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Impact of glaciations on the long-term erosion in Southern Patagonian Andes

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The Southern Patagonian Andes are an ideal setting to study the impact of Late-Cenozoic climate cooling and onset of glaciations impact on the erosional history of mountain belts. The lack of tectonic activity during the last ∼12 Myr makes the denudation history mainly controlled by surface processes, not by tectonics. Moreover, the glaciations history of Patagonia shows the best-preserved records within the southern hemisphere (with the exception of Antarctica). Indeed, the dry climate on the leeward side of Patagonia and the presence of lava flows interbedded with glacial deposits has allowed an exceptional preservation of late Cenozoic moraines with precise dating using K-Ar analyses on lava flow. The chronology of moraines reveals a long history covering all the Quaternary, Pliocene, and up to the Upper Miocene. The early growth of large glaciers flowing on eastern foothills started at ∼7-6 Myr, while the maximum ice-sheet extent dates from approximately 1.1 Myr.

In order to quantify the erosion history of the Southern Patagonian Andes and compare it to the glaciations sediment record, we collected samples along an age-elevation profile for low-temperature thermochronology in the eastern side of the mountain belt (Torres del Paine massif). The (U-Th)/He age-elevation relationship shows a clear convex shape providing an apparent long-term exhumation rate of ∼0.2 km/Myr followed by an exhumation rate increase at ∼6 Myr. Preliminary results of 4He/3He thermochronometry for a subset of samples complete the erosion history for the Plio-Pleistocene epoch. We used inverse procedure predicting 4He distributions within an apatite grain using a radiation-damage and annealing model to quantify He-diffusion kinetics in apatite. The model also allows quantifying the impact of potential U-Th zonation throughout each apatite crystal. Inversion results reveal a denudation history composed by a pulse of denudation at ∼6 Ma, as suggested by the age-elevation relationship, followed by a decrease in denudation rate to very low value (<0.1 km/Myr) and late-stage exhumation phase at ∼1 km/Myr for the last ∼2 Myr.

Our (U-Th)/He and 4He/3He data demonstrate a tight connection between the glaciation history from moraines record and long-term erosion rates derived from low-temperature thermochronology. These results highlight the high sensitivity of the Southern Patagonian Andes to the progressive Late-Cenozoic climate cooling and the strong glacial imprint on erosion history and landscape evolution since the Late Miocene. Indeed, we interpret the observed increase in erosion at ∼6 Myr as the landscape response to the onset of the Patagonian ice cap, while the inferred recent increase in erosion rates may reflect the intensification of the climate cooling since the Plio-Pleistocene.