Taylor Notes from Dave Montgomery OSU Talk, May 29, 2003-05-30
Topic: Fluvial Disturbance Regimes – Pyroclastic Debris and Glacial Dynamics

I. Mt. Pinatubo 1991 Eruption Phillipines –

5-6 cubic km of pyroclastic debris total released, significant portion released into watersheds surrounding Mt Pinatubo.

Pyroclastic eruptions = instant oversupply of sediment on hillslopes and in drainage basins

Channel systems overloaded with sediments, localized pyroclastic flow deposits, thick lahar deposits in valleys; streams and rivers subsequently incise into lahar deposits to form step-faced "lahar terraces"

The scale of the volcanic deposits is very large relative to the scale of the watershed; net result = over-loading of rivers.

Implies intense aggradation and incision cycle, since 1991, rivers have been working to move sediment out of watersheds.

Sediment yield on rivers since 1991 follows exponential decay function

Sediment delivery mechanisms to channels:

1. mass wasting / slumps / slides from lahar terraces
2. erosion of rill fields
3. channel bed erosion, winnowing of fine sediments, armoring of channel with coarse gravel

Channel System Response

Early post-eruption: roughness of channel very low, smooth, increased transport of large gravel along channel bottom by rolling and sliding

Later post-eruption: winnowing of fines, increase coarse armoring, increase roughness of bed, > roughness results in positive feedback by promoting stabilization of bed with coarser gravel

River Recovery Process: winnowing of fines, coarsening of channel bed, increase in roughness elements, increased deposition in mid-channel bars, vegetative stabilization

Environmental Significance

1. Lahar hazard on flanks of explosive, pyroclastic volcanoes
2. Severe river ecological impact / overloading of channel systems with sediment
    a. removal of vegetation and fish

Glacially Impacted River Systems on Tibetan Plateau

River Characteristics

1. High alpine, mountainous terrain with active glaciation, and recent past glaciation
2. Rapid tectonic uplift and mountain building in Himalayan collision zone
3. Rapid uplift + steep slopes = rapid erosion, vertical incision by rivers, steep canyons

Geology of Past 1000-2000 years

Active glaciation – development of morain-dammed lakes
Catastrophic outburst flooding

- hazard to populations living in river valleys down stream
- rapid incision and terrace development along river
- varved lacustrine deposits remain as markers behind morain-dam

Related Readings / Abstracts for Mt. Pinatubo

Hayes, S., Montgomery, D.R., and Newhall, J., 2002, Fluvial sediment transport and deposition following the 1991 eruption of Mount Pinatubo: Geomorphology, v. 45, no. 3-4, p. 211-224

The 1991 eruption of Mount Pinatubo generated extreme sediment yields from watersheds heavily impacted by pyroclastic flows. Bedload sampling in the Pasig-Potrero River, one of the most heavily impacted rivers, revealed negligible critical shear stress and very high transport rates that reflected an essentially unlimited sediment supply and the enhanced mobility of particles moving over a smooth, fine-grained bed. Dimensionless bedload transport rates in the Pasig-Potrero River differed substantially from those previously reported for rivers in temperate regions for the same dimensionless shear stress, but were similar to rates identified in rivers on other volcanoes and ephemeral streams in arid environments. The similarity between volcanically disturbed and arid rivers appears to arise from the lack of an armored bed surface due to very high relative sediment supply; in arid rivers, this is attributed to a flashy hydrograph, whereas volcanically disturbed rivers lack armoring due to sustained high rates of sediment delivery. This work suggests that the increases in sediment supply accompanying massive disturbance induce morphologic and hydrologic changes that temporarily enhance transport efficiency until the watershed recovers and sediment supply is reduced.

Montgomery, David R. ; Panfil, Maria S. ; Hayes, Shannon K., 1999, Channel-bed mobility response to extreme sediment loading at Mount Pinatubo: Geology, v. 27, p. 271-274

Since the 1991 eruption of Mount Pinatubo, the specific sediment yields from watersheds draining its slopes have been the highest ever recorded. In spite of this overwhelming sediment load, rivers inundated by pyroclastic-flow deposits delivered almost half of the initial deposits to downslope alluvial and/or debris fans by 1996. Although most of this transport occurred by hyperconcentrated flows and debris flows (lahars), very high sediment transport rates also characterize low flow. Measured flow velocities and depths, channel properties, and the size of both mobile and stable clasts in the Sacobia and Pasig-Potrero Rivers indicate median bed-surface grain sizes of 2 to 8 mm, grain-size-independent dimensionless critical shear stresses (tau (super *) (sub c)) of 0.016 to 0.041 and Manning's n values of 0.017 to 0.024, values well below those previously reported for steep mountain channels. The dramatic bed-surface fining, bed mobility, and selective transport in these extremely sediment-rich channels indicate that changes in grain size, tau (super *) (sub c) values, and bed roughness can increase transport capacity in response to high sediment supply. Our observations also suggest viewing the apparently contradictory concepts of an equal threshold of bed mobility and grain-size-dependent selective transport as end-member concepts that apply to channels with low (or intermittent) and high (or continuous) sediment supply, respectively.