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Experiments on the grain size gap across gravel-sand transitions

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An abrupt transition in river bed grain size occurs from gravel to sand over a short downstream distance, often only a few channel widths, and is termed the gravel-sand transition (GST). At this point, the bed structure also changes from framework- to matrix-supported. Whether the GST is externally imposed, a result of internal dynamics (sediment sorting, abrasion, suspension deposition) or due to some other emergent property is unclear. There is also a general absence of rivers beds with median surface grain sizes between ~1 and 5 mm, often referred to as the grain size gap. Here we present two sets of new laboratory experiments, examining changes in fluid and sediment dynamics across the GST. In the first set, we created stable GSTs with a 10 mm gravel and 0.5 mm sand that show GST formation is consistent with previous theory suggesting that at shear velocities of ~0.1 m/s, sand particles rapidly fall out of suspension as a result of a particle Reynolds number dependency (i.e. a viscous effect). In a second set of experiments, we explored the fate of grain size gap material. We formed a gravel wedge composed of ~2 to 5 mm sediment, then fed 0.5 mm sand. Our observations indicate that where sand rapidly starts to fall out of suspension, the gravel bed becomes inherently unstable. Gravel is transported downstream until the grain size gap material is largely exhausted from the system (e.g. buried under sand or rafted out of the flume). This occurs because sand sized particles fill or bridge interstitial pockets in the fine gravel bed surface, generating fluid acceleration in the near-bed region (i.e. a geometric effect specific to these grain sizes). As such, particles in the grain size gap do not form the dominant mode in river bed sediments.