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Uncoupled vs. coupled thrust belt-foreland deformation: a model for northern Patagonia inferred from U-Th/He and apatite fission track dating

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The study of the Cretaceous – Cenozoic evolution of the Patagonian Andes represents a great opportunity to investigate the effects of coupling between deep lithospheric processes and near-surface deformation. Low-temperature thermochronological systems are ideally suited for detecting events involving rocks in the uppermost part of the crust because they record time and rates of cooling related to exhumation of the top few kilometers of the crust. The Patagonia region, although characterized by a general continuity of the Andean orogen along its strike, shows an appreciable internal tectonic segmentation (marked by a variable position of the magmatic arc and of the deformation front in the retroarc area) at various latitudes. This complex structural architecture has been interpreted as the result of different processes acting since the Late Cretaceous. The present-day configuration of the southern Andes is interpreted to have been controlled by alternating stages of flat- and steep-slab subduction, which produced shortening and upper plate extension episodes,, respectively. Furthermore, the deformation in this whole retroarc sector varied not only in time (i.e. with major 'cycles' of mountain building and orogenic collapse), but also in space, due to the variable transmission of horizontal compressive stress away from the orogen, that produced an irregular unroofing pattern.
In this study, we have integrated field structural observations with new apatite (U-Th)/He data (AHe) and apatite fission-track (AFT) ages in the north Patagonia region (at latitudes between 40° and 44°S) in order to analyse and compare the exhumation patterns from the frontal part of the orogen and from the adjacent foreland sector, as well as to gain new insights into the timing and modes of coupling vs. uncoupling of the deformation between the northern Patagonian fold and thrust belt and its foreland. The obtained data indicate a markedly different unroofing pattern between the 'broken foreland' area (characterized by Late Cretaceous to Paleogene exhumation) and the adjacent Andean sector to the west, which is dominated by Miocene-Pliocene exhumation.
Our study supports the idea that the configuration of the slab (flat vs. steep) during subduction controls the coupling vs. uncoupling of the deformation between the thrust belt and the foreland. Along the studied transect, late Miocene to Pliocene AHe ages from the frontal part of the northern Patagonian Andes correlate well with a rapid recent shortening and exhumation stage that took place in the thrust belt during steep-slab subduction and rollback. On the other hand, AHe ages obtained for the 'broken foreland' unravelled exhumation at near-surface conditions during Late Cretaceous to Paleogene times, when a prolonged phase of flat-slab subduction favoured the coupling between the thrust belt and the foreland area and associated widespread shortening able to reactivate inherited rift-related structures.