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Influence of glacial modification of catchments on sediment fluxes in the eastern Sierra Nevada, California

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Catchment-fan systems contain both the sediment source and the sediment sink. Thus, fans allow investigation of the integrated effects of production, storage, and transport of sediment. Since periods of major sediment removal from a catchment result in fan aggradation, periods of low sediment fluxes from the catchment lead to incision of the fan head. While the controls on fan-head incision are not well understood, several different mechanisms have been proposed, related to changes in the sediment-water ratio, the tectonic uplift rate, changes in base level, or autocyclic variations. Here we describe how an additional parameter, the internal morphology of two catchments, one glacially modified and the other without glacial modification, controls sediment evacuation from the catchments and the pattern of debris-flow deposition on fans in the Sierra Nevada, California.

We mapped the spatial distribution of sediment deposition on two adjacent fans (Symmes and Shepherd Creek) to establish the timing of sediment removal from the two catchments by constraining the absolute timing of debris-flow fan deposition using cosmogenic radionuclide exposure dating of debris-flow boulders. The geomorphology and potential for sediment storage in the associated catchments were assessed using topographic analysis of a 10-m resolution digital terrain model and field mapping.

Our results show that a) enhanced sediment flux seems to correlate with wetter climate conditions during glaciations in the Sierra Nevada, and b) despite similar tectonic, climatic, and base level histories in the two catchments, the depth of fan-head incision

varies on both fans and leads to significant differences in the length of the preserved depositional fan records. While Symmes Creek fan has been completely resurfaced during the Holocene, the Shepherd Creek fan shows evidence of late Pleistocene and Holocene debris-flow activity on distinct lobes. Preservation of older fan lobes is permitted by incision at the head of Shepherd Creek fan. We suggest that this fan-head incision occurs during interglacial periods, when sediment storage in glacially-modified subbasins within in the Shepherd Creek catchment leads to sediment-deficient flows, which in turn incise the fan head. In contrast, the lack of sediment-supply limited conditions in the glacially-unmodified Symmes Creek catchment allows continuous sediment evacuation from the catchment over time with fan aggradation rather than incision. Our study shows that external controls such as climate cause an increase in sediment flux from the catchment, but that local parameters such as catchment morphology are able to damp or modify the response of a sediment transport system to large-scale forcing.