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A 9 Myr record of erosion rates in Northern Tienshan based on 10Be cosmogenic nuclides

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Erosion plays a fundamental role in coupling climate to tectonics and it is therefore critical to constrain modes and rates of erosion throughout the Earth's history. However, quantitative, direct estimates of erosion rates on time scales >1 Ma are notoriously lacking. Zhang and Molnar (Nature, 2001) showed that there has been a worldwide acceleration in sediment accumulation rates since ∼5Ma, which they linked to the onset of Quaternary glaciations. However, erosion rates derived from sediment budgets are subject to serious drawbacks and potential flaws. The reality of this acceleration is therefore a matter of intense debate. Several authors have indeed raised arguments against this hypothesis.

Since the 90's, cosmogenic isotopes have been extensively used in modern rivers to determine basin-averaged denudation rates, but only few studies have expanded this method to ancient sediments. Here, we report in situ produced cosmogenic 10Be concentrations in magnetostratigraphically dated continental sediments, in order to derive a ∼9 Ma long, high resolution record of paleoerosion rates.The watershed studied, the Kuitun River, is located in the Northern Tian-Shan range (Central Asia, China). This area is of primary importance for the ongoing debate relating to the apparent acceleration in erosion rates proposed by Zhang and Molnar. Indeed, because of its intracontinental endorheic setting, erosion in this region is insensitive to global sea-level variations.
Due to significant Holocene river entrenchment into the fold-and-thrust belts of this piedmont region, several exceptional sections of well dated Cenozoic sediments are accessible for high resolution sampling. Moreover, the present-day denudation of these outcrops is rapid enough to ensure modern cosmogenic build-up is negligible. Production of cosmogenic 10Be during the sediment burial was accounted for by using magnetostratigraphically determined paleoaccumulation rates.

The so-obtained paleoerosion rates are almost invariant from 9 to 2.5 Ma. A significant ∼5 fold increase is then observed at the onset of Quaternary glaciations (∼2.5 Ma), followed by a drop after ∼1.7 Ma. Recent erosion rates are thus comparable to the long term Cenozoic value (between 0.1 and 1 mm.yr-1). This new record suggests that the onset of glaciations could have had a significant but transient impact on denudation rates.
Although the transient characteristic of this erosion shift may be the result of a specific local phenomenon, this TianShan record brings new insights to the debate. More generally, this method based on the measurement of fossil cosmogenic signals represents a powerful and promising new approach to determine quantitative paleoerosion rates.