
Self-organisation of morphology and sediment transport in alluvial rivers

Éric Lajeunesse^{*1}, Olivier Devauchelle¹, Predrag Popovic², and Martin Chaigne³

¹Institut de Physique du Globe de Paris – Université Paris Cité, Institut de physique du globe de Paris, CNRS, F-75005 Paris, France – France

²Faculty of Physics, Belgrade University – Serbie

³Institut de Physique du Globe de Paris (IPG Paris) – Université Paris Cité, CNRS – 1 rue Jussieu, 75005 Paris, France

Résumé

The coupling of sediment transport with the flow that drives it shapes the bed of alluvial rivers. The channel steers the flow, which in turns deforms the bed through erosion and sedimentation. To investigate this process, we produce a small river in a laboratory experiment by pouring a viscous fluid on a layer of plastic sediment. This laminar river gradually reaches its equilibrium shape. In the absence of sediment transport, the combination of gravity and flow-induced stress maintains the bed surface at the threshold of motion. If we impose a sediment discharge, the river widens and shallows to accommodate the sediment input. Particle tracking reveals that the grains entrained by the flow behave as random walkers, and diffuse towards the less active areas of the bed. The river thus adjusts its shape to maintain the balance between this diffusive flux, which pushes the grains towards the banks, and gravity, which pulls them towards the center of the channel. This dynamical equilibrium manifests itself through a peculiar Boltzmann distribution, in which the local sediment flux decreases exponentially with the elevation of the bed. Experiments also show that, above some threshold sediment discharge, the river destabilizes into a braided river made of multiple channels. Although our results were derived from small-scale laminar flow experiments, they can be scaled to natural rivers, allowing us to use the morphology of rivers as a proxy for their sediment discharge.

Mots-Clés: rivers, sediment transport, geomorphology

*Intervenant