Geophysical Research Abstracts,
Vol. 11, EGU2009-7830, 2009
EGU General Assembly 2009


# The action of sediment in bedrock river erosion

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Sediment acts in two contrasting ways in the erosion of bedrock rivers. Firstly, there is a 'tools' effect whereby grains in transport impact and abrade the bed, and, secondly, a 'cover' effect in which deposited sediment protects the bed from erosion. The bed erosion rate depends on the balance between these two effects, which is known to be a function of factors including sediment supply and shear stress. Possible forms of this relationship have been presented by Sklar and Dietrich (2004, 2006) and Turowski et al. (2007); further testing and validation of the suggested relationships are however necessary. Grain interactions are known to exert an important control over sediment transport in alluvial rivers and a limitation of current bedrock erosion relationships is that whilst they consider the grain-scale dynamics of grain saltation, they do not consider the grain-scale interactions that influence sediment entrainment.

A simple cellular automaton (CA) model of sediment transport in bedrock rivers has provided an alternative approach to investigating the form of the erosion relationship. The CA model explicitly reproduces the entrainment, transportation and deposition of individual sediment grains through a bedrock reach. The influence of grain-scale dynamics on grain entrainment is reproduced by altering the entrainment probability of each grain as a function of the presence of surrounding grains, with isolated grains having a higher probability of entrainment than grains in clusters. Initial results have demonstrated that the effect of sediment supply on the extent of sediment cover, and hence erosion rate, is sensitive to the grain entrainment probabilities. Field data are therefore necessary for appropriate parameterisation of these probabilities.

Field experiments have been performed using magnetically-tagged tracer grains in an upland reach of the River Calder, Scotland. This is a small bedrock river with patchy sediment cover, median grain size of 51 mm, and reach average slope of 0.009. Initial experiments demonstrated high sediment mobility, with all tracers, which have b-axes of between 22 and 90 mm, being displaced by shear stresses of up to 150 Pa (up to five times threshold). The maximum recorded displacement was 635 m during 17 above threshold flood events over 58 days. Subsequent experiments have recorded tracer entrainment over a range of flow conditions, providing data for CA model parameterisation and enabling a new form of the erosion relationship to be deduced.