EGU21-13384
https://doi.org/10.5194/egusphere-egu21-13384
EGU General Assembly 2021

River discharge variability in the rock record? Disentangling the relative role of flow variability and morphodynamic hierarchies on bedform preservation

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River discharge variability is a fundamental control on fluvial morphodynamics and, in principle, stratigraphic architecture. The ability to quantitatively constrain discharge variability from fluvial stratigraphy would newly enable us to reconstruct instantaneous or interannual responses of rivers to climatic perturbation in the geologic past. However, the extent to which we can extract quantitative information about discharge variability from fluvial stratigraphy is currently unknown. Recent experimental work indicates that preserved cross-set geometries can potentially be used to inform formative flow conditions and durations. However, to date, this has not been tested on field examples of ancient fluvial systems. Here we use detailed measurements of cross-sets to assess bedform kinematics and formative flow conditions in fluvial strata of three Late Cretaceous geologic formations: the Blackhawk Formation, Castlegate Sandstone, and Ferron Sandstone, which crop out in central Utah, USA.

Unanimously low coefficients of variation (*CV*) in preserved cross-set heights of 0.25–0.5 are consistent with the hypothesis that CV<<0.88 arises from preservation of bedforms in disequilibrium conditions, which typically occurs during rapid flood recession in a “flashy” flood hydrograph. Bedform preservation in disequilibrium conditions requires that formative flow durations are shorter than bedform turnover timescales. We reconstruct median turnover timescales of 2–3 days, with a 10–90 percentile range of ~1–10 days, which implies that formative flow durations were of order hours to a few days. These durations are consistent with storm-related flood durations in perennial discharge regimes, as opposed to the more sustained flood durations that are typical of subtropical/monsoonal climate regimes. However, it is also possible that this same *CV* signature (CV<<0.88) can be achieved simply by the presence of morphodynamic hierarchies, e.g. concurrently migrating bedforms and bars. We explore whether it is possible to disentangle the relative role of formative flow conditions and morphodynamic hierarchies on bedform preservation using our field data, models of flood stratigraphy, and estimates of bedform preservation ratios. Moreover, we identify future steps that will further our ability to quantitatively extract formative flow variability and, ultimately, discharge variability from the rock record.