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Establishing an Unambiguous Connection between Grain Size, Basal Shear Stress and Style of Sediment Transport in the Lower Niobrara River, Nebraska, USA

V. Leung (1,2), D. Mohrig (1,3)

(1) Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Massachusetts, USA, (2) Now at the Institute of Geosciences, University of Potsdam, Golm, Germany, (3) Now at the Department of Geological Sciences, Jackson School of Geosciences, University of Texas at Austin, Texas, USA (vvleung@alum.mit.edu)

We propose a method for determining local sediment-transporting conditions using the distribution of grain sizes traveling in the water column. Previous research has shown that the style of sediment transport is related to mean flow conditions and bed topography. Direct application of experimentally derived relations to natural rivers, however, is difficult due the presence of complex bed structures and large variations in flow direction and velocity. In the Niobrara River, a sand bedded alluvial river in Nebraska, USA, we use miniaturized Helley-Smith bedload samplers to measure sediment concentrations at fixed heights above the river bed. Instantaneous shear stress at each location is found by fitting the Rouse profile for suspended-sediment concentration to the concentrations measured at three sampling heights over the bed. This inversion provides an estimate for the localized basal shear stress that is driving the transport of sediment. Empirical criteria are used to determine the fraction of sediment traveling as suspended load and bedload, two end-member sediment-transport modes. Application of this method to the Niobrara River shows approximately 80 % of the sediment is traveling as suspended load, 20 % is traveling in a transitional mode between bedload and suspended load and less than 1 % is traveling as pure bedload. We establish an unambiguous connection between grain size and the style of sediment transport and highlight the importance of the transitional transport mode in natural sandy systems. This technique is a unique method for constraining local basal shear stresses in the field under variable topographic and transport conditions.