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Decoding sediment transport dynamics on alluvial fans from spatial changes in grain size, Death Valley, California

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How fluvial sediment transport processes are transmitted to the sedimentary record remains a complex problem for the interpretation of fluvial stratigraphy. Alluvial fans represent the condensed sedimentary archive of upstream fluvial processes, controlled by the interplay between tectonics and climate over time, infused with the complex signal of internal autogenic processes. With high sedimentation rates and near complete preservation, alluvial fans present a unique opportunity to tackle the problem of landscape sensitivity to external boundary conditions such as climate.

For three coupled catchments-fan systems in the tectonically well-constrained northern Death Valley, we measure grain size trends across well-preserved Holocene and Late-Pleistocene deposits, which we have mapped in detail. Our results show that fan surfaces from the Late-Pleistocene are, on average, 50% coarser than counterpart active or Holocene fan surfaces, with clear variations in input grain sizes observed between surfaces of differing age. Furthermore, the change in ratio between mean grain size and standard deviation is stable downstream for all surfaces, satisfying the statistical definition of self-similarity.

Applying a self-similarity model of selective deposition, we derive a relative mobility function directly from our grain size distributions, and we evaluate for each fan surface the grain size for which the ratio of the probability of transport to deposition is 1. We show that the “equally mobile” grain size lies in the range of 20 to 35 mm, varies over time, and is clearly lower in the Holocene than in the Pleistocene. Our results indicate that coarser grain sizes on alluvial fans are much less mobile than in river systems where such an analysis has been previously applied.

These results support recent findings that alluvial fan sediment characteristics can be used as an archive of past environmental change and that landscapes are sensitive to environmental change over a glacial-interglacial cycle. Significantly, the self-similarity methodology offers a means to constrain relative mobility of grain sizes from field measurements where hydrological information is lost or irretrievable.