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# Glacial disruption of Cenozoic steady-state denudation in the North Cascades range

Thibaud Simon-labric (1,2), Peter van der Beek (1), Peter Reiners (3), Christian Teyssier (4), Gilles Brocard (5), and Donna Whitney (4)

(1) University of Grenoble, ISTerre, Grenoble, France (thibaud.simon-labric@ujf-grenoble.fr), (2) Institute of Geology and Paleontology, Lausanne University, Lausanne, Switzerland., (3) Geosciences, University of Arizona, Tucson, AZ, United States., (4) Department of Geology and Geophysics, University of Minnesota, minneapolis, MN, United States., (5) Department of Earth and Environmental Science, University of Pennsylvania, Philadelphia, United States.

We use numerical thermokinematic models to evaluate the Cenozoic exhumation history of the North Cascades range and specify the nature of climatic forcing on the dynamics of the range. We use an extensive dataset of apatite (U-Th)/He ages that we complement with 29 new apatite and zircon (U-Th)/He ages. Our results confirm the spatial correlation between apatite (U-Th)/He ages and precipitation rate, with the youngest ages indicating the most rapid exhumation located on the windward side of the orogen. However, inverse thermo-kinematic modeling of the North Cascades age-elevation profiles reveals that denudation of the range is spatially and temporally constant at $\sim$120 m/Ma between $\sim$32 and $\sim$2 Ma, which likely reflects uplift and magmatic crustal thickening since the initiation of the Cenozoic stage of the continental magmatic arc. In contrast, the west-facing flank of the North Cascades is affected by an ten-fold acceleration in exhumation rate at $\sim$2 Ma, that we interpret as forced by the initiation of glaciation. Around 3 km of crust have been eroded in the central part of the windward flank, inducing isostasic rebound and consequent rapid rock uplift. Our results imply that the spatial correlation between present-day precipitation and AHe ages is caused by glaciations and demonstrate the primary control of precipitation rate on glacial erosion. Secondly, they show the contrast between variable uplift across the range and the present-day relief, with summits defining a tilted planar surface, interpreted as the signature of a “glacial buzzsaw”. Finally, our results illustrate the strong control of the main drainage divide on the localisation of the glacially-driven increase in exhumation rate. We interpret this pattern as the record of headward retreat of drainage in the direction of the arid flank of the range. To sum up, glaciation has three distinct effects on the dynamics of this mountain range: (1) it increases erosion, exhumation and uplift rates where precipitation rates are sufficient to drive efficient glacial erosion; (2) it limits the altitude of mountain ranges; and (3) it leads to widening of the humid flank and contraction of the arid flank of the belt.