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Evolution of a Toxic Fan: Lessons from the Yuba River, California

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ABSTRACT

Perturbed fluvial systems beset by sediment aggradation do not adhere to equilibrium theories; instead they tend towards a regime of episodic sediment reworking, wherein progressively larger floods are required to mobilize sediments in terraces emerging along channel margins. Hydraulic gold mining within the Yuba River basin, California, resulted in ∼400 x108 m3 of sediment aggradation, succeeded by river incision that formed legacy terraces that are dosed with mercury (Hg) used in gold separation. Currently there is notable uncertainty about the processes and patterns of toxic terrace erosion, the partitioning of bed material load and washload, and thus the residence/exhaustion timescales of this legacy sediment. We use total Hg (HgT) analysis from >250 sediment samples collected along the entire Yuba River fan to interpret the erosion/sedimentation histories of these sediments. We investigate the history of sediment evacuation for particular river reaches using high resolution spatial datasets and investigate the evolution of the longitudinal profile. We use hydrologic data and flow routing over high resolution bathymetry to interpret frequency of terrace failure. Grain size data from terrace materials and bar surfaces is employed within a bed material transport model to calculate bed evolution in response to terrace inputs under different hydrologic forcing.

We find HgT varies over 3 orders of magnitude allowing for discrimination of primary legacy sediments from those in background (nonmining) sediments from those which have undergone mixing. This enables us to map out the spatiotemporal history of toxic fan evolution. A general pattern of high to low HgT is found from upstream to downstream. However, primary mining sediments are still found in downstream parts of the Yuba in overbank deposits. Most deposits in active channel banks are composed of several sediment units that decrease in HgT up-section, indicating dilution of mining sediments through time. The sediment budget data show systematic evacuation of mining sediments from all near channel areas and modest accumulation of sediment in downstream floodplains. This redistribution of sediment occurs during flood events. Our hydrologic/sediment transport analyses suggest that although large floods are responsible for eroding terraces on decadal timescales, the evolution of the bed surface and the evacuation of the finer fractions of collapsed terraces largely occur during more frequent moderate floods. This is supported by the armored state of bed and bar surfaces found throughout

the study area. These results provide a new context for interpreting the century-scale evolution of major sediment slugs in fluvial systems and for assessing the downstream risk of Hg contamination.