



The Geomorphic Impact of Rock Avalanches on Landscape Evolution

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Rock-avalanches (RAs) are large erosional events which, in a matter of minutes, can deliver a catastrophic volume of debris ($\geq 1 \times 10^6 \text{ m}^3$) directly to a fluvial system, often damming mountainous rivers. RAs have a boulder carapace protecting readily transportable sediment sizes, differing from landslides. Evidence suggests that the point-load sediment delivery of rock-avalanche deposits (RADs) on fluvial systems can force rivers into a chronically disturbed state for up to 10^4 years. Fieldwork and micro-scale modelling are used to trace RA sediment dispersion in Ram Creek, New Zealand. The data forms a new conceptual model of river erosion and depositional response, changes to river planform and sediment yield, and an effective model timescale of perturbation for both RA and landslide dams.

Fieldwork investigation shows large scale aggradation from RA outburst flood sediment dispersion, buffering vertical bedrock incision. The system is unable to transport the quantity of dam-derived sediments, and will not attain equilibrium before the next major event; it is in a state of persistent disturbance where localised reworking dominates. Lateral bevelling in the slot-type bedrock gorge topography appears to be the dominant form of erosion promoting gorge widening of the weak bedrock. It is theorised that aggradation of RA debris and lateral bevelling may result in the formation of a strath terrace if sediment cover persists, independent of external tectonic and climatic forcing. Normalised steepness and concavity indices of the Ram Creek river profile were compared to four neighbouring streams. The RAD perturbation to profile metrics is not substantial enough to be discernible from neighbouring streams containing large tectonically induced knickpoints. This suggests RA frequency estimates may be underrepresented in landscape evolution models.

Micro-scale modelling of the responses to a catastrophic sediment input into Ram Creek; either a RA (including carapace) or a landslide, each show different geomorphic responses. The RA model shows an un-breached carapace acts to trap fluvial sediments, resulting in partial burial. Further downstream, initial sediment starved incision is followed by a slower recovery to pre-RA bed elevations, and continued aggradation of fluvial sediment to vertically displace the profile up towards the RA. In the landslide model, immediate breach channel formation results in a sediment pulse downstream. Dispersed sediment forces aggradation, controlling fluvial geomorphology.

Fieldwork and modelling both show catastrophic sediment inputs control fluvial planform, sediment yield, calibre, and storage, and geomorphic forms throughout the affected fluvial profile. This contradicts the view that rivers in the Southern Alps, are under-loaded and transport all sediment that is supplied to them. The inability of the river to remove both the RA and landslide deposits suggests that the river will not recover before the return period for the next large sediment input, and is a scenario witnessed across numerous other feeder catchments to larger rivers in New Zealand. It is suggested here that RA and landslide sediment storage from multiple events controls the geomorphic evolution of smaller mountainous catchments, and RA forced dis-equilibrium may actually be the 'normal' state in many mountainous streams.