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Size segregation due to finer grain infiltration in bedload sediment transport

Bedload, the coarser material transported in contact with the bed by turbulent flow in stream channels, has major consequences for environmental sustainability and public safety. Size segregation is largely responsible for our limited ability to predict sediment flux and river morphology, hence to mitigate risks, especially in mountains where steep slopes drive an intense transport of a wide range of grain sizes.

Specific experiments [1] were carried out in a 10% steep, narrow channel, with a constant turbulent and supercritical flow in two stages. In the first stage, coarse spherical beads of diameter 5 mm were introduced at a constant feed rate to create a one-size-equilibrium sediment bed (i.e. a constant flow rate and a sediment outflux equal to the influx). In the second stage, finer beads of various diameters (from 0.7 mm to 4 mm) were introduced at different feed rates, while maintaining a constant coarse feed rate. The objective was to study the influence of (1) the ratio of coarse to fine grain size and (2) the percentage of finer material in the total feed. Depending on these parameters, the slope of the bed evolved eventually reaching a new two-size equilibrium value either larger (aggradation) or smaller (degradation) than the one-size slope [1].

Each experiment was recorded at a high temporal image frequency. Particle tracking algorithms based on a continuous minimisation energy method [2] permitted us to detect the coarse beads, and to track their trajectories. Once the two-size equilibrium is reached, we will analyse the depth profiles of particle streamwise velocity, concentration and sediment transport rate of the coarse beads. Depending on the grain size ratio and the percentage of the finer feed rate in the total feed, we observe a variable-thickness layer of fine grains on top of which coarse grains moved. For the same constant coarse sediment rate, the coarse grains moved either in concentrated low-velocity clusters or individually at a higher velocity.

A better understanding of bedload size segregation at the grain scale should permit upscaling for a more accurate river morphology modelling.

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2. Frey, P., Ducottet, C., 2025. Particle Tracking with Continuous Energy Minimization for the Study of Segregation in Bedload Transport. Experiments in Fluids **66**, 150. https://doi.org/10.1007/s00348-025-04072-3