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Channelized and hillslope sediment transport and the geomorphology of mountain belts

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This contribution presents the results of landscape evolution models and morphometric data from the Andes of northern Peru to illustrate how the ratio between sediment transport on hillslopes and in channels influences landscape and channel network morphologies and dynamics. The headwaters of fluvial- and debris flow-dominated systems (channelized processes) are characterized by rough, high-relief, highly incised surfaces which contain a dense and hence a closely-spaced channel network, a thin regolith cover and highly sinuous valleys. Also, these systems tend to respond rapidly to modifications in external forcing (e.g., rock uplift and/or precipitation). This is the case because the high channel density results in a high bulk diffusivity. In contrast, headwaters where landsliding is an important sediment source are characterized by a low channel density and by rather straight and unstable channels. In addition, the topographies are generally smooth. The low channel density then results in a relatively low bulk diffusivity. As a consequence, response times are greater in headwaters of landslide dominated systems than in highly dissected drainages. This situation, however, is different for the trunk stream segments of drainage systems. Specifically, according to numerical models, the lateral distance between trunk streams is larger in landslide-dominated systems than in drainages where channelized processes are predominant. Because the greater channel spacing results in larger sizes of contributing areas, water discharge and therefore stream power and sediment transport capacity are enhanced. As a result, the trunk stream segments of landslide-dominated systems tend to lower the valley floors more efficiently than the trunk stream portions of the highly dissected counterparts, thereby increasing the local relief, promoting headward erosion and initiating further landslides. Hence, landslide dominated drainage basins tend to be more erosive at longer time scales.