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Model studies of different sized tracer particles in bedload transport

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When gravel particles move down a riverbed, one might suspect that apparently random particle movements would lead to a relatively uniform mixture. However, it is well-known that, in general, this is not the case. Instead, particles tend to sort by size. Well-known examples of this include downstream fining, armouring, and gravel patch formation. To isolate certain particle sorting mechanisms, we study vertical and streamwise particle movement in a sediment feed flume using tracer particles of different sizes in a relatively uniform bed. The flume was run under conditions of relatively low sediment feed rate and water flow rate so that the sediment in the flume moved exclusively in bedload transport under lower-regime plane-bed equilibrium conditions. (The Shield's stress was approximately 0.1.) Nevertheless, while there were no bedforms, there were local fluctuations in the height of the bed which were monitored. We measured three aspects of sediment transport: (1) entrainment rates for particles starting at different depths within the bed, (2) deposition rates of particles to different depths within the bed, and (3) travel distance of particles over the duration of a run. We found that even for short durations, small particles are much more likely to become entrained and then buried once deposited than large particles. The large particles that are entrained travel farther per duration of run. This has implications for models of particle sorting in riverbeds, particularly armouring and gravel patch formation which we will discuss. Additionally, we discuss our observations in the context of a recently proposed model relating the statistical displacement patterns of particles to the channel-averaged hydraulic parameters.