Erosion rates and their controlling factors along the eastern Qilian Shan Mountian, China

PAN B., HU X., GENG H., LI Q., GAO H.
Key Laboratory of Western China?s Environmental Systems (Ministry of Education), Lanzhou University, LANZHOU, CHINA

The interaction among earth-surface erosion, tectonic uplift and the climate is a key issue to understand the earth surface evolution. In recent two decades, a number of studies are carried out in orogens, especially in the Himalaya area, trying to solve the erosion problem, and also arouse big controversy on which factor is in controlling the erosion rate. One of the uplifting mountain belts along the northeastern Tibetan Plateau, the Qilian Shan Mountain, has been experiencing intense deformation in late Cenozoic. Varied erosion rates in different mountain zones supply an ideally natural lab of the Qilian Shan to study the surface erosion and its controlling factors. With different methods, we obtained erosion rates in different time scales along the eastern Qilian Shan. Apatite fission track and apatite (U-Th)/He studies in the Xiying River basin give cooling ages of 56~80 Ma and of 22-45 Ma, respectively. Thermo-history modeling results show that: From ~ 70 to 10-8 Ma, the rock was cooling in a relatively low rate; from 10-8 Ma to present, the rock was cooling in a relatively high rate of 7.5±1.8 ℃/Ma. Estimated average rate of rock erosion since 10-8 Ma is ~ 0.23 mm/a, and the results illustrate a higher erosion rate in the south (hanging wall) of the Huangchen-Taerzhuang thrust fault (the H-T fault). In the late Quaternary, river terraces are mainly formed in five periods: 10 ka, 20-25 ka, 30-37 ka, 51-56 ka and 67-71 ka. Based on the terrace heights and ages, calculated river incision rates are between 0.3 and 2.5 mm/a. Spatial pattern of river incision rates shows the higher rates are also located in the south of the H-T fault. Cs^{137} contents give modern erosion rates of 0.1~0.4 mm/a, and show a good correlation with slope gradient. After we correlate the different erosion rates of different time scales with the tectonic uplift and precipitation, we find out that the erosion rate is mainly controlled by tectonic uplift.

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Rain, water, and ice: driving forces behind rapid erosion in western Bhutan

PORTENGA E.(1), BIERMAN P.(2), DUNCAN C.(3)
(1) University of Glasgow & Macquarie University, GLASGOW, UNITED KINGDOM ; (2) University of Vermont, BURLINGTON, VT, UNITED STATES ; (3) GISmatters, AMHERST, MA, UNITED STATES

We employ the cosmogenic nuclide, ^{10}Be, to quantify basin-averaged erosion rates on millennial timescales and analyze spatial patterns of erosion in western Bhutan where knickpoint retreat, tectonic uplift, monsoonal precipitation, and glacial erosion actively shape the landscape. Measurements of ^{10}Be in quartz purified from modern stream sediment in 47 drainage basins (4-8,000 km^2) span almost three orders of magnitude, from 560±290 atoms/g to $3.8x10^5±7x10^3$ atoms/g, yielding erosion rates ranging from ~98-21,000 m/My; the median erosion rate is 880 m/My. Erosion rates are not correlated with topographic metrics such as elevation, relief, mean annual precipitation, or ice cover. Erosion rates, however, reach a maximum in basins where the average basin slope exceeds 25°. These steep basins are geographically grouped into two regions: one region is south of an uplifted and preserved low-relief step associated with the Greater Himalayan Sequence (27.0-27.4°N) and the other is north of this same preserved land surface (27.6-28.4°N). Monsoonal rains drive erosion along the range front where average basin slope angles are steepest. Headwater streams are likely oversteepened, adjusting to the passing of a knickpoint which is propagating through the Greater Himalayan Sequence, exposing the underlying Lesser Himalayan Sequence. A declining precipitation gradient with increasing latitude (R^2 = 0.74) suggests that other factors dominate erosion north of the preserved low-relief step. The percentage of basins covered with ice and glaciers increases abruptly north of the raised step and includes the majority of basins exhibiting high erosion rates. Rates from these northernmost basins are likely the combined result of intense glacial erosion and steepened valleys nearing threshold slope angles. The calculated erosion rates are similar to fission track exhumation rates for western Bhutan but are twice as fast as basin-average erosion rates from eastern Bhutan.