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# Landslide dams: causes, catastrophic failure prediction and downstream consequences

**S.A. Dunning**, D.N. Petley, N.J. Rosser

International Landslide Centre, Department of Geography, University of Durham, DH1 3LE, UK (s.a.dunning@dur.ac.uk / Phone +44 (0)191 334 1918)

Rock avalanches are an extreme form of bedrock landslide, greater than 1 x $10^6$ $m^3$ in volume, traveling many kilometers at speeds of over 300 km $h^{-1}$ and being, to date, unpredictable. The frequency-magnitude relationship for many regions is unknown, but it is estimated that the global occurrence of such events exceeds one per annum . A common consequence of the rock avalanche process is the interaction with drainage lines, and where the valley configuration and deposit morphology are suitable a natural dam can form. The outburst flood hazard via catastrophic breaching posed by such dams can be orders of magnitudes greater than that of the initial rock avalanche. The numbers of deaths and infrastructure damage attributed to individual rock avalanche events is controlled by the kilometer-scale runout and the presence of population centres, limited by the factors that favor failure. Outburst flood events, which can be termed extreme events, are capable of traveling tens to hundreds of kilometers. For example, it is estimated that over five million people live within the range of effect of an outburst flood from the Usoy rock avalanche dam, Tajikistan as compared to the relatively few deaths attributed to deposit emplacement.

The lifespan of a rock-avalanche dam is critical; evacuation is often the only option available in the developing world to prevent loss of life. Artificial breaching or diversionary engineering requires specialist knowledge and the costs may run to hundreds of millions of US dollars. Frequency magnitude relationships for dam failure events show that 85 % of landslide dams, if they fail, will fail within one year of formation, though some may persist for hundreds to thousands of years. The differentiation between a dam that will fail and one that will remain stable in the long term is a difficult task. This work presents on the modelling of rock-avalanche dam deposits using a unique sedimentary data-set applicable to all regardless of setting. The failure style

and timing in a prescribed period is shown to relate to the deposit morphology, sedimentological properties of deposit, and the disequilibrium between the dam system inputs such as river flow and lake impoundment potential, and the outputs such as seepage and periods of overtopping.