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Experimental insights on the effects of varying discharge on fluvial landscape evolution

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River floods are known to have large impacts on fluvial morphology as the capacity to carry water and rework sediment during these events is large. However, recent experimental findings are conflicting: some suggest that varying discharge contributes to a more single-thread pattern whereas others suggest that discharge variations cause multiple threads to be active, and yet others show no significant effect on the morphology. Our objective is to study the effect of varying discharge on experimental river patterns with otherwise similar conditions, and to quantitatively compare the resulting morphology and deposits.

Our experiments were conducted in a flume of 10x6 meter, which was split up into two separate fluvial plains (each 10x3 m). Fluvial landscape evolution was recorded by high-resolution line-laser scanning and digital Single Lens Reflex (SLR) camera used for channel-floodplain segmentation and particle size estimation. The bed sediment consisted of a poorly sorted sediment mixture ranging from fine sand to fine gravel.

First, a braided and meandering river pattern evolved for identical and constant boundary conditions, except that slightly cohesive silt-sized silica flour was added to the feed sediment of the meandering channel. A second set of experiments had an identical cycled discharge regime with a long-duration low flow and a short-duration high flow.The varying discharge largely affected the fluvial landscape by biasing the morphology towards the high flow conditions. This was reflected by an increase of the bar wave length with nearly a factor 2. Also, the depth of maximum erosion increased, which affects the preservation potential. The meandering and braided patterns responded differently to the floods. The noncohesive sediment combination with varying discharge results in a higher degree of braiding when compared to constant discharge. This was observed as a higher number of re-activating channels during high flow. In contrast, the silica flour acted as floodplain builder, which was more efficiently distributed during floods. As a result, the system with slightly cohesive sediment remained mostly confined to one migrating meandering channel that developed scroll bars, channel fills, splays and levees.

We conclude that the response to varying discharge depends on the availability and cohesion of fine floodplain-forming sediment in combination with the potential of high flows to re-activate residual channels.