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Denudation outpaced by crustal thickening during mountain building: example from the eastern Tianshan in central Asia

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Intracontinental orogenic belts typically grow as single or double vergent prisms where the material is accumulated through thrusting under both sides of the wedge. The topography of the range may then reach a steady state where the crustal thickening is balanced by the denudation. The Tianshan in central Asia is one of the largest, highest and most active intracontinental orogenic belts in the world. This topography results from the reactivation of an old Paleozoic orogenic belt when India collided Asia. Though this long history of deformation the range exhibits a complex topography composed of several intermontane basins separated by high elevated ranges. How fast this particular topography is growing, and whether it has reached steady-state or not are open questions.
Here, from the in situ 10Be cosmogenic analysis of 34 river stream sediments, we document the denudation rates in the eastern part of the Tianshan range. The concentration measured in the sediments range from 3.0±0.2 x104 at/gr to 30.2±1.4 x104at/gr. The derived basin average denudation rates range from 0.02±0.002 mm/yr to 0.43±0.09 mm/yr if the cosmogenic production rates are corrected for paleomagnetism. The denudation rates are in average higher in the Northern piedmont where rainfall is higher with mean of 0.17±0.09 mm/yr while in the southern lee side of the range they average to 0.1± 0.05 mm/yr.
Based on quantitative morphotectonic observations and age constraints derived from cosmogenic 10Be dating, single-grain post-infrared infrared stimulated luminescence (p-IR IRSL) dating and modeling of fault scarp degradation, we quantify the deformation in the two piedmonts and in the intermontane basins. Our results indicate that at least 1.4mm/yr of horizontal crustal shortening is accommodated within the internal part of the range and up to 4.5 mm/yr in the two piedmonts. These shortening rates implies that the Eastern Central Tianshan is thickening at a mean rate of ∼1.2mm/yr, a rate that is significantly higher than the average denudation rate derived from our cosmogenic analysis. This discrepancy suggests that the Tianshan range has not yet reached a steady-state topography and remains in a transient state of topographic growth, most likely due to limited denudation rates driven by the arid climate of Central Asia.