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Controls on lateral channel mobility and the reworked area of active alluvial surfaces

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Temporal and spatial scales of alluvial channel migration across active floodplains, valleys, or fans control, for example, the stratigraphic architecture of fluvial deposits, the residence time of sediment on floodplains, and the formation of strath terraces across uplifting structures. We aim to better understand the controls on two key parameters that describe alluvial surface reworking: the total area of the reworked surface and the rate at which this reworking occurs. Whereas the detailed pattern of channel migration is inherently stochastic, the overall rate of reworking of an active alluvial surface is commonly interpreted to be controlled by water and sediment fluxes. However, these two parameters do not explain all of the variability of reworking rates in experimental and natural systems. In turn, controls on the reworked area are even less clear, especially in rivers that are not net aggrading but close to a steady state. In these rivers, channels do not necessarily have to visit the entire area that is available to them.

Here, we present results from laboratory experiments on a braided channel system fed from a fixed inlet and with a constant base level. We find that the rate of surface reworking (or channel mobility) is inversely correlated with the height of confining channel walls – either channel banks or valley walls – and that changes in wall height influence lateral channel mobility more strongly than do changes in sediment fluxes. Additionally, the area of the actively reworked fluvial surface is strongly limited by the confining channel walls. Perhaps surprisingly, gentler, slower flowing channels with less sediment flux tend to rework wider areas than steeper, fast-flowing streams. We develop a model that explains these observations and presents a step toward a general parameterization of the lateral migration of streams. The strong dependence of lateral mobility on valley-wall heights carries with it a sensitivity of migration dynamics to fluctuations in water and sediment supplies: for example, a small, transient increase in water supply can create incision that strongly restricts channel motion until the incision is filled.