Steep slopes can be stable too

Anne Voigtländer, Rachel Glade & Jens M. Turowski

Geomorphometrics of landscapes are often used as an indicator for stability and the trajectory they evolve to. The most prevailing characterization of landscapes is the slope angle, alongside the common assumption that the steeper the slope the more unstable it is. Eventually, this leads to circular reasoning and threshold hillslopes, defining high hazard susceptibility to vast regions or the inexistence of steep slopes in landscape evolution models. Acknowledging all steep rock walls on Earth and beyond, we proclaim that steep slopes can be stable too! To substantiate our claim, we reconsider existing limit equilibrium fracture and thus failure criteria. Based in mechanics and rheology we propose an additional tensile strength limit criterion (TSL). The relief of slopes themselves, which constitutes the driving stress consisting of the height, h, and density, ρ of the mass, accelerated by gravity, g and modulated by the slope, α. The material strength required to balance this stress defines the limit to relief. The slope angle becomes merely a component that influences the compressive stress a rock has to resist. First-order estimates of the criteria show that the tensile strength limit of different lithology and their material properties are in good agreement with the height of cliffs and slopes of the same lithology. Implications of the reconsideration of failure criteria of rock slopes include, (i) over-steepening does not necessarily exist, (ii) limit equilibrium analysis need to include rock response to stress, and (iii) material properties are integral to geomorphological studies.

Kontakt:

Anne Voigtländer: GFZ Potsdam, E-Mail: anne.voigtlaender@gfz-potsdam.de