Geophysical Research Abstracts
Vol. 21, EGU2019-17326-1, 2019
EGU General Assembly 2019

Tectonic and glacial controls on topographic evolution in the Southern Patagonian Andes (47°S lat)

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Glacial erosion is hypothesized to be a major control on the topographic evolution of mountain belts. Previous studies often used the Southern Patagonian Andes to illustrate the dominant role of glacial erosion on topographic variations. However, contemporaneously with glacial periods this region has been affected by the subduction of oceanic spreading-ridge segments and oblique convergence, which has resulted in the partitioning of deformation into regional strike-slip and thrust faulting. This suggests an important contribution from tectonics on the topographic evolution in the studied region.

Here, we investigate tectonic and glacial controls on the topography in the area inboard of the Chile Triple Junction (47°S). We used a modified version of the 3D thermokinematic model Pecube integrated by 33 new and 41 previously published bedrock cooling ages. Thermokinematic modeling was conducted to identify temporal and spatial variations in rock uplift and topographic change before, during, and after glaciation. Our new data include thermochronometric ages dated with the apatite and zircon (U-Th)/He method (AHe and ZHe, respectively) and apatite and zircon fission track method (AFT and ZFT, respectively).

Several samples close to the eastern foothills of the mountain range yield generally young AFT (4–10 Ma), ZHe (4–12 Ma), and ZFT (6-14 Ma) ages, whereas farther east the age distribution becomes older (AFT: 28–32 Ma, ZHe: 68–117 Ma). Preliminary 3D thermokinematic modeling results suggest that AFT, ZHe, and ZFT ages can be explained by a parabolic-shaped exhumation pattern with the highest exhumation rates of up to 1.5 mm/yr in the past 8-6 m.y. We interpret these rates as predominantly related to tectonically induced rock uplift, whereas the shape of the exhumation pattern is probably controlled by the geometry of the subducted oceanic ridge and/or a restraining bend in the Liquiñe-Ofqui strike-slip fault zone. Moreover, AHe ages ranging from 6 to 4 Ma suggest that such tectonically induced exhumation was concurrent with effective glacial erosion after onset of glaciation in Patagonia 5-7 Ma ago and high exhumation rates were maintained. Additionally, the youngest AHe ages, scattered across the study region, can be explained by acceleration (up to 1 mm/yr) of exhumation rates in the past 3–2 m.y. Interestingly, this acceleration is coeval with the impact of Plio-Pleistocene glaciation suggesting a strong impact of glacial erosion on the topography. Taken together, these results highlight that the present-day topography and distribution of cooling ages in the region are a function of both the tectonic history of the orogen as well as a superposed glacial modification of the landscape.