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Sediment supply accommodated through streambed coarsening in gravel bed rivers: re-visiting the armour ratio

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Streambed texture and grain-size distribution in gravel-bed rivers adjust to a balance between water and sediment supplies. In this regard, streambed surface in gravel-bed rivers is usually coarser than the subsurface bed material. This textural pattern of vertical sorting, or reverse grading, often named 'surface armouring', is very typical in degrading beds and river-reaches with no sediment feed (e.g. gravel-bed reaches below dams or lakes). However, non-degrading gravel-bed streams with considerable sediment supplies may also exhibit some degree of surface coarsening. At the same time, different types of bedforms and particle arrangements develop with the progressive coarsening of the streambed. Thus, armouring somehow proxies the overall streambed's organization in gravel-bed streams.

Evidences from previous flume experiments and field observations reported that reductions in sediment feed tend to induce surface coarsening in gravel-bed rivers, together with active channel narrowing and bedload fining. Fluvial geomorphologists normally describe surface armouring by means of the 'armour ratio': ratio between a characteristic grain size for the surface layer and the equivalent for the subsurface bed material. Flume experiments have already shown an asymptotic raise in the armour ratio with the decline in sediment supply. In this paper, we explore whether a comparable trend might be observed on field data from gravel-bed rivers. To quantify how surface armouring varies with sediment supply in natural rivers could be interesting to improve our understanding of gravel-bed river morphodynamics. To accomplish this, we employed a dataset of bedload and grain size measurements from more than 40 natural gravel-bed streams compiled from the scientific literature.

We obtained a strong and statistically significant correlation between bedload rates at bankfull and armour ratios for the field examples: armour ratios increase with the negative power of bedload rates. This fit is comparable to that observed on data from flume experiments with varying sediment feed. In addition, the shape of the obtained empirical fit is very similar to the relation between armour ratio and bedload yields that we inferred from dimensional analysis based on a bedload formula.

Our results highlight that the balance between sediment supply and transport capacities has a quantifiable reflection on armour ratios in natural gravel-bed rivers: the sediment supply regime has a quantitative imprint over the armour ratio in gravel-bed settings. Here, we provide a general quantification of this textural signature of sediment supply. Since armouring provides important information about the bedload regime of a specific reach (e.g. partial mobility vs full mobility, streambed organization), this may potentially furnish some interesting clues for interpreting armour ratios measured in the field.