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Effects of episodic sediment supply on experimental step-pool channel morphology, bedload transport and channel stability

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Steep step-pool streams are often coupled to adjacent hillslope, directly receiving episodic sediment supply from mass movement processes such as landslides and debris flows. The response of step-pool channels to the variations in sediment supply remains largely unexplored. We conducted flume experiments with a poorly sorted grain-size distribution in an 8%-steep, 5-m long flume with variable width at the University of British Columbia, to study the effects of episodic sediment supply on channel evolution. After a conditioning phase with no feed, the channel was subjected to sediment pulses of different magnitude and frequency under constant flow discharge. High-resolution data of hydraulics, bedload transport, bed surface grain size, and channel morphology were collected every 10-20 minutes and an additional time at the end of each pulse.

In response to sediment pulses, we recorded an increase in bedload transport rates, channel aggradation, bed surface fining, and continuous step formation and collapse. In between pulses, bedload rates dropped by several orders of magnitude, net erosion occurred, the bed surface gradually coarsened, and steps became more stable. The small-magnitude high-frequency pulses caused smaller but more frequent spikes in bedload transport, bed surface evolution, and thus step stability. Instead, the large-magnitude low-frequency pulses cause larger changes but provided a longer time for the channel to recover. This suggests that in step-pool channels pulse magnitude is a key control on channel rearrangement, while pulse frequency controls how fast and strong the recovery is.

The frequency and stability of steps varied as a function of local channel width, showing that channel geometry is a primary control on step formation and stability even under episodic sediment supply conditions. Instead, the effect of sediment pulses is less important because the total number and average survival time of steps were similar among runs with different pulses. The critical Shields stress decreased following sediment pulses, then increased immediately after, and fluctuated until the next pulse. The variations in sediment supply caused cycles in bedload transport rate, surface and bedload texture, thus controlling the variability in the threshold for

motion.

Our results indicate that episodic sediment supply is a primary control on the evolution of step-pool channels, with sediment feed magnitude affecting mostly morphological changes, and sediment feed frequency controlling channel stability.