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Debris flows and cosmogenic catchment wide denudation rates

F. Kober (1), K. Hippe (2), B. Salcher (1), S. Ivy-Ochs (3), P.W. Kubik (4), M. Christl (4), and L. Wacker (4)

(1) Institute of Geology, ETH Zürich, Zurich, Switzerland (kober@erdw.ethz.ch, +41-(0)44-6321422), (2) Institute of Geochemistry and Petrology, ETH Zürich, 8092 Zürich Switzerland, (3) Institute of Ion Beam Physics, ETH Zürich, 8093 Zürich Switzerland/Institute of Geography,Universtity of Zürich, 8057 Zürich, Switzerland, (4) Institute of Ion Beam Physics, ETH Zürich, 8093 Zürich Switzerland

One of the basic question in alpine Quantitative Geomorphology is: Are widely measured cosmogenic nuclide-derived denudation rates in alpine catchments truly representative for the whole catchment at any given time? Or in contrast can they vary markedly in response to extreme events and perturbations? And if such perturbations affect cosmogenic nuclide-derived denudation rates then what bias can occur when such denudation rates are compared with sediment yield or thermochronological data or to various morphometric parameters, such as slope, mean elevation or uplift rates as potential controlling factors?

We present 10Be and 14C results measured in sand samples from an active river channel from a single catchment (upper Aare), in the Swiss Alps (up to monthly sampling between 2008 to 2011). Our goal was to establish a time series to see if extreme events (such as landslides or debris flows) do have a discernible effect on derived denudation rates. The admixture of sediment of debris flows in 2009, originating upstream of the sampling spot, began to have a marked effect on 10Be concentrations and thus catchment wide denudation rates that are assumed to be in a long-term range mode prior to 2009. In summer of 2010, several extreme debris flows were recorded in the studied catchment. Samples taken document a doubling of denudation rates over the values determined from 2008. These cosmogenic nuclide data clearly demonstrate the impact of episodic events on sediment flux and the related perturbation of catchment wide denudation rates. We have recently expanded this dataset into 2011, with i) a spatial sub-sampling of debris flow and non-debris flow catchment compartments and ii) including again a major debris flow event in early autumn 2011. These data will be presented at the conference.

Never-the-less the fact that the CWDR's only doubled does suggest a certain robustness in the method beyond a certain catchment size. In addition to the 10Be data, in situ 14C measurements in CWDR-studies in quartz allow to quantify how long sediment may have been stored prior to entrainment in debris flows. Several of our paired data points spot to storage of unconsolidated sediment for up to several thousand years. The estimation of burial or storage times is key parameter for quantifying recharge volumes and residence times. Sediment that is stored in the headwater regions of the debris flow initiation zones pose one of the most important but least understood potential natural hazards due to changing climate, and most notably in light of present thawing of permafrost in steep alpine catchments.