Geophysical Research Abstracts
Vol. 20, EGU2018-17479-1, 2018
EGU General Assembly 2018

Optimal stress levels for geomorphologists

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Conceptually, in geomorphic applications, stress fields have been viewed as (self-) enhancing factors especially in theoretical and numerical models. Common assumptions are that high magnitudes of stress result in stronger deformational responses, and that stress concentrations draw further stress concentrations, which may lead to fracture propagation. This point of view acknowledges only the positive feedback and the active part of stress fields, where fracturing and erosion happens when stress exceeds the strength of the rocks. Intriguingly the contrary might also be true. It could also be argued that a river can easily incise or a fracture propagate where material is destressed or are subject to tensile stress fields, thus have a lower threshold for erosion. Additional an interaction of highly stressed and destressed could be assumed as a) incision due to locally destressed material could lead to a negative feedback by stress-induced strengthening of valley walls or b) a highly stressed region is easily eroded to a form that yields a contemporary lower level of stress field.
If both over- and under-stressed regions can yield a geomorphically relevant response of the material, we can postulates that there should be an optimum amount of stress that can be sustained on the one hand and is enough to statically strengthen the form on the other hand. The exact location of this optimum within the phase space of material properties will vary with time as exposed material is environmentally altered and the material strength degrades. In addition, stress fields can change, for example due to displacement of material by erosion of material, human impact, biota, or catastrophic events such as storms. It might also be governed by its tectonic and geomorphic history, i.e. tectonics, glaciation, deposition and incision, which may cause directional differences and interaction of actual and former stress fields and remnant deformation.
The long-term strength of rock and the rheological response curve to low magnitude stress fields is still poorly quantified, even though those stress magnitudes control the rates of weathering and erosion processes, which in turn drive landscape evolution. Here, we draw together concepts from rock mechanics, granular physics and fracture mechanics to develop a more complete picture of the role of stress in geomorphology.