1 INTRODUCTION

Bedload sheets are low-amplitude bedforms with heights of 1-2 grain diameters developed by sorting patterns in poorly sorted sediment. First identified by Whiting et al. (1988), they appear in river channels as bands of the coarser fractions of the bed material that grade upstream to the finer fractions. These features are commonly aligned across the primary flow path in river channels and migrate downstream, but it is not uncommon to see bedload sheets shoaling onto bars as a result of secondary flow patterns (Wooldridge and Hickin, 2005).

The formative mechanism for bedload sheets has not been fully elucidated, but they form and migrate downstream as a consequence of the 'catch and mobilize' process, in which large grains are caught in the wakes of other large grains, followed by infilling of their interstices by smaller particles, which can in turn smooth out hydraulic wakes causing large particles to be remobilized (Whiting et al., 1988; Venditti et al., in prep.). The sorting patterns across bedload sheets suggests that they pose abrupt changes in roughness and turbulence structure (Best 1996 and references therein) and Seminara et al. (1996) proposed that the stress perturbation due to this sorting structure allows for the growth of bedload sheets.

Bedload sheets are widely thought to be the a precursor to gravel dune development when flows are sufficiently large that grain inertia is overcome to proposed for bar types (e.g. Seminara, 1997), sediment patches can be identified as either 'forced patches' (spatially persistent associated with topographic controls), 'fixed patches' (spatially persistent due to coarsening), and 'free patches' (migrating patches) (Nelson et al., in prep). Bedload sheets belong to the latter type of migrating patches. Field and flume studies suggest that sediment supply and bed texture are dynamically linked, suggesting a linkage between sediment patch dynamics and sediment supply. For example, Dietrich et al. (1989) proposed that surface armoring depended on sedi-

sand. In the Berkeley Experiments, the front of bedload sheets was composed of relatively well-sorted moderately coarse (8-14 mm) gravel, where gravel of like-sized material became deposited over a coarser inactive bed. Fine (3 mm) gravel then filled the interstices of the sheet front and the front material was remobilized. Both of these processes illustrate of the 'catch and mobilize' phenomenon described by Whiting et al. (1988). This process creates the downstream-sorted structure of a bedload sheet and also provides a mechanism for its movement. While this phenomenon has thus far only been observed in poorly sorted sand-gravel mixtures, our observations in the sand-free Berkeley Experiments suggest that the ratio of coarse and fine grain sizes is probably more important to this process than the mere presence or absence of sand. The mobilization effect of the fine grains on the coarse grains is likely related to a hydrodynamic smoothing effect that increases the near-bed velocity and drag on the coarse particles (Venditti et al., in prep.).

The bedload sheets caused order of magnitude fluctuations in sediment flux that decreased as the feed was reduced. Figure 4 plots the variations in sediment flux caused by bedload sheets exiting the Berkeley flume. Observations during the experiment suggest that flux spikes occurred when fine gravel filled the interstices of a coarse head, dramatically increasing the transport of both the coarse and fine fractions of the grain-size distribution. This is supported by observations from the Tsukuba Experiments where dramatic increases in sediment flux are linked to increases in gravel transport, and not necessarily sand. Decreased transport events are linked with periods when a coarse sheet head is trapping like-sized particles. Careful mapping during the Tsukuba Experiments permitted examination of bedload sheet celerity and length. These results suggest that both bedload sheet velocity and length decrease as sediment supply is reduced.

When sediment supply was completely eliminated in the Berkeley Experiments, the coarse stationary patches expanded to encompass the entire bed. Thus bedload sheets no longer occur, but the channel hydraulics remain essentially the same. Collectively, these results appear to demonstrate that bedload sheet dynamics, extent, abundance, and occurrence are controlled by sediment supply and not the hydraulics of the channel.

3 DISCUSSION AND CONCLUSIONS

These results have important implications for inclusion of bedload sheets and, potentially all bedforms in mixed-size sediment, on traditional bedform phase diagrams for sandy bedforms. Indeed, the fact that sheet dynamics and occurrence are controlled by sediment supply, suggest that hydraulically-based phase diagrams are not appropriate predictors of bedload sheet occurrence.

We suggest that the way forward lies in development of bedform occurrence diagram and occur

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