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# Quantifying canyon incision and Andean Plateau surface uplift, southwest Peru: A thermochronometer and numerical modeling approach

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Transient thermal signals resulting from near-surface isotherm adjustment to changes in surface morphology can provide excellent records of landscape evolution. Apatite and zircon (U-Th)/He thermochronometer cooling ages from Cotahuasi-Ocoña Canyon at the northwest margin of the Central Andean Plateau provide information on rock cooling histories induced by a major phase of canyon incision. We quantify the timing and magnitude of canyon incision by integrating 20 previously published samples from the valley bottom with 26 new samples from five vertical transects. Interpretation of the canyon incision history from cooling ages is complicated by a southwest to northeast increase in temperatures at the base of the crust due to active subduction. Furthermore, the large magnitude of canyon incision in this region leads to additional three-dimensional variations in sample cooling histories that depend on the style of landscape evolution. We address these complications with coupled finite-element thermal, landscape evolution, and thermochronometer age-prediction models to quantify the range of topographic evolution scenarios consistent with observed cooling ages. Geological evidence for early canyon depths of at least 200 m and comparison of 196 model simulations to observed cooling ages and regional heat flow determinations identify a best-fit history with 0.2 to 0.64 km of incision starting prior to $\sim$15 Ma and 2.56 to 3.0 km of incision starting at ca. 10 to 11 Ma. Young thermochronometer ages and a $^{40}$Ar/$^{39}$Ar age on a valley-filling volcanic flow imply that incision ended between ca. 3.5 and 2.21 $\pm$ 0.02 Ma.

Canyon incision starting at 10 to 11 Ma must coincide with or post-date surface uplift, given that incision on the order of several kilometers in magnitude must be driven by surface uplift of at least this magnitude. Contemporaneous surface uplift recorded in the interior and eastern margin of the plateau suggest that uplift was driven by geodynamic mechanisms capable of producing uplift over several hundred kilometers, possibly including delamination of a high-density lithospheric root, lateral flow of lower crust, or subduction zone mechanisms such as thermal weakening and ablative subduction.