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Linking the transport of water and sediments with the bed characteristics of a steep mountain stream

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With increasing stream gradient, typically the grain size distribution coarsens, the number of immobile boulders increases and the channel bed morphology changes (from pool riffle, to step-pool and cascade morphology). This changing bed morphology has a significant impact on the transport of water and sediments as the flow resistance increases, thus raising the critical thresholds for particle entrainment.

The Riedbach (Switzerland) is a mountain stream with a stream gradient that steepens along the 1 km study reach from just 3% at the glacier forefield to more than 40% at a water intake. The runoff regime is dominated by glacier melt with daily peak discharge rates up to 4 m3/s in summer. We used a fluorescent dye tracer to measure flow velocities in 10 sub-reaches over a wide range of discharge conditions. In addition, we measured sediment transport rates in the flat study reach (3% stream gradient) using portable bedload traps and at the water intake structure downstream of the steep study reach (40% stream gradient) using a calibrated geophone system. Finally, we characterized the streambed using the characteristic grain sizes and roughness parameters derived from terrestrial laser scanning point clouds.

We found that both the characteristic grain size D50 and the standard deviation of the bed topography approximately increase with the square root of the channel bed slope. We also found that, although the bed gradient increases by more than an order of magnitude along the study reach, the mean flow velocity and the sediment transport rates remain approximately constant. Thus the increase in bed roughness compensates almost completly for the increase in stream gradient. Possible mechanisms behind this balance between roughness and stream gradient will be discussed.