glacial erosion rates in soft calcareous lithologies of the Penninic Nappes where deep gorges preferentially form are more than adequate to explain Quaternary exhumation rates, substantial additional erosion is required to account for the long-term exhumation of harder, crystalline rocks. We propose contrasting styles in the relative influence of glacial versus fluvial erosion in which glaciers remove crystalline rocks at rates far higher than during post-glacial times, but protect gorges in mechanically weak rocks through thick buffers of subglacial sediment fills through multiple glacial cycles. This counter-intuitive topographic resilience of gorges warrants re-examining conventional notions and models regarding the efficacy of glaciers and rivers in Alpine relief production during the Quaternary.