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# Fill-terrace formation and sediment-signal disruption in response to environmental perturbations

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Sediment production and transport along sediment-routing systems are thought to vary with prevailing climatic and tectonic conditions. As such, the environmental conditions (climate, tectonics) of the past can potentially be reconstructed from sedimentary deposits. Reconstructions, however, must account for sedimentary signal modification through temporary storage and remobilization along the sediment-routing system. Fluvial fill terraces – the product of alternating phases of channel-bed aggradation and incision – are geomorphic features that result from temporary sediment storage and release. Although a range of field studies, physical experiments, and numerical models have investigated alluvial-channel responses and fill-terrace formation due to changes in environmental boundary conditions, we lack a systematic comparison of differences in channel morphology and terrace morphology formed by different types of perturbations.

Here, we show results from seven physical experiments, in which sediment supply, water discharge and base-level elevation were regulated individually. We investigated how different perturbations affected channel morphology, fill-terrace formation, and the transient response of sediment discharge. We found that either a decrease in water discharge or an increase in sediment supply resulted in channel-bed aggradation and channel steepening. In contrast, an increase in water discharge, a decrease in sediment supply, or a drop in base-level triggered channel incision and terrace abandonment. The lag-time between perturbation onset and terrace cutting defines how well channel morphology prior to the perturbation is preserved in the terrace morphology. Lag-times were found to depend on the local channel incision rate and on the synchronicity of incision along the channel. An increase in water discharge caused faster channel incision (and shorter lag-times) compared to a decrease in sediment supply. Whereas incision driven by water- and sediment-discharge changes were initiated nearly simultaneously along the entire channel reach, incision related to base-level drop caused a wave of upstream knickzone migration and diffusion, forming terraces with decreasing ages in the upstream direction. We found that channel conditions prior to perturbation were best preserved by terraces formed following increases in discharge.

Morphological adjustments of the channel in response to changes in incoming water or sediment supply also affected sediment discharge at the basin outlet. An increase or decrease in water discharge triggered channel incision or aggradation, recognizable as a temporary increase or decrease, respectively, in sediment discharge at the outlet. Permanent changes in upstream sediment supply were not recognizable at the outlet during the channel adjustment phase due to a negative feedback between the amount of sediment supply and the channel gradient. Changes in upstream sediment supply are thought to become measurable at the outlet only once the channel has adjusted to its new boundary conditions.