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Rapid weathering and slow erosion in a tectonically active tropical setting

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Over the past two decades, many long-held ideas concerning the drivers of chemical and physical weathering have been challenged. One of the key causes of this revolution has been the continued refinement of cosmogenic nuclide techniques for determining in-situ rates of landscape denudation. In tropical Sri Lanka, von Blanckenburg and colleagues (2004) used cosmogenic 10Be in river sediment to show that physical erosion rates are extremely low, in spite of high mean annual temperature and precipitation. The implication of their work is that tectonic setting is a stronger control on erosion than climatic setting. This has been borne out in global compilations (e.g., Portenga and Bierman, 2011), with tectonically inactive sites generally having lower erosion rates than tectonically active sites. However, there have been few studies in tectonically active tropical settings. Furthermore, the relationship between chemical and physical weathering has not been clearly demonstrated. To address this, we collected stream sediment and soil samples from the Suckling-Dayman massif (SDM) in south-eastern Papua New Guinea. The footwall of the SDM has been uplifted over 3 km over the last $\sim$3 Ma along the active Mai'iu low-angle normal fault, which dips $\sim$21° at the surface. The domed and striated morphology of the SDM suggests that it is little eroded, aside from deep fluvial incision of several north-flowing drainages. Cosmogenic nuclide-derived slip rates on the Mai'iu fault (Webber et al., 2018) suggest recent slip of >11 mm/yr (>3mm/yr vertical uplift). Such rapid uplift would normally be assumed to result in rapid physical erosion of these mountains. 10Be concentrations from soils and stream sediment indicate orders of magnitude slower denudation, between 0.03 and 0.18 mm/yr. Zirconium concentrations from the same soil samples indicate complete chemical weathering of the near-surface metabasalt within 10-20 ka. We suggest that the high mean annual temperature and rainfall, combined with easily weathered metabasalt bedrock, lead to reduced physical erosion through increased biological fixing of the surface sediments. Our results provide tantalising evidence that climate may, counterintuitively, play a key role in limiting denudation rates in actively uplifting tropical settings.