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Growth and erosion of mountain ranges at the northeastern margin of Tibet

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The hypothesis that mountain belts may reach a steady state, in which rock uplift is balanced by erosion, has been supported by numerous field studies and numerical models. The early evolution of mountain ranges, however, and especially the relation between fault growth and topographic response has received little attention. By using a space-for-time substitution we illustrate how active thrust faults and small, fault-bounded mountain ranges evolve into mature mountain chains that will ultimately be incorporated into the laterally growing Tibetan Plateau. At an early stage of development, when faults propagate laterally, slip rates are constant along strike [1-3]. As long as no significant topographic relief has developed, tectonic uplift is at least an order of magnitude faster than the rate of erosion [2,4]. During progressive relief growth and the establishment of drainage basins, erosion of the rising mountain ranges becomes more important, but the studied ranges are still in a pre-steady state and continue to grow both vertically and laterally [5]. During this stage the rate of erosion is linearly correlated to the mean hillslope gradient and the mean local relief, if differences in lithology or rock strength are negligible [6]. The rate of relief growth may be inferred from the difference between local erosion rates on ridge crests and catchment-wide denudation rates [7] – the latter may be taken as a surrogate for the rate of river incision. As hillslopes approach a threshold value, landsliding becomes the dominant process of mass transport and erosion rates increase non-linearly with slope. Once a steady state has been reached, the erosion rate is equal to the rate of rock uplift. A key problem is how the rate of rock uplift can be quantified in such regions, because the stochastic distribution of landslides causes the denudation rates inferred from 10Be in river sediment to be highly variable [8].

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