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Lithologic controls on mountain stream geometry and bedload transport

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In this contribution we characterize the morphology, the downstream hydraulic geometry and the bedload transport of two mountain streams, Rio Val Ussaia (2.3 km2) and Rio Tinto (5.5 km2), located in Val di Sole, Eastern Italian Alps. The former flows on tonalites of the Adamello batholith, the latter follows the path of a strike-slip active fault and flows on highly fractured limestones and marls of the Brenta Dolomites Group. Both streams have been repeatedly ovverridden by continental Pleistocene glaciations and as such, in places, are covered by thick glacigenic sediment blankets. The two study streams have identical mean annual precipitation (870 mm) with maxima falling in May and in October-November.

Methods for each study channel include: (i) field surveys along the entire longitudinal profile (i.e. local slope, surficial channel bed texture, 511 channel cross sections); (ii) bedload monitoring in relation to water discharge (from September 2012 to December 2014) of the distal channel reaches via release of 429 PIT-tagged clasts (b-axis ranging from 35 mm to 140 mm), whose travel distances were measured after each rainfall event; and (iii) repeated detailed topographic surveys of the thalweg along the monitored channel reaches.

Results show that, regardless of lithology type, bankfull width and depth, as well as D50, D84, bankfull shear stress, and total stream power increase downstream down to the fan apex, where they all start declining rapidly. Even though Rio Tinto basin is over two times larger than Rio Val Ussaia basin, maximum values of bankfull channel cross-sectional variables for the two streams are virtually identical, an indication of substantial water loss in Rio Tinto due to dissolution-driven effects in highly fractured lithologies. Lithology affects the caliber of the mobile bedload fractions in that the D50 and D84 of more resistant tonalite clasts in Rio Val Ussaia are about twice the size of those found in marls and limestone clasts in Rio Tinto.

Bedload monitoring indicates that boulder steps in Rio Val Ussaia are extremely unstable and mobile due to the abundance of till-derived sand. Conversely, in Rio Tinto we observe that the majority of steps are made of jammed, interlocked key stones, stabilized by the presence of a cohesive fine fraction derived from crushed marly limestones. Maximum single displacements of PIT-tagged stones associated with peak flow events in both streams are in the order of hundreds of meters.