Global Pliocene cooling digs deep canyons into the Andean Plateau

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Canyon on the Eastern margin of the Andean Plateau, Bolivia. Credit: Todd Ehlers 2013

Incision of canyons into mountains is often interpreted by geoscientists

as a proxy for surface uplift of the surroundings by geodynamic and tectonic processes. However, another possible cause for incision is climate change. Richard O. Lease and Professor Todd A. Ehlers of the Department of Geosciences of the University of Tübingen have analyzed the developmental history of a series of 1.5 to 2.5 kilometer deep canyons along a 1250 kilometer portion of the Eastern margin of the Andean Plateau, South America (Peru and Bolivia). They found that Miocene faulting and mountain building of the Northeastern Plateau margin initiated at or before 20 million years ago at the Rio San Gaban catchment, Peru, and was then followed by Pliocene incision of the canyons 4 to 3 million years before present. At the same time as this incision, early global Pliocene warmth shifted to a late Pliocene cooling.

The scientists state that the pacemaker of canyon incision into the Andean Plateau was a previously documented change towards global cooling that resulted from a change in sea surface temperatures. This event enhanced moisture transport to the Andean Plateau and increased river erosion and incision. The research results are now being published by *Science*.

Defining the role of tectonic and climate processes for shaping a mountain landscape is often difficult. The scientists overcame this problem by reconstructing the river incision history into the Andean Plateau using geochemical techniques. They found that canyon incision at the Eastern Plateau margin had accelerated some million years ago.

They examined the cooling rate of rocks now exposed in the Rio San Gaban canyon to determine the starting point of when river incision accelerated. Samples taken from both sides of a major fault and at different levels of elevation in the incised canyon were dated by uranium-thorium-helium thermochronology for the minerals apatite and zircon. The method is based on the time-dependent radioactive decay of uranium and thorium to produce helium. As mountains erode rocks are

slowly brought to the Earth's surface from great depths and cool. Beneath a so-called closure temperature these minerals start retaining helium and function as a geological clock. Measurement of these different elements reveals the cooling age to the scientists.

"Our analyses show that several canyons in different locations of the 1250 kilometer long Eastern Andean Plateau margin had formed in a short period of time during the Pliocene, 3 to 4 million years ago," Todd Ehlers says. Pliocene incision occurred across different tectonic and geodynamic boundaries, suggesting that a mechanism unrelated to these processes was responsible for incision.

"In contrast, the river incision over these large distances developed in parallel to global Pliocene climate change," the scientist points out. During the shift from early Pliocene warmth to late Pliocene cooling, sea surface temperatures changed and brought a considerable increase in precipitation to the Eastern margin of the Andean Plateau. "We conclude that 3 to 4 million years before present, climate change caused Pliocene canyon incision at the Eastern margin of the Andean Plateau," Todd Ehlers says.

More information: Lease, R. and Ehlers, T. Incision into the eastern Andean Plateau during Pliocene cooling, *Science*, 16 August 2013.

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