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Glacial control on active mountain development: A southward latitudinal transition from glacial buzzsaw to glacial shield in the Patagonian Andes

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Alpine glaciers have been hypothesized to have sufficient erosive power to control the ultimate height of actively developing mountains regardless of the rate at which uplift occurs: a process commonly labeled the "glacial buzzsaw". Evidence includes the observation of remarkable correlation between glacial equilibrium line altitude (ELA) and mean elevation in several mid- to high latitude active orogens independent of highly variable late Cenozoic exhumation rates. In contrast, extremely low late Cenozoic erosion rates have been demonstrated below frozen-based subpolar to polar glaciers and ice sheets with the ice acting to shield the landscape from further erosion. In an actively uplifting mountain range this could potentially lead to increased mean elevations. Conceptual models of a critical-taper orogen undergoing dominantly glacial erosion indicate that if efficiency of glacial erosion during late Cenozoic climate change is strong, then following onset of late Cenozoic climate change and ELA lowering, a significant increase in erosion rates is predicted, the magnitude of the rate change being higher if the orogen responds by active uplift driven by accretion as opposed to passive isostatic rebound. Alternatively, if after onset of climatic cooling, glacial erosion is inefficient, owing to, say, the inception of cold-based glaciers and/or slow-moving ice sheets, then no increase in erosion rates is predicted.

To investigate the efficiency of glacial erosion and its effects on mountain building

we have undertaken low-temperature thermochronologic analysis (fission-track and (U-Th)/He dating) at various latitudes along the Chilean Patagonian Andes: a high latitude active orogen with a well-documented late Cenozoic tectonic, climatic, and glacial history. New data from regional transects from 38°S to 49°S reveal that the highest rates and magnitudes of late Cenozoic erosion are restricted to the main divide and its windward western flank. Here age-elevation relationships demonstrate a marked and consistent acceleration in erosion at 8 to 6 Ma to rates between 0.4 and 0.6 mm/yr coeval with the timing of onset of major Patagonian glaciation between ca. 5 and 7 Ma, but well after initial surface uplift of the Patagonian Andes at around 17-14 Ma. The estimated erosion rates are consistent with conceptual predictions for either (1) moderately efficient glacial erosion acting on an active orogen, or (2) very efficient glacial erosion acting on an inactive orogen responding by passive isostatic rebound. In contrast, new thermochronometric data from further south (49°S to 56°S) show no evidence of enhanced late Cenozoic bedrock erosion along the main divide with old ($>$10 Ma) apatite (U-Th)/He ages despite the apparent presence of widespread glaciation. These data imply that that long-term glacial erosion has been less efficient further south. We speculate that during each of the many glacial cycles in the late Cenozoic, the Patagonian Andes south of ca. 45°S glaciation was dominated by either frozen-based glaciation and/or slow moving ice caps. Inefficient glacial erosion at these more south latitudes also explains well the anomalously high non-volcanic summit elevations along the main divide within the South Patagonian icefield between 46°S and 51°S now situated well above the modern and last glacial maximum ELA.