TI: Can coarse surface layers in gravel–bedded rivers be mobilized by finer gravel bedload?

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AB: In response to reductions in sediment supply, gravel–bed rivers undergo a coarsening of the sediments that comprise the river's bed and, over some longer time scale, a river's grade may also be reduced as sediments are depleted from upstream reaches. Coarse, degraded river reaches are commonly observed downstream of dams across the Western United States. Following dam closure, these riverbeds become immobile under the altered flow and sediment supply regimes, leading to a reduction in the available salmon spawning and rearing habitat. Gravel augmentation to these streams is now common practice. This augmentation is typically seen as resurfacing the static coarse bed. As an alternative, we propose that the addition of appropriately finer gravels to these channels may be capable of mobilizing an otherwise immobile coarse surface layer, creating the potential to release fine material trapped beneath the surface. A series of laboratory experiments are being undertaken to test this hypothesis in a 30 m long and 0.86 m
wide gravel–bedded flume channel using a constant discharge and a unimodal bed sediment with a median grain size of 8 mm and no sand present. The channel width-to-depth ratio of ~4 suppresses the development of lateral topography and allows us to focus on grain-to-grain interactions. Experiments proceed by maintaining a constant sediment feed until an equilibrium grade and transport rate are established, starving the flume of sediment for at least 24 hours, and then adding narrowly graded gravel over a period of one to two hours at a rate that is ~4x the bedload rate observed prior to terminating the sediment supply. The bed prior to sediment addition has an armor median grain size that is typically twice that of the subsurface and feed size distribution. The volume and median grain size of the resulting pulses are varied. Pulses move downstream rapidly with well-defined fronts in the form of bedload sheets and cause peaks in the sediment flux approximately equal to the supply rate. Once the pulse has passed through the flume, bedload flux rapidly drops to background values, leaving few introduced grains on the bed. When the sediment feed is the median grain size of the subsurface bed material mixture, few armor grains are mobilized, although there is some exchange between the surface and bedload. Pulses composed of the fine tail of the surface grain size distribution are capable of mobilizing all grain sizes in the armor (including the largest grains) as finer bedload fills the interstices of the coarse surface layer. This suggests that gravel augmentation using fine gravel may provide an effective means of improving bed mobility conditions. Further experiments are underway to explore the effects of repeated fine gravel addition on bed state.

DE: 1825 Geomorphology: fluvial (1625)
DE: 1856 River channels (0483, 0744)
DE: 1862 Sediment transport (4558)
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