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Temporal changes in rock uplift rates of folds in the foreland of the Tian Shan and the Pamir from geodetic and geologic data

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Constraints on temporal changes in rock-uplift rates of individual faults and folds provide a critical context for linking individual measurements of tectonic deformation to a general understanding of landscape evolution and the development of continental deformation zones. Whereas deformation mechanics for many types of fault and fold structures are well understood, better constraints on the spatial and temporal partitioning of deformation across the entire development of such structures are required to reconstruct their kinematic history.

Based on geologic and geodetic data, we present the temporal evolution of rock-uplift rates of two structurally simple Quaternary detachment folds in the foreland of the Tian Shan from their initiation in the Pleistocene to the modern day. A new interferometric synthetic aperture radar (InSAR) analysis confirms significant a-seismic deformation of these detachment folds across the 7-year measurement interval and reveals spatial gradients of rock-uplift rates on scales of 5-10 km along the axes of the structures. The decadal uplift rates from the InSAR analysis are within error of average uplift rates calculated from deformed, 30 – 80 ky-old fluvial terrace deposits that were dated using optically stimulated luminescence. However, the rates are up to a factor of two different from previous estimates of average uplift rates since the initiation of the structures millions of years ago. Together with the spatial pattern of rock-uplift rates, these observations suggest that on these a-seismically deforming structures, gradual rate changes, rather than step-like ones dominate the temporal pattern of uplift rates. Using a simple Monte Carlo model to fit rock-uplift rates as a function of time with piecewise linear functions, we find envelopes of admissible temporal evolution of uplift rates that allow both step-wise and gradual rate changes. The data and model suggest relatively large differences in the temporal pattern of uplift-rates between nearby, but discrete detachment folds, and moderate differences across distances of 10 – 30 km along the axis of a single structure. Thus, even for relatively simple detachment folds, caution is warranted when laterally extrapolating temporal patterns of uplift-rates that have been constrained at a single site.