

Spatial variations in surface sediment structure in riffle-pool sequences: a preliminary test of the Differential Sediment Entrainment Hypothesis (DSEH)

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Riffle-pool sequences are maintained through the preferential entrainment of sediment grains from pools rather than riffles. This preferential entrainment has been attributed to a reversal in the magnitude of velocity and shear stress under high flows; however the Differential Sediment Entrainment Hypothesis (DSEH) postulates that differential entrainment can instead result from spatial sedimentological contrasts. Here we use a novel suite of in-situ grain-scale field measurements from a riffle-pool sequence to parameterise a physically-based model of grain entrainment. Field measurements include pivoting angles, lift forces and high resolution DEMs acquired using Terrestrial Laser Scanning, from which particle exposure, protrusion and surface roughness were derived. The entrainment model results show that grains in pools have a lower critical entrainment shear stress than grains in either pool exits or riffles. This is because pool grains have looser packing, hence greater exposure and lower pivoting angles. Conversely, riffle and pool exit grains have denser packing, lower exposure and higher pivoting angles. A cohesive matrix further stabilises pool exit grains. The resulting predictions of critical entrainment shear stress for grains in different subunits are compared with spatial patterns of bed shear stress derived from a 2D Computational Fluid Dynamics (CFD) model of the reach. The CFD model predicts that, under bankfull conditions, pools experience lower shear stresses than riffles and pool exits. However, the difference in sediment entrainment shear stress is sufficiently large that sediment in pools is still more likely to be entrained than sediment in pool exits or riffles, resulting in differential entrainment under bankfull flows. Significantly, this differential entrainment does not require a reversal in flow velocities or shear stress, suggesting that sedimentological contrasts alone may be sufficient for the maintenance of riffle-pool sequences. This finding has implications for the prediction of sediment transport and the morphological evolution of gravel-bed rivers.