Extreme landscape disequilibrium and slow erosion during rapid mountain building

Details

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Abstract

In this study, we examine topography and erosion in Taiwan, where high rates of tectonic convergence, easily erodible bedrock, and a highly erosive climate have produced some of the steepest landscapes and highest erosion rates in the world. Through a combined analysis of topography throughout the Central Range and cosmogenic radionulcide 10Be erosion rates measured in quartz purified from river sediment, we show that Taiwan preserves broad (up to 10-20 km2) areas of anomalous, low slope, low relief terrain and exhibits a wide range of short-term (103-104 yr) 10Be erosion rates (0.1 to ~10 mm/yr) within topography that has been exhuming at 3-5 mm/yr for at least the past 1.5 Ma. The extreme landscape disequilibrium observed in Taiwan highlights the variation in erosion and morphology that mountain belts can exhibit despite strong tectonic forcing and a highly erosive climate. The wide range in cosmogenic erosion rates observed in Taiwan is a direct consequence of the presence of low slope, low relief topography within a rapid uplifting and exhuming orogen. Low relief, slowly eroding areas are consistently found at high elevations near the main topographic divide of the Central Range and in the upstream headwaters where it is more likely to preserve relict topography.Their existence in combination with constant, rapid background exhumation suggest that Taiwan has seen large scale shifts in mean elevation over the last 2 Ma, a conclusion that challenges classic notion of orogeny evolution in Taiwan, the archetype example of arc-continent collision and rapid mountain around the world.Conversely, because Taiwan exhibits rapid rock uplift, frequent landslides and high rates of erosion, it may be the type landscape where dynamic landscape process of river capture and in situ formation of low relief landscape allow for the highest range of millennial scale erosion rates anywhere in the world. Either way, this study highlights that spatial variation erosion rate and landscape morphology (e.g., slope, relief) is possible within rapidly deforming mountain belts, with important implications for interpreting tectonics and factors controlling landscape evolution.

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