

## ***Interactive comment on “Clast imbrications in coarse-grained sediments suggest changes from upper to lower flow regime conditions” by Fritz Schlunegger and Philippos Garefalakis***

**S. McLelland (Referee)**

s.j.mcllelland@hull.ac.uk

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I think that the paper by Schlunegger and Garefalakis is very interesting and thought provoking, however, whilst changes in flow regime may contribute to the development of imbricated structures, I think it may just be one of many possible explanations for clast imbrication. Hence, it is unclear that the results from the paper can really ‘test’ the proposed hypothesis.

I think the paper lacks a clear explanation of the possible processes and mechanisms for imbrication. As suggested in previous the comments by P. Carling and R. Hodge, there are many flume studies that show imbrication can develop under steady flow

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conditions. Powell et al. (2016) showed that imbrication developed under steady flow conditions as a mobile armour layer develops with dimensionless shear stresses ranging from  $\sim 0.025$  to  $\sim 0.045$  and subcritical flows. Powell et al. also demonstrated that imbrication developed very rapidly in the absence of any change in flow regime. Analysis by Qin et al. (2012) of static armours developed in flume experiments by Aberle and Nikora (2006) also show the presence of imbrication when flows remain steady but the sediment transport rate is diminishing. Both these experimental studies show that imbrication can develop without any change in flow regime whatsoever and when transport rates are constant or reducing. In reply to P. Carling, the authors suggest that the steepness of imbrication may indicate a change in flow regime. It’s unclear whether there is evidence to support this? Other work has shown that gravel bed structures can change even under sub –critical flow conditions (e.g. Haynes and Pender, 2007; Ockelford and Haynes, 2013). I suggest therefore that it is possible that steepness of imbrication could be a reflection of the flow history in the absence of upper flow regime conditions.

It is possible that imbrication will develop when flow regimes change, but there is also significant evidence that imbrication can develop without any change in flow regime. Therefore it doesn’t seem possible to demonstrate the presence of a given flow regime using the evidence of imbricated sediments. It’s unclear to me that the presence of a structure in sediment deposits can unlock a single the flow regime that produced that structure. Experimental evidences suggests these bed structures could have been produced under conditions of high or low dimensionless shear stress and may even develop without those sediments being transported as a consequence of bed restructuring during lower flows.

Haynes H, Pender G. 2007. Stress history effects on graded bed stability. *Journal of Hydraulic Engineering* 33: 343–349. Aberle J, Nikora V. 2006. Statistical properties of armored gravel bed surfaces. *Water Resources Research* 42: W11414. DOI: 10.1029/2005WR0 04674 Haynes H, Pender G. 2007. Stress history effects on graded

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bed stability. *Journal of Hydraulic Engineering* 33: 343–349. Ockelford, A., and H. Haynes (2013), The impact of stress history on bed structure, *Earth Surf. Processes Landforms*, 38, 717–727, doi:10.1002/esp.3348. Powell, D. M., A. Ockelford, S. P. Rice, J. K. Hillier, T. Nguyen, I. Reid, N. J. Tate, and D. Ackerley (2016), Structural properties of mobile armors formed at different flow strengths in gravel-bed rivers, *J. Geophys. Res. Earth Surf.*, 121, 1494–1515, doi:10.1002/2015JF003794. Qin, J., D. Zhong, G. Wang, and S. L. Ng (2012), On characterization of the imbrication of armored gravel surfaces, *Geomorphology*, 159–160, 116–124, doi:10.1016/j.geomorph.2012.03.012.

Comments by line (I've avoided repeating comments already made by others): 50: The diagram suggests that hydraulic jumps occur at a grain-scale (as shown in Figure 1 and later in Fig 5)? Is this a representative of realistic situations? 169: It's not clear why sediment structures are associated with 'channel forming floods'. As experiments have shown, bed structuring can take place as mobile or static armours develop which may be just high flow events rather than channel forming events. 288: Are these groups of imbricated clasts cluster bedforms or are they just embedded in the bed structure? It would be useful to distinguish whether or not your structures are clusters both in terms of the modern streams and stratigraphic record. 355: You use  $D/d$  in text, but  $D_{84}/d$  in equations. 373: Equation 1 does directly related to flow depth ( $d$ ) or  $D_{84}$

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