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Sediment delivery from bedrock rock avalanching: quantification using Terrestrial Laser Scanning

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Landsliding is one of the principal agents of erosion of mountainous terrain. Landslides have been demonstrated to be coupled with valley floor systems on a range of scales from single catchments to regional and national levels. In many cases landslide-derived material forms the bulk of fluvial sediment leaving mountain belts. This coupling is dependent on the transport capacity and competence of the river system, often showing marked seasonal variability due to monsoonal and snow-melt inputs and shorter term variability from events such as rainstorms. The number and volume of landsliding events is also often related to this seasonal variability of inputs in the case of rainfall induced failure, with events triggered by seismic shaking appearing episodically through a cycle.

Rock avalanches are a high magnitude, low frequency mass movement event consisting of a minimum of 1 x 10^6 m^3 of bedrock, triggered by intense or prolonged precipitation, seismic shaking or human activity. Events can occur as first time failures, as progressive landslides and/or as reactivation of relict slides. Rock avalanches deliver an extreme point sediment load into the drainage network essentially instantaneously. Few, if any, rivers have the competence and capacity to remove such a single deposit from the valley floor rapidly, especially when compared to the effects of a similar volume emplaced in a multitude of smaller events over many kilometres of river channel. Rock-avalanche deposits therefore often form natural dams that then provide a significant sediment store within the impounded lake, which in turn starves the downstream reaches of the usual sediment load. The subsequent timing of release of this sediment is a key research question in the role of landslide erosion and its contribution to the sedimentary budget. Landslide dams can exist for thousands of years, or they can fail rapidly and catastrophically, delivering sediment loads as part of a

flood wave, with subsequent flow dependent erosion and debris pulses of the remains for many hundreds of years.

This work presents the data collected after the delivery of 35 x 10^6 m^3 of material to a minor, monsoonal drainage system in the Bhutan Himalaya. After forming a sediment store for the eroded material for 10 months, catastrophic failure occurred. The resulting flood, which had a peak discharge of 5900 m^3 sec^{-1}, eroded two-thirds of the deposit volume. The debris subsequently entered a major drainage channel, and material was transported for over 35 km until it reached and was deposited in an HEP reservoir. Using a Terrestrial Laser Scanning system, detailed surveying has been carried out on the resulting flood terraces deposited at a number of sites downstream of the dam site. Data is presented on the initial results to quantify the volumes of debris emplaced by the flood wave and available for subsequent delivery to the drainage and hydropower reservoir during monsoonal river flows.