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A numerical model for predicting alluvial cover in clast-rough and clast-smooth bedrock channel

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The areal fraction of bedrock covered by alluvium is typically modeled as a function of relative sediment flux (sediment supply rate over bedload transport capacity), yet little is known about how the roughness of the underlying bedrock affects the extent of alluvial cover. In this study, we performed flume experiments under varied sediment supply rates and bedrock surface topographies. We then developed a two-dimensional numerical model for predicting the cover fraction in consideration of the relative roughness (bedrock hydraulic-roughness over grain size), and tested the sensitivity of the model to changes in bedrock relative roughness and relative sediment flux.

The numerical results show that: 1) the cover fraction is smaller when the bedrock relative roughness is smaller; 2) when bedrock roughness is larger than alluvial roughness (clast-rough bedrock), the cover fraction gradually increases with sediment supply; 3) in the case of clast-rough bedrock with high sediment supply, mixed alluvial-bedrock alternate bars form, and a meandering thread of alluvial material migrates downstream; 4) when bedrock roughness is smaller than alluvial roughness (clast-smooth bedrock), a fully exposed bedrock channel requires a relatively large sediment supply before any alluvial patch is formed, and as supply increases, rapidly transitions to a fully alluvial channel; 5) in the case of clast-smooth bedrock, the transition between a fully exposed bedrock channel and a fully alluvial channel has hysteresis.

Keywords: Bedrock river, Fluvial geomorphology, Modeling, Sediment transport