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Quantifying sediment dynamics and intermittency of gravel bed rivers; examples from the Gulf of Corinth

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Stratigraphic architecture within a basin is fundamentally controlled by the volumes, grain sizes and characteristics of sediment supplied from rivers. However, few studies have constrained how intermittent sediment discharge is into a basin and how regional climate may affect the partitioning of sediment within active transport and basin stratigraphy, especially at a regional scale for multiple rivers. For example, gravel bedload flux occurs primarily in occasional large discharge events, however, finer particles are likely to be transported more frequently in lower discharges, thus enabling efficient transport of finer bedload to the sink. The intermittency factor (I_Q) allows us to calculate how long sediment is in transport and therefore how frequently a river experiences geomorphologically significant events, which may shed light on storminess and climate.

We investigate the intermittency for 49 rivers draining into the Gulf of Corinth, Greece. These rivers are gravel-dominated and typically form large Gilbert-type deltas. In contrast, the offshore basin stratigraphy is largely mud dominated. We measured the full-weighted grain-size distribution of channel bars at the river mouths by in-situ sieving and quantified channel hydraulic geometries using a laser- range finder. The median grain-size (D_{50}) of the rivers range from <1 mm to ~ 40 mm, and the overall D_{50} is 15 mm. We used our D_{50} measurements and hydraulic geometries to calculate shield stress at the river mouths. From this we estimated the bedload transport capacity of each river using the Meyer-Peter-Muller equation. Together, these measurements allowed us to constrain the bedload transport capacity at short timescales.

We define the intermittency of these rivers as the ratio of the bedload transport capacity estimated from morphological measurements of the channels and the grain-size to the long-term sediment flux derived over millennial timescales. For constraining the long-term river sediment flux, we calculated the annual suspended sediment flux for each river using the BQART sediment flux model, ground-truthed to seismically-derived measurements of basin volume in the Gulf. Assuming that bedload to suspended-load partitioning is 35:65, we derived an annual bedload flux for each river, which represents an averaged value over the Holocene.

We find that the rivers have an overall median intermittency of 0.001. When we compare this with the Lower Mississippi, an I_Q of ~ 0.3, the Greek rivers are 20,000% less active. This therefore indicates that the rivers are sporadically active and likely move the median sediment during large storms. On average, our results indicate that the median-sized sediment is in active transport for only 12 hours per year, suggesting that high enough discharges occur in only a few intense storms per year. We propose that this highly intermittent nature of sediment transport may be responsible for disparate timescales of transit for the gravel- and sand- (or finer) sized sediment, and may result in gravel-sized sediment being trapped within the active transport pathways forming the Gilbert deltas. Our analyses may also provide a mechanistic underpinning for the abundance of mud and sand in the basin, which may bypass the active transport pathways relatively quickly during storm events.