Landscape Evolution in High-Elevation Andean River Basins, Northern Peru: Mass Failure and Fluvial Transport

Stuart C. Trabant
Hydraulic Engineer, Mussetter Engineering, Inc., Fort Collins

Michael D. Harvey
Principal Geomorphologist, Mussetter Engineering, Inc., Fort Collins

Abstract.
Landscape evolution in the Quebrada Honda (QH) drainage basin, located at an elevation of about 4,000 meters in the cool and humid Andes Mountain Range of Northern Peru, is dominated by episodic cycles of slope mass failure and subsequent fluvial removal of the failed slope materials. The approximately 4 km$^2$ drainage basin is characterized by grassed rolling uplands with steep side slopes underlain by highly erosion-resistant silicified volcanic rocks that extend down to the treads of glacio-fluvial strath terraces that bound deeply incised and narrow channels that have eroded into weaker hydrothermally-altered volcanic rocks. The longitudinal profiles of the channels are highly irregular and are composed of locally flatter and steeper segments, as well as segments that are convex. The irregularities in the profiles are formed by outcrops along the channels of bedrock of varying resistance to erosion, and accumulations of large (>1 m) diameter boulders that are lag deposits from mass failures of glacial till. The results of geomorphic, hydraulic and sediment-transport analyses of the two primary tributaries within the QH basin, the Rio Colorado and the Quebrada Pampa Larga (QPL) indicate that the channels are non-equilibrium forms that are still adjusting to a range of large scale perturbations including, tectonic uplift, glaciation and baselevel lowering. Repeated mass failures of the strath terraces and hillslopes that bound the channels over long periods of time increase the channel width, and have produced a scalloped appearance to the channel margins. Periodicity of the erosion is confirmed by the wide range of revegetation and recovery of the individual failure scarps.

Almost all of the observed erosion of the hillslopes and strath terraces is related to saturation during the wet summer period. Very little of the observed erosion is due to entrainment by flows within the channels because the flow depths rarely overtop the bedrock outcrop that generally forms the toes of the banks, thereby preventing undercutting. The in-channel flows are responsible, however, for removal of the bulk of the introduced sediments since these are primarily composed of relatively fine-grained sediments, even though some larger rocks are present in the failed bank material. The larger rocks are only transported downstream a short distance by landslide-induced dam-break surges, and therefore, accumulate in the bed of the channels, and overtime this leads to net aggradation that both limits further erosion of recently failed scarps by developing toe armor and may accelerate erosion at unprotected locations by diverting flows into the base of the slope.

1Mussetter Engineering, Inc., 1730 S. College Avenue, Suite 100, Fort Collins, CO 80525; Tel: (970)-224-4612; Email: stuartt@mussei.com