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Sediment transfer in an alpine catchment, assessed by ^{10}Be

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Landscape evolution in mountainous catchments is the result of multiple factors acting at different scales in time and space. The main components affecting basin morphologies are: uplift, glacial cycles, erosion (long timescale), mass movements and cycles of freeze-thaw (short timescale). In this study, we quantify the rates of sediment production and transfer from an alpine catchment in which debris flows are a dominant geomorphic agent. We use cosmogenic nuclides to determine the connectivity between source areas and sinks and to estimate the timescale of sediment production and the fluxes of sediment through the basin.

The Zielbach basin consists of a ca. 30 km^2-large central basin where cascade and step-pool channels have eroded into the highly fractured and foliated metamorphic bedrock, and a ca. 10 km^2-large eastern tributary basin where a network of debris flow channels are perched on a deep-seated sackung. Whereas the central basin shows a poor connectivity between hillslopes and the channel network, the debris flow channels of the eastern tributary basin are closely connected with the bordering hillslopes. In the central basin, the geometry of the channel network is strongly affected by the litho-tectonic fabric as channels parallel the major faults and foliations. In the headwaters, rock glaciers and rock fall deposits tens of meters thick form transverse topographic ridges which retain the sediment in a semi-closed sedimentary traps. Moreover field work and GIS analysis reveal a strong relationship between structural setting and sediments production in which sediment production is high in weakened shear and fault zones. The eastern tributary basin has highly fractured bedrock, partially related to ice retreat after the LGM age. The whole catchment is characterize by a high production of sediments related both to tectonic structure present in the area and to the steep slopes left by the glacial retreat. The geomorphology shows a clear difference between the main basin and the debris flow tributary: the first one is composed by several lateral valley in which sediment can be stored before reaching the channel network, while the tributary is characterize by a long steep slope where the sediments produced can be easily moved down to the fan. ^{10}Be based denudation rates confirm these differences: rates are nearly constant at between 0.3-0.6 mm/yr in the decoupled hillslope-channel segments. This central tributary system of the Zielbach basin can thus be understood as a supply-limited basin with a poor connectivity between sediment sources and drainage network. In contrast, basin averaged denudation rates are high and locally exceed 2.7 mm/yr in the eastern debris flow basin revealing a high connectivity between hillslopes and channel network. Mass balance calculations reveal that individual debris flows contribute up to 90% of the sediment budget of the entire Zielbach basin. These results reveal the importance of stochastic sediment transfer from a high-connectivity tributary on the sediment budget of an entire drainage basin.