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Variations in lateral erosion rates control fluvial planation and strath terrace formation on uplifting folds: Evidence from both the field and sandbox models

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Fluvial planation surfaces eroded into bedrock, such as straths, commonly serve as recorders of climatic and tectonic processes in uplifting landscapes. Here, we focus on planation surfaces on deforming folds in the arid Kashi foreland of the Tian Shan, NW China. Despite rapid late Quaternary uplift rates of 1-3 mm/y, rivers beveled kilometer-wide planation surfaces into the uplifting, weakly-lithified bedrock. Most of these surfaces are presently abandoned, and narrow canyons dissect the folds. Reconciling the scales of canyons and planation surfaces requires lateral erosion rates that are at least 70-600 times higher than rates of average vertical incision. Moreover, lateral erosion rates have to change by at least one order-of-magnitude between episodes of planation and episodes of incision. These field-observations are consistent with results from sandbox experiments in which a competition between lateral channel mobility and uplift rate predicts the extent to which the topography of a growing fold is expressed in the landscape. Our results challenge the application of models that link strath terrace formation primarily to changes in the vertical erosion rate. Rather, the formation of planation surfaces in weak bedrock appears to be limited by the lateral channel mobility and by rates of wall erosion. We hypothesize that channel mobility controls landscape planation by influencing the frequency of bedrock wall-contacts, the wall height, and the variability of angles at which the channel attacks the bedrock wall. Wall-erosion in turn may be modulated by the availability and the type of “tools” in the bedload.