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Flood magnitude-frequency analysis and sediment transport capacity rate assessment in a mixed alluvial-bedrock channel at Val Lumnezia, Eastern Switzerland, (Graubünden)

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There is growing evidence in the literature that flood frequency has a large impact on the effective time scale of hillslope-derived sediment transport. Here, we present quantitative data on sediment transport in the mountainous Glenner River that drains the 120 km2-large Val Lumnezia basin, eastern Swiss Alps. The longitudinal profile of this stream is characterized by the presence of three ca. 500 m-long knickzones where channel gradients range from 0.02 to 0.2 mm-1 and the stream narrows to < 2 m wide gorges. Upstream and downstream of these knickzone reaches, the stream is flat with gradients < 0.01 mm-1, and cross-sectional widths $\geq$ 30 m. Measurements of the grain size distribution along the stream yield d84 values that range from ca. 10 to 28 cm, whereas the d50 values scatter around 10 cm. We explore the consequences of the channel morphology and the grain size distribution for the time scales of sediment transport by using a 1-D step-back water hydraulic model (HEC-RAS), to estimate hydraulic conditions at number of flood events and to predict hydraulic parameters and the boundary shear stress. The results reveal that along the knickzone reaches, a 2 years return period flood event Q2 is capable of mobilizing the d84 fraction where boundary critical shear stress exceeds the Shields critical shear stress value at incipient motion. In all other flat stream segments, the d84 fraction is barely attaining incipient motion where the critical boundary shear stress is approximately equal to the Shields critical shear stress at incipient motion. The results differ for smaller grain sizes , where Q2 is capable of mobilizing the d50 fraction along the entire stream. We anticipate that the overall effect of Q2 floods is the enrichment of coarse-grained sediment in the flat channel reaches by the entrainment of the d50 fraction, shifting to a better sorting of the bed particles. As a result, the degree of interlocking of coarse grain material may increases, which ultimately leads to enhanced stabilization of the channel bed and thus to a higher threshold of critical stress of incipient motion. Q10 floods, in contrast, are capable of moving both the d50 and d84 fractions, which implies that Q10 represents an effective flood that is results in the evacuation of hillslope-derived material over longer distances. Our results thus support the idea that the mechanisms and timescales of sediment transport in high mountain streams strongly depend on stream geometry and flood magnitude-frequency.