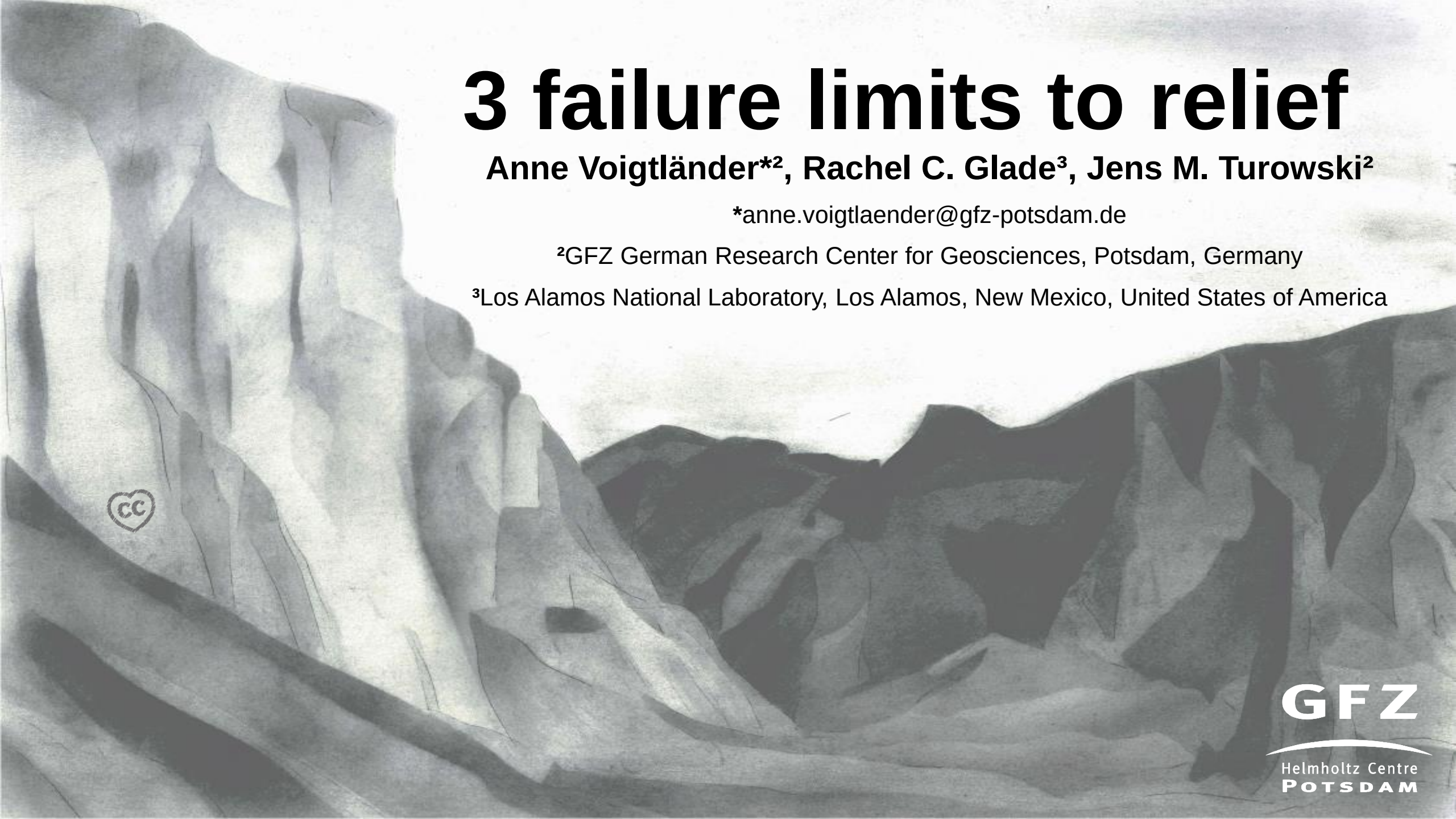

3 failure limits to relief

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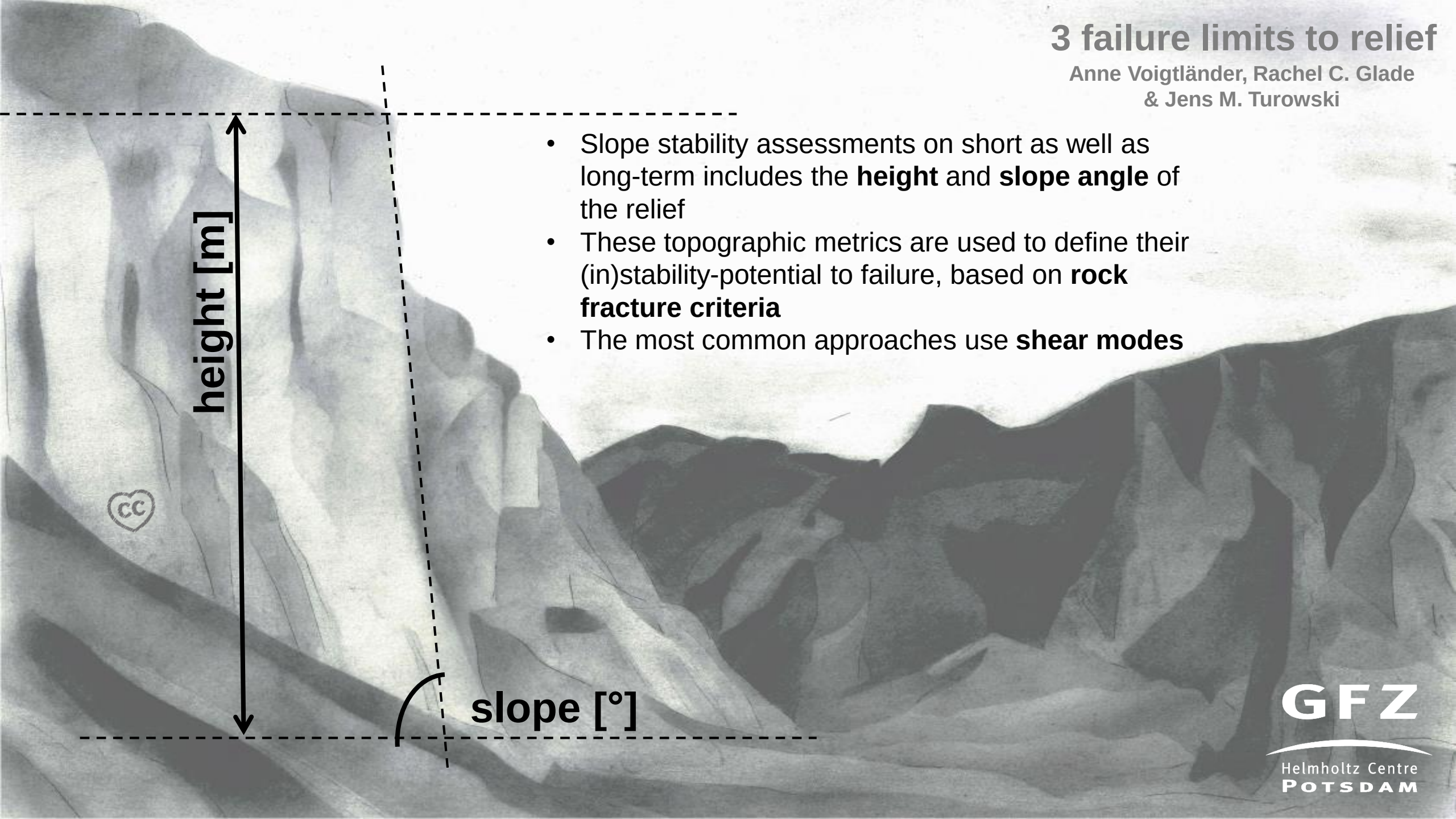

- Slope stability assessments on short as well as long-term includes the **height** and **slope angle** of the relief
- These topographic metrics are used to define their (in)stability-potential to failure, based on **rock fracture criteria**
- The most common approaches use **shear modes**

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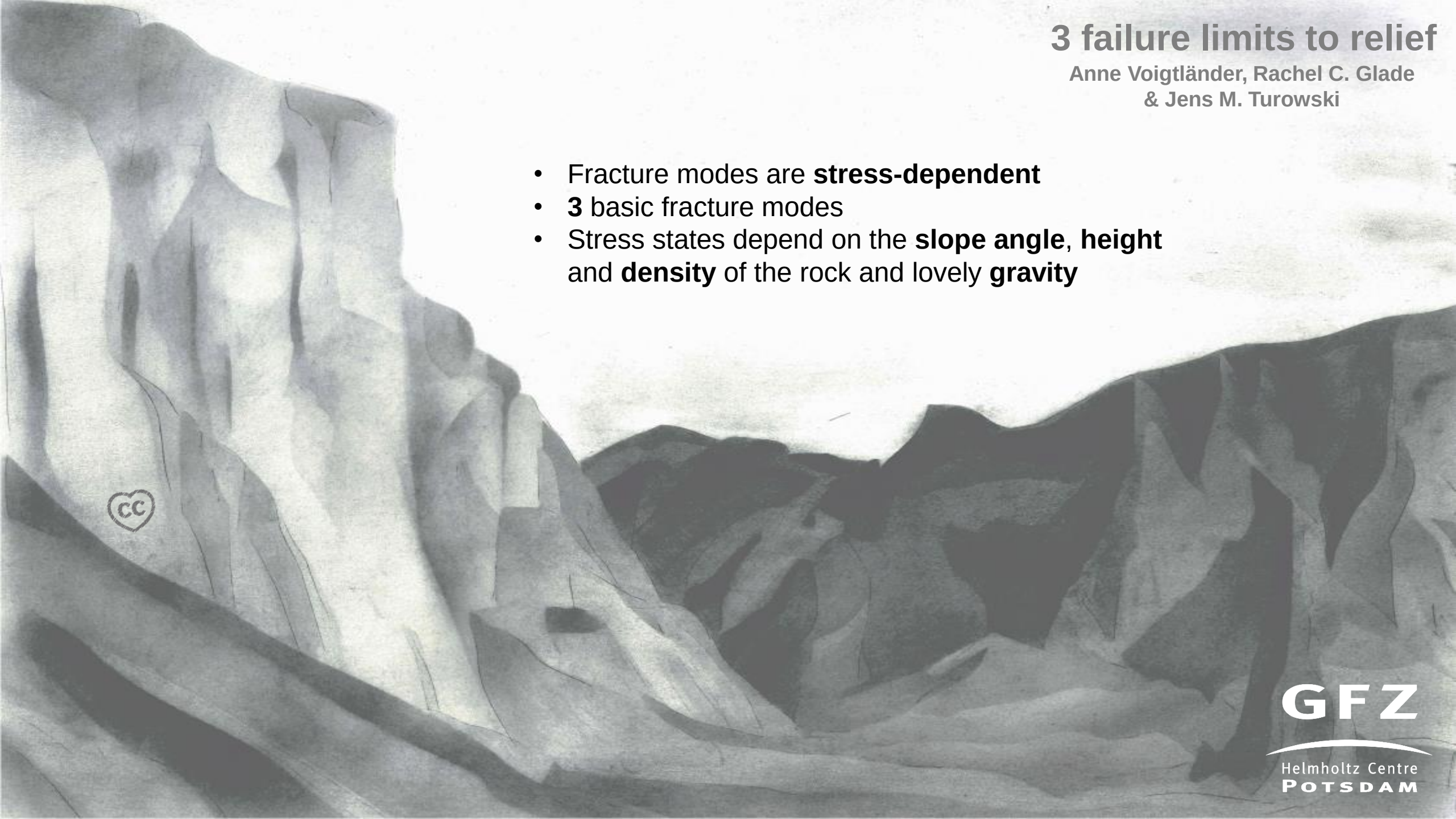

- Fracture modes are **stress-dependent**
- **3** basic fracture modes
- Stress states depend on the **slope angle**, **height** and **density** of the rock and lovely **gravity**

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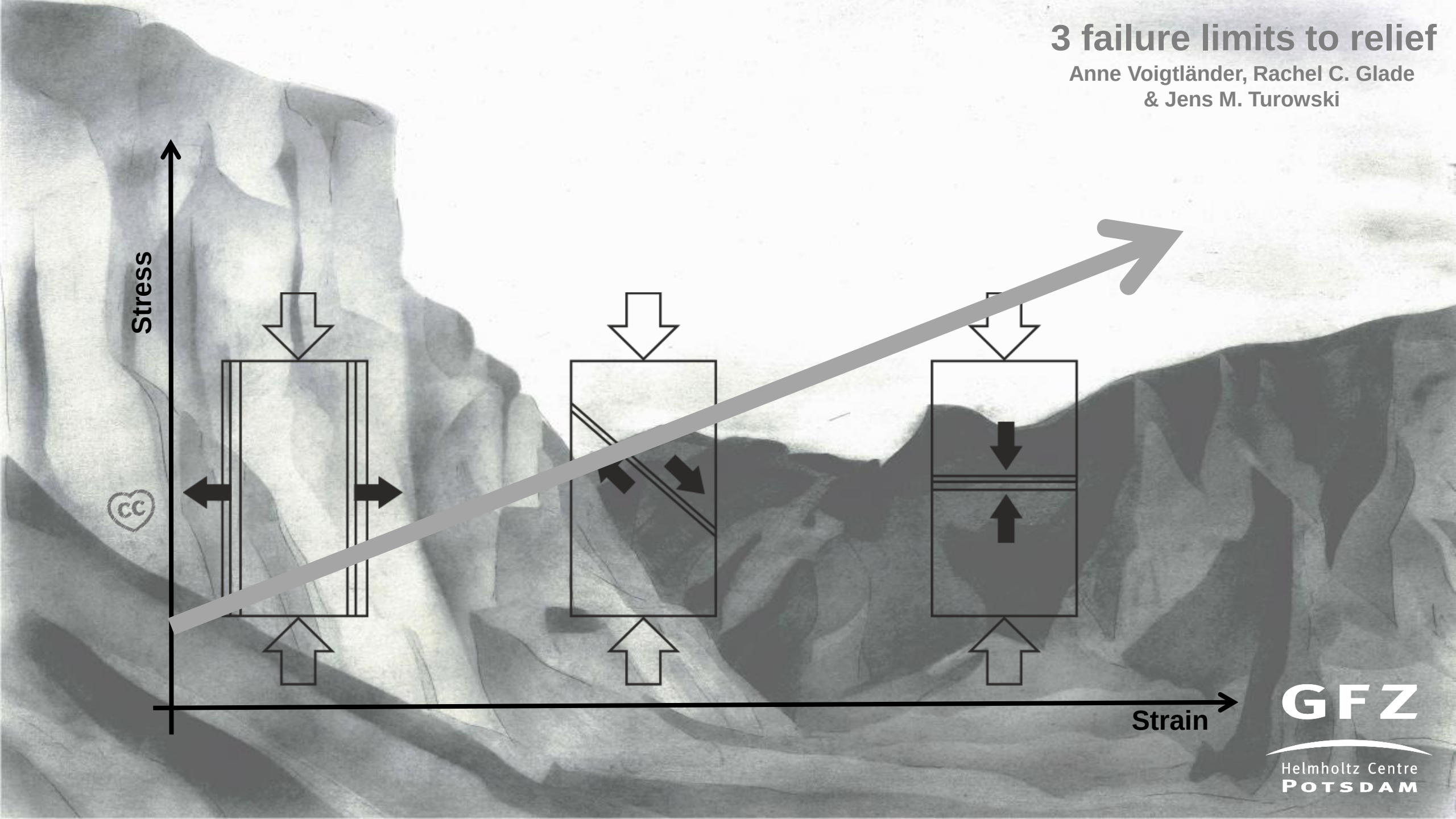

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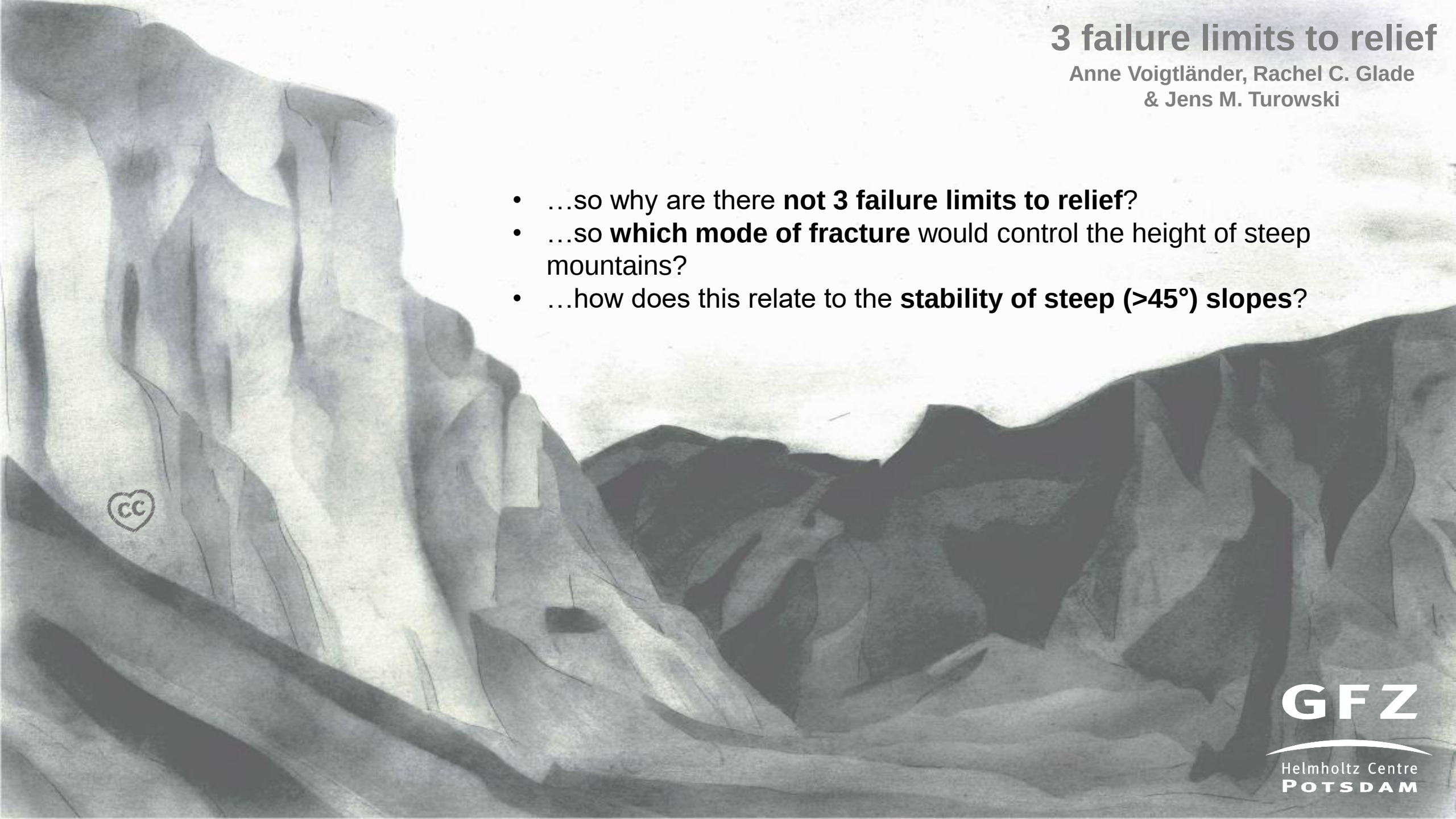

- …so why are there **not 3 failure limits to relief**?
- …so **which mode of fracture** would control the height of steep mountains?
- …how does this relate to the **stability of steep (>45°) slopes**?

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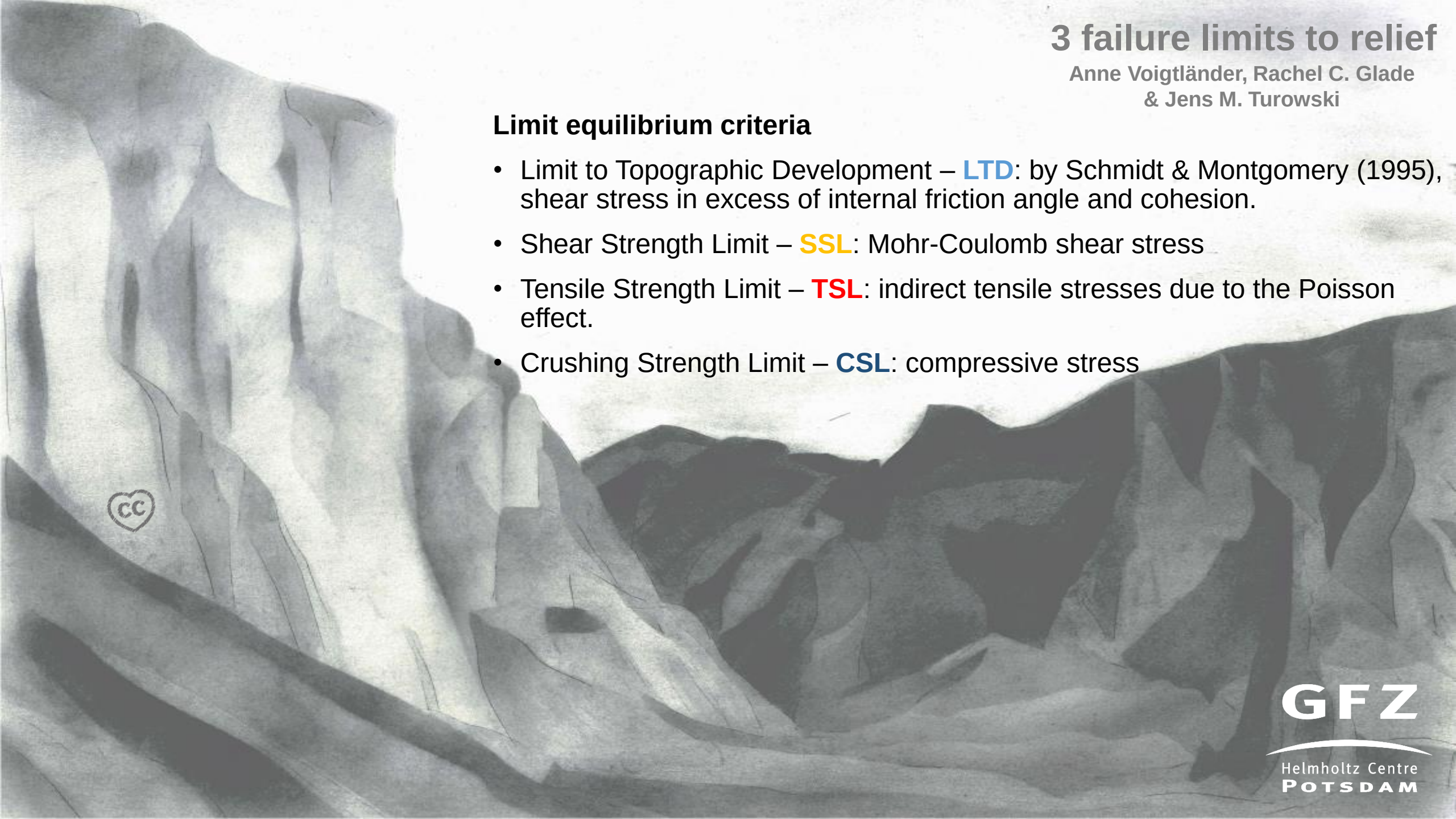

Limit equilibrium criteria

- 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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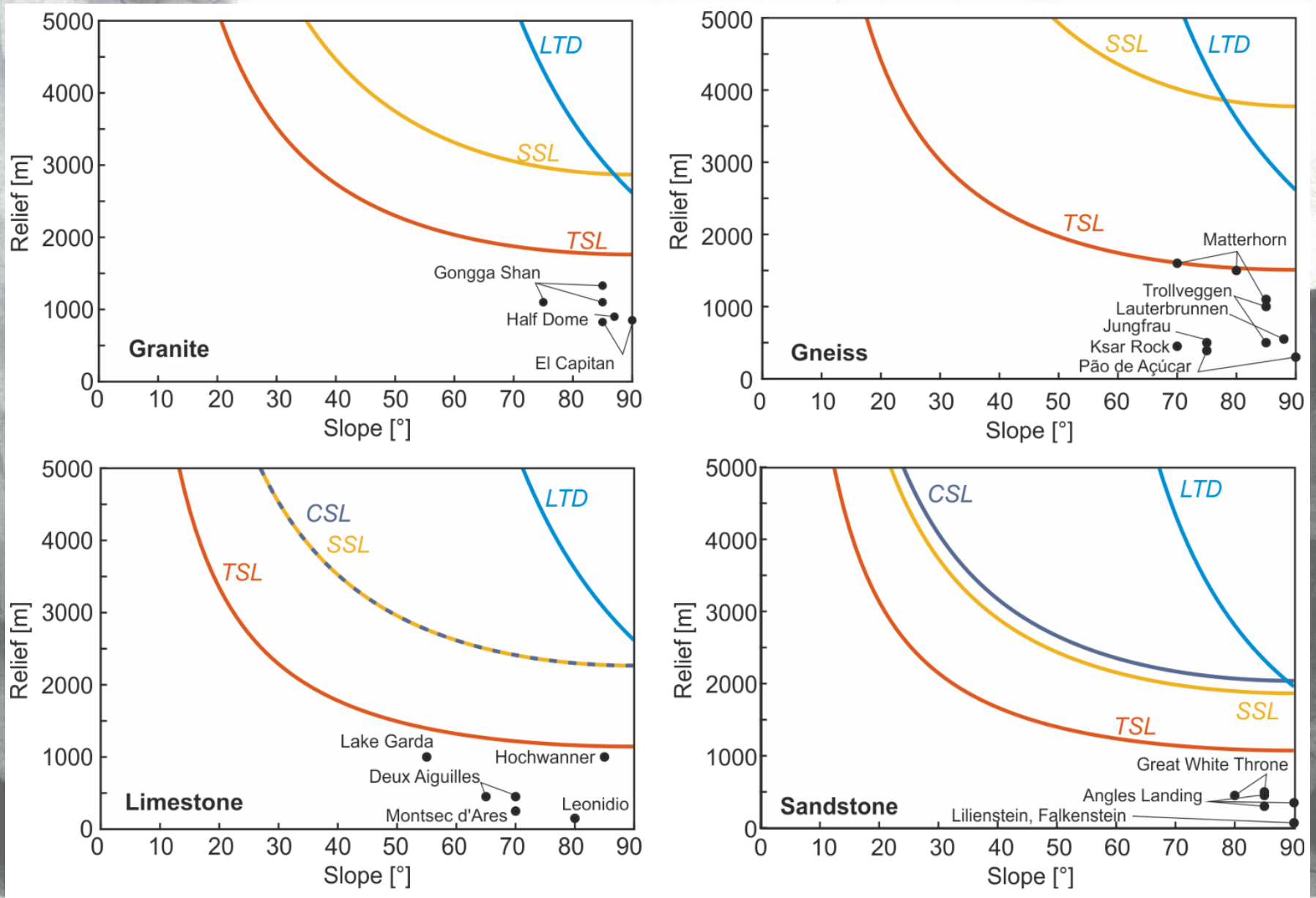
Limit equilibrium criteria



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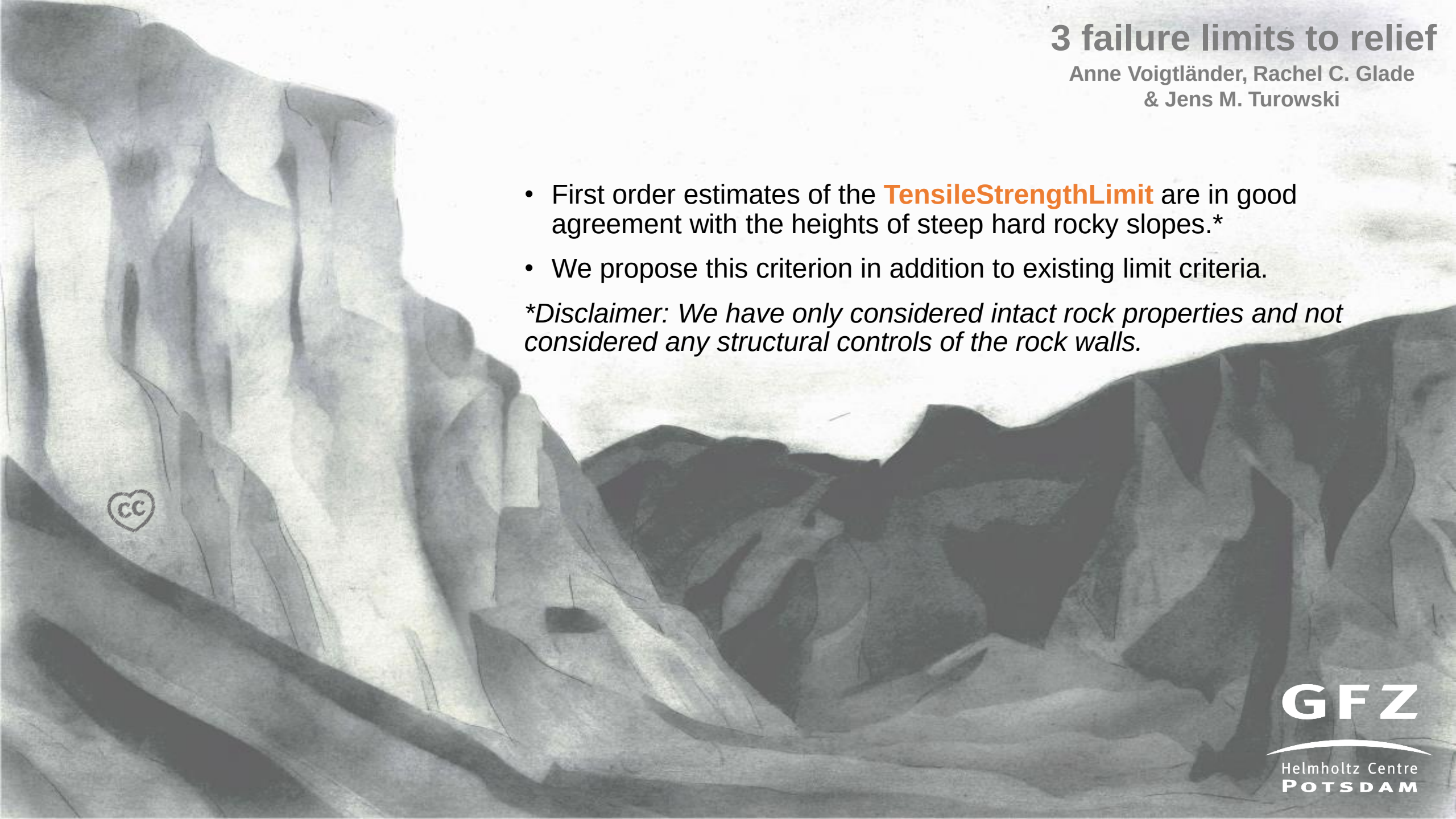

- First order estimates of the **TensileStrengthLimit** are in good agreement with the heights of steep hard rocky slopes.*
- We propose this criterion in addition to existing limit criteria.

**Disclaimer: We have only considered intact rock properties and not considered any structural controls of the rock walls.*

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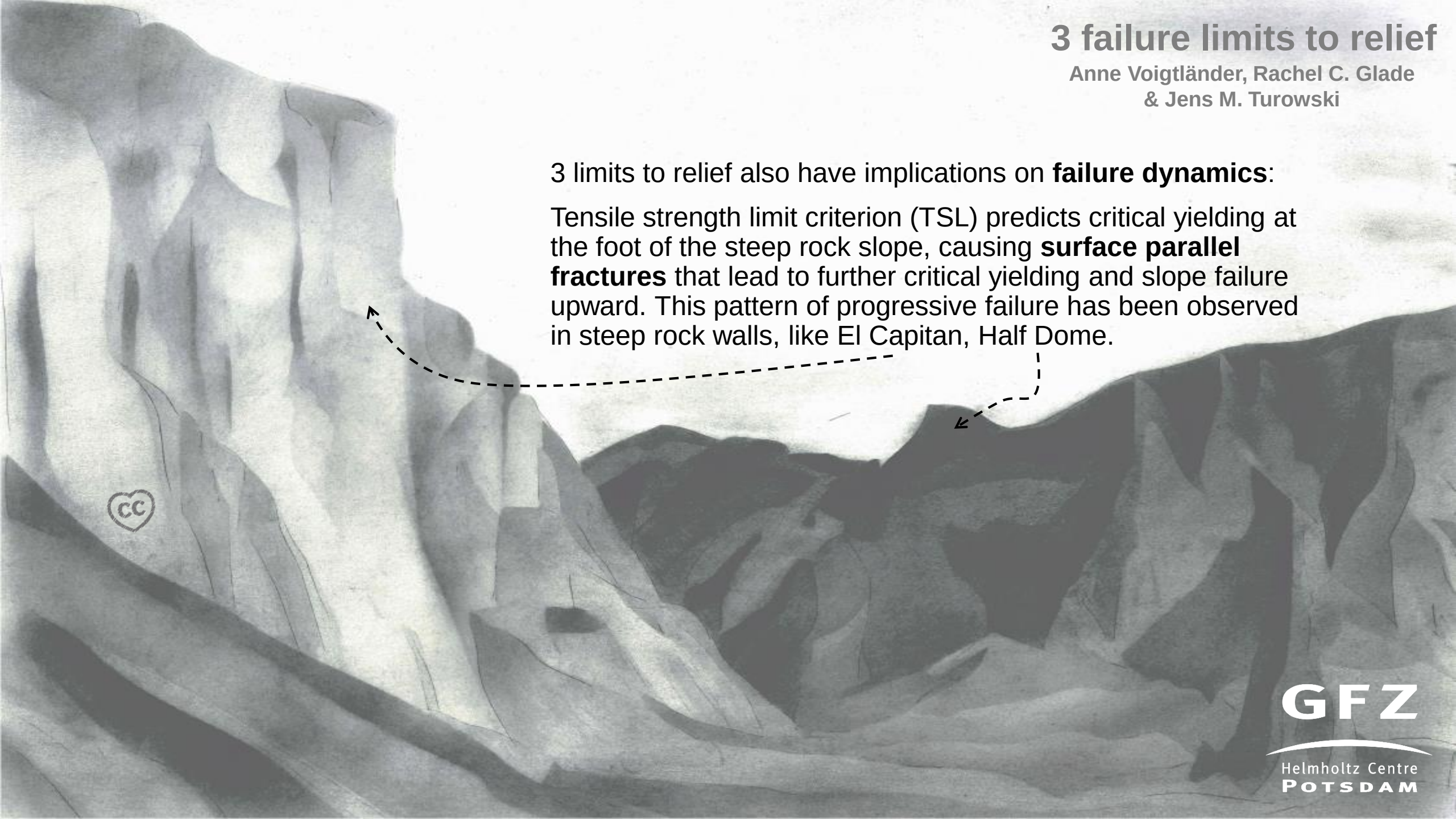

3 limits to relief also have implications on **failure dynamics**:

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.

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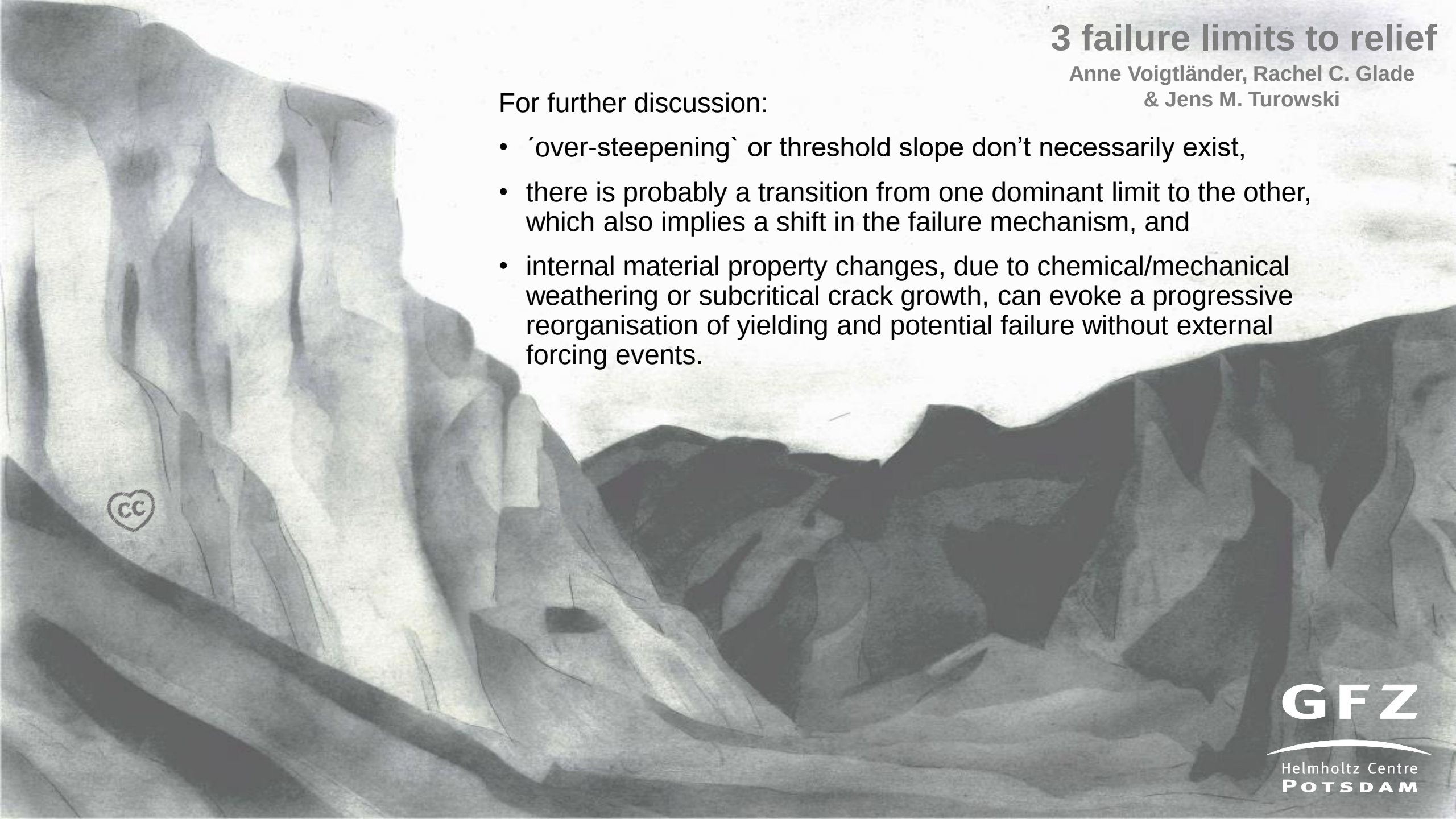

For further discussion:

- ´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.

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