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Timing and Controls of Debris-Flow Fan Deposition and Abandonment on alluvial Fans in Owens Valley, California

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The question of whether debris-flow fan evolution is mainly controlled by tectonics or climate, has been discussed in many studies. But lack of absolute age control on fan depositional chronologies, unconstrained tectonic boundary conditions, and poor understanding of catchment dynamics have limited the ability to resolve the exact relationship in coupled catchment-fan systems. Although external forcing mechanisms such as climate and tectonics may play an important role, the internal structure of a catchment has rarely been considered as a control on sediment delivery to the fan and the dynamics of fan deposition and incision.

We attempt to elucidate the relative roles of climate, tectonics, and internal catchment morphology, in the evolution of catchment-fan systems in Owens Valley, California. We characterize the catchments using field observations, digital orthoquads and 10 m resolution digital topographic data. We establish a relative surface chronology for the debris-flow fans using geomorphic criteria such as surface roughness, boulder size, degree of boulder disseggregation, channel width, and levee height. This relative chronology of fan activity and abandonment is then linked to absolute ages estimated from measurement of cosmogenic ^{10}Be and ^{26}Al from large boulders on different surfaces.

Our first results show that fans in the Eastern Sierra Nevada can be divided into two types: those with multiple depositional lobes that record discrete periods of fan deposi-

tion and abandonment, and those that appear to consist of a single, active depositional surface. Topographic analysis of the corresponding catchments reveals that the former correspond to stepped, glacially-sculpted valleys, with large volumes of sediment currently in storage in moraines and in glacially overdeepened sub-basins. In contrast, single-aged fans appear to correspond to simple valleys with less sediment storage. The observation of these coupled catchment-fan systems led us to the hypothesis that the stepped morphology of the Eastern Sierran catchments is a fundamental control on deposition and incision of basin-margin fans. Bedrock-dammed sub-basins act as efficient sediment traps. Debris flows are only capable of bypassing these traps if (1) the sub-basins are filled with sediment, (2) the flows are large enough to overtop the barriers, or (3) they originate downstream of the barriers. Thus, the sub-basins act as low-pass filters on the debris flow size distribution. Trapping of sediment, in turn, may lead to undercapacity water flows that are capable of incising the fan head, causing abandonment and switching of depositional lobes.

This filtering effect will result in a damped or strongly modified response of the sediment transport system to climatic and tectonic forcing. Therefore, chronologies of fan deposition may not necessarily reflect variations in external forcing, but are expected to be strongly dependent on internal catchment morphology – in particular, the presence, location, and sizes of sub-basins. This may frustrate efforts to derive systematic information on forcing variations from depositional records of adjacent catchment-fan systems.