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Experimental study of the relationship between mobile alluvial cover dynamics and sediment supply.

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Sediment cover blanketing the bed of erosional channels reduces or even inhibits vertical incision and favor lateral erosion. As such, the dynamics of alluvial cover is expected to play a fundamental role in controlling the long-term evolution of bedrock channels and the formation of fluvial terraces. Recent theoretical studies have suggested various formulations to relate the steady-state extent of bed cover as a function of sediment supply for initially bare bedrock channels below transport capacity. Voluntarily simplified to be tractable analytically, they cannot capture the complexity of sediment transport, bedform development and the coupling with fluid dynamics. We thus performed a series of simplified experiments to study alluvial cover development on a bare rough surface under steady supply of sediment. As bedload also plays a key role in the incision process by potentially abrading bare bedrock, we also study the relationship between sediment supply and the mode of sediment transport (bedload, suspended load or via bedform slow migration).

Our experimental setup is a 3m long, 12 cm wide and 3.5 cm deep rectangular plexiglass duct. At the entrance of the channel, a new system of sediment supply allows the precise control of the incoming sediment rate, independently of the water flow rate. We carried out a set of experiments at a fixed flow rate ($u* = 2.6 cm.s^{-1}$, Reynolds number = 14000) varying the incoming sediment rate Qin. In order to better understand the coupling between the morphodynamics of the bed and the fluid hydraulics, we monitor both the 3D topography of the bed with a projection moiré system and the grain dynamics with a 2D particle tracking system. Working with a fixed duct section allows us to explore high fluid velocity at small scale while retaining a size commensurate with bed topography and particle dynamics measurements. The total average sediment transport Q_{TOT} rate can be split in three distinct contributions : (1) the bed-load contribution Q_{BL}, (2) the suspended part Q_{SP}, and (3) the sediment transported by the sediment deposits during their migrations Q_D. Q_D is deduced from measurements of the height and migration speed of the deposit, while Q_{SP} is estimated with a particle tracking system. Q_{BL} is estimated indirectly at steady state using the fact that $Q_{TOT} = Q_{in}$.

Our preliminary results show that mobile sediment cover develops even at very low rate of sediment supply. For each experiment, cover development starts with the growth of sediment deposits until reaching a steady-state configuration. At steady-state, the cover increases with Qin from 50 to 85 percent. We found that at low sediment discharge, the three different modes of transport are on the same order of magnitude, while as Qin increases, the bed-load transport prevails over the other mechanisms of transport. Although the present experimental configuration cannot fully translates into natural conditions because of the absence of a free surface, these experiments allow to better understand the coupling between alluvial cover development, fluid hydraulics and sediment transport.