Mountain erosion accelerates under a cooling climate

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Photograph taken in southern Tibet. Erosion rates have globally increased in mountain ranges in response to glacial erosion. This picture illustrates the work of glaciers in carving valleys and creating large volumes of sediments. Moutains dominate the global production of sediment, so a global increase in sediment production implies a global increase in sediment production. Credit: Amos Aikman

The Earth's continental topography reflects the balance between tectonics, climate, and their interaction through erosion. However, understanding the impact of individual factors on Earth's topography remains elusive. Professor Todd Ehlers of the University of Tübingen Geoscience Department, in cooperation with international colleagues, has studied the coupling of climate and erosion on a global scale. The scientists investigated the effect of global cooling and glaciation on topogrpahy over the last two to three million years. To quantify erosion, they compiled bedrock thermochronometric data from around the world. Their data show that mountain erosion rates have increased since circa 6 million years and most rapidly in the last 2 million years. Moreover, alpine glaciers play a significant role in the increase of erosion rates under a cool climate. The results are published in the current edition of *Nature*.

The scientists have compiled data from 18,000 rock samples to globally estimate temporal and spatial variations in erosion rates. During mountain erosion rocks travel from about 10 kilometers depth in the crust to the Earth's surface. During this process, the rocks cool from great depths to the surface. Thermochronology exploits that small quantities of radioactive uranium contained in the rock decay in a time-dependent process. Below a given so-called closure temperature rocks accumulate the products of radioactive decay. In quantifying decay products, scientists are able to calculate the travel time of a rock from a determined depth to the surface and the time elapsed for cooling. Finally, these data can be converted into an erosion rate using sophisticated computer models.

The study's broad approach that uses a global distribution of samples reduces the influence of individual regional tectonic events on the overall study results. The overall global picture that emerged was a strong correlation of erosion rates with the global climate change over the last several million years.

"On a global scale erosion rates span four orders of magnitude in the last eight million years from one hundredth millimeter up to ten millimeters a year," Todd Ehlers says. Six million years ago, increase of erosion rates was expressed at all latitudes, but was most pronounced in glaciated mountain ranges, indicating that glaciers played a significant role.

Furthermore, erosion rates accelerated more in the last two million years with the most substantial changes at latitudes greater than 30°, for example in the European Alps, Patagonia, Alaska, the South Island of New Zealand and The Coast Mountains of British Columbia. These areas are highly variable in their tectonic activity, but they have in common that they have all been glaciated in the past few million years. Mountain erosion rates since about six million years ago were increased once more by nearly a factor of two for the Pleistocene compared to the Pliocene. "This change with increased activity of glaciers and higher sediment flux shows a clear temporal correspondence with further Late Cenozoic cooling," Todd Ehlers comments. These results have important implications in general for improving our understanding of the coupling between climate and erosion.

More information: Frédéric Herman, Diane Seward, Pierre G. Valla, Andrew Carter, Barry Kohn, Sean D. Willett, Todd A. Ehlers: Worldwide acceleration of mountain erosion under a cooling climate. *Nature*, 19 December 2013.

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