3 failure limits to relief

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- Slope stability assessments on short as well as long-term include the **height** and **slope angle** of the relief.
- These topographic metrics are used to define their (in)stability-potential to failure, based on **rock fracture criteria**.
- The most common approaches use **shear modes**.
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- Fracture modes are **stress-dependent**
- 3 basic fracture modes
- Stress states depend on the **slope angle**, **height** and **density** of the rock and lovely **gravity**
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• …so why are there **not 3 failure limits to relief**?
• …so **which mode of fracture** would control the height of steep mountains?
• …how does this relating to the **stability of steep (>45°) slopes**?
Limit equilibrium criteria

• Limit to Topographic Development – **LTD**: by Schmidt & Montgomery (1995), shear stress in excess of internal friction angle and cohesion.

• Shear Strength Limit – **SSL**: Mohr-Coulomb shear stress

• Tensile Strength Limit – **TSL**: indirect tensile stresses due to the Poisson effect.

• Crushing Strength Limit – **CSL**: compressive stress
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Limit equilibrium criteria

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• First order estimates of the TensileStrengthLimit are in good agreement with the heights of steep hard rocky slopes.*

• We propose this criterion in addition to existing limit criteria.

*Disclaimer: We have only considered intact rock properties and not considered any structural controls of the rock walls.
3 limits to relief also have implications on **failure dynamics**:

Tensile strength limit criterion (TSL) predicts critical yielding at the foot of the steep rock slope, causing **surface parallel fractures** that lead to further critical yielding and slope failure upward. This pattern of progressive failure has been observed in steep rock walls, like El Capitan, Half Dome.
For further discussion:

- ‘over-steepening’ or threshold slope don’t necessarily exist,
- there is probably a transition from one dominant limit to the other, which also implies a shift in the failure mechanism, and
- internal material property changes, due to chemical/mechanical weathering or subcritical crack growth, can evoke a progressive reorganisation of yielding and potential failure without external forcing events.