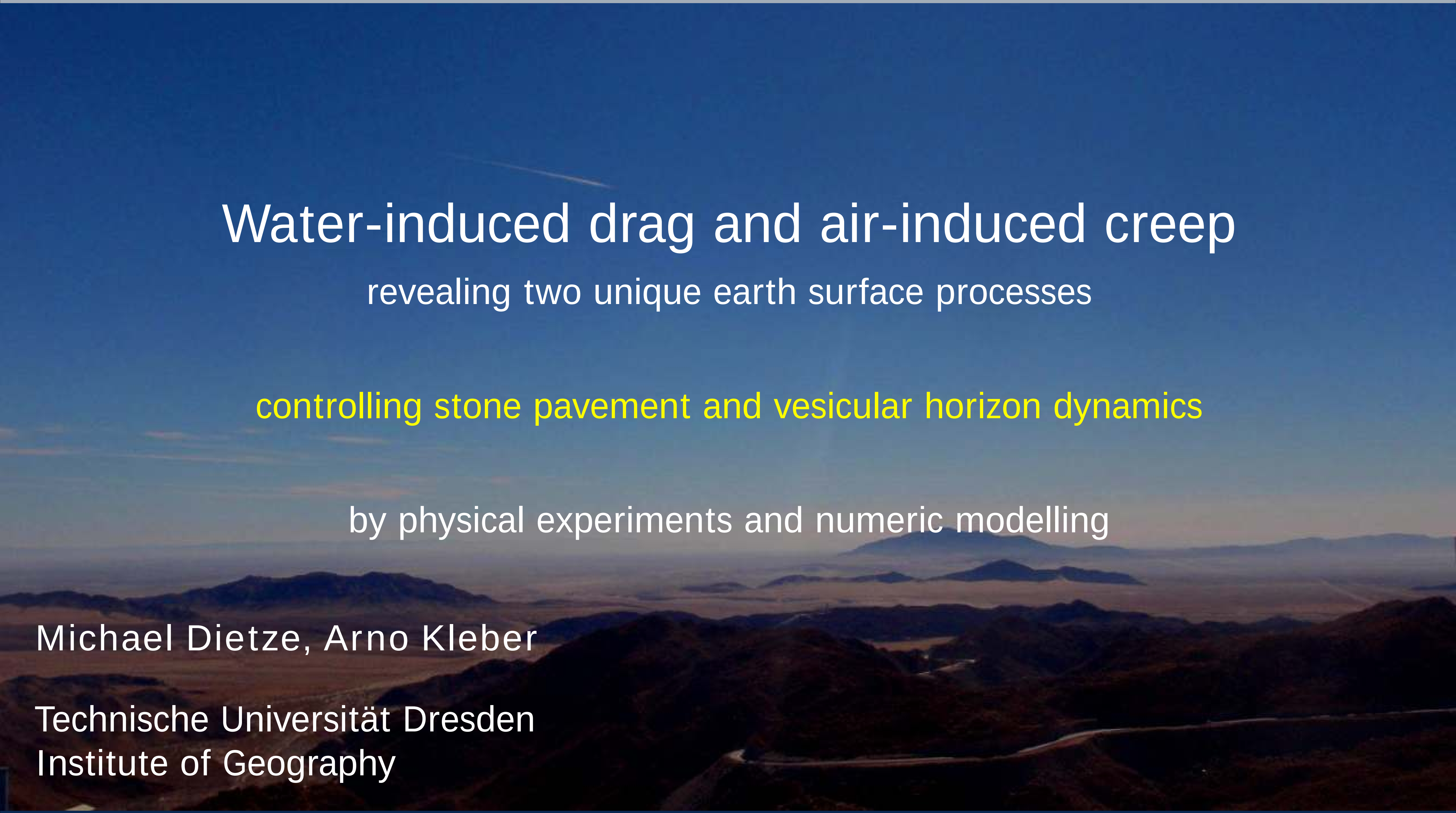
Water-induced drag and air-induced creep

revealing two unique earth surface processes

by physical experiments and numeric modelling

Michael Dietze, Arno Kleber

Technische Universität Dresden
Institute of Geography



Water-induced drag and air-induced creep

revealing two unique earth surface processes

controlling stone pavement and vesicular horizon dynamics

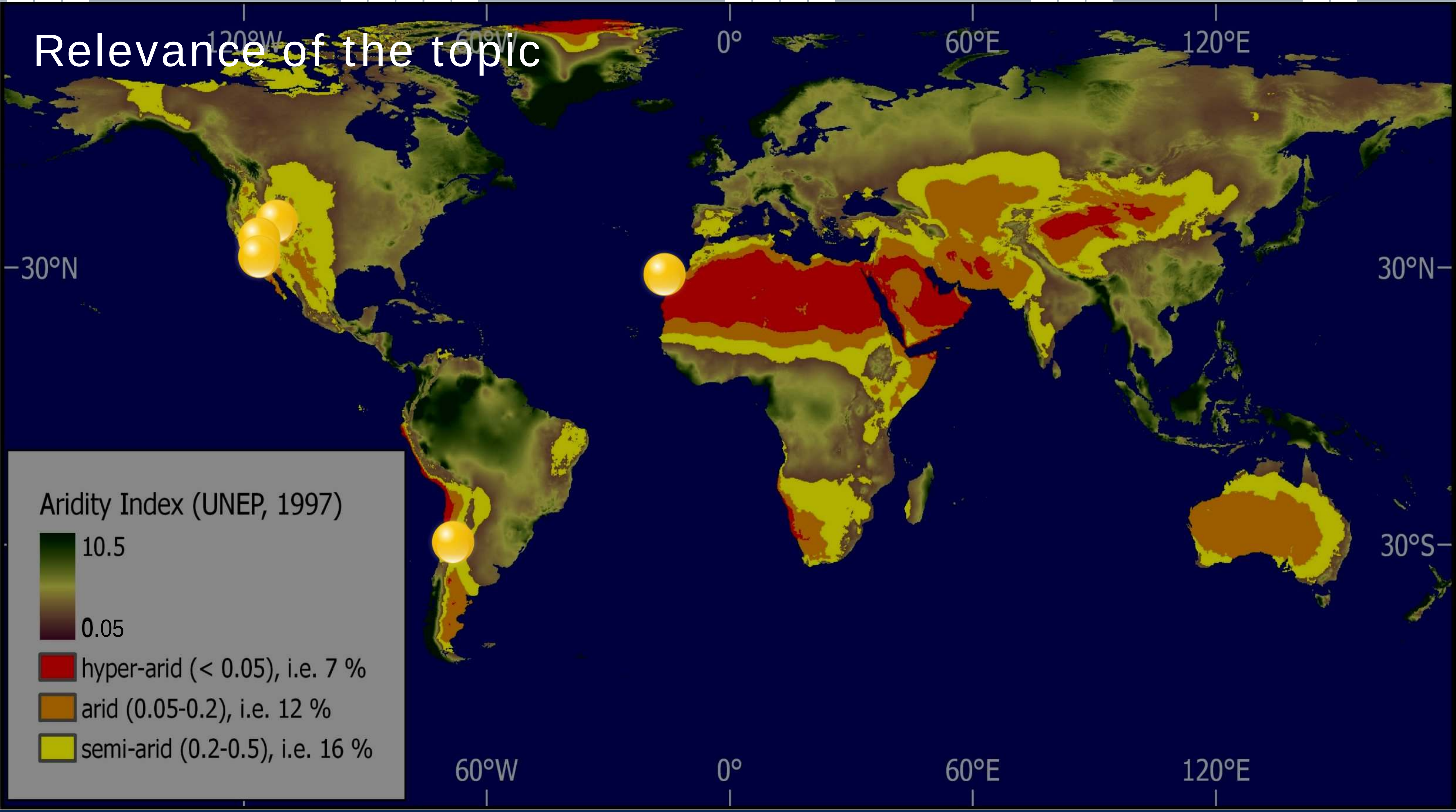
by physical experiments and numeric modelling

Michael Dietze, Arno Kleber

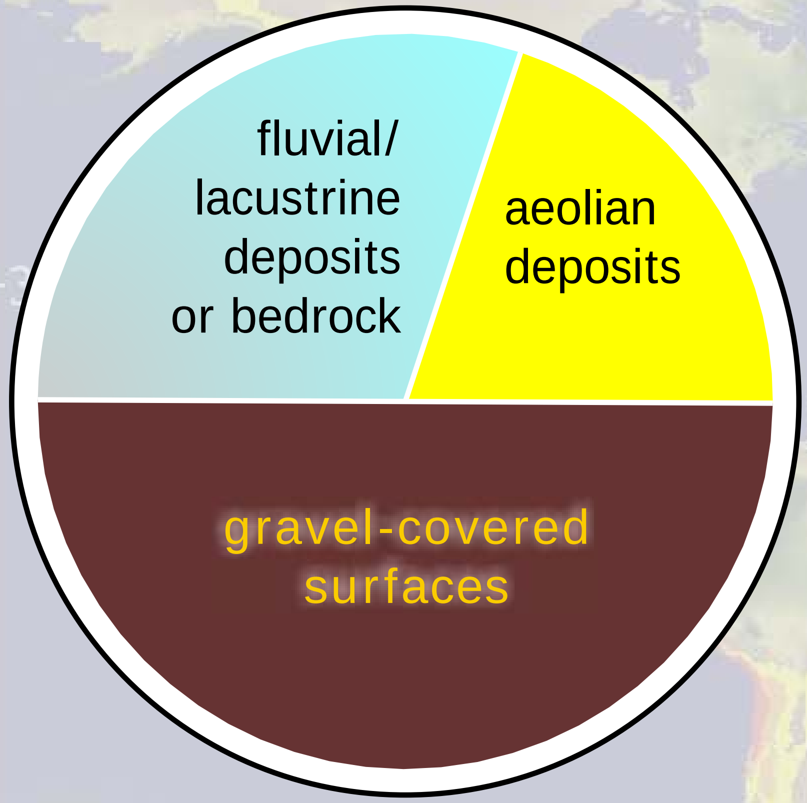
Technische Universität Dresden
Institute of Geography

Stone pavement and vesicular horizon

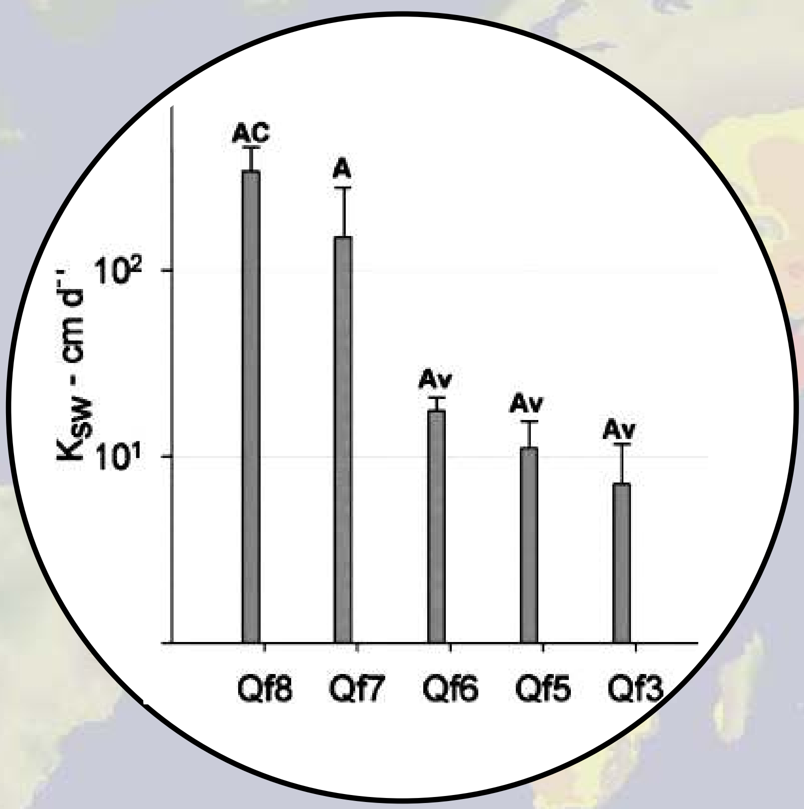
Relevance of the topic



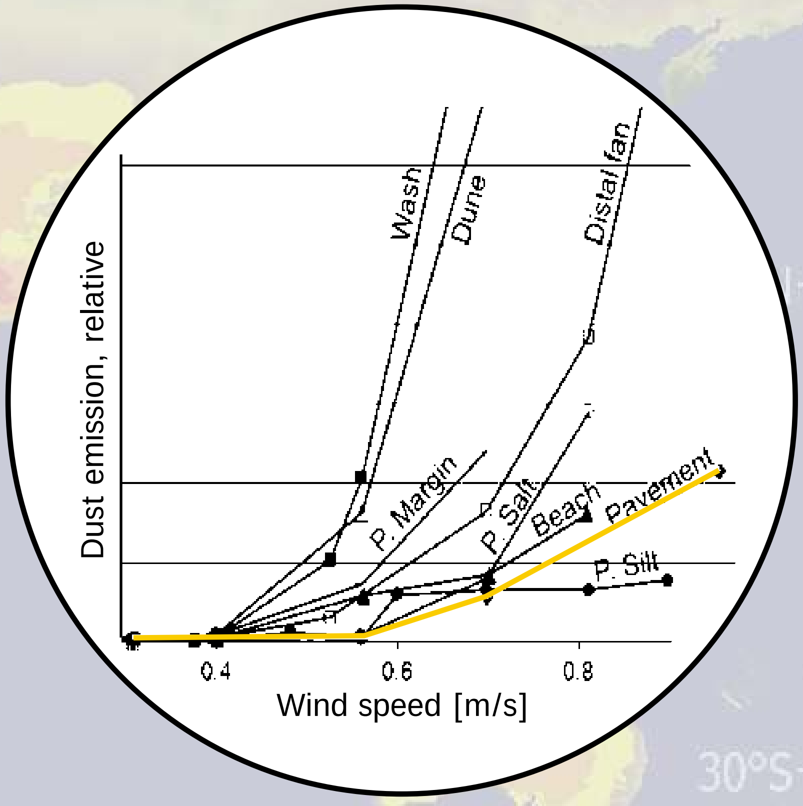
Relevance of the topic



Walker (1986)



Young et al. (2004)



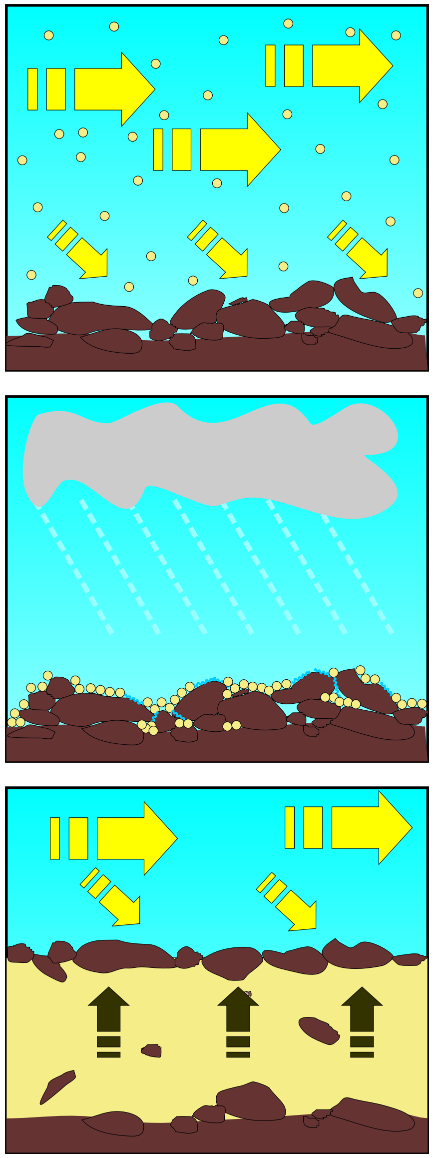
Sweeney et al. (2011)

great spatial extent

infiltration/ surface runoff

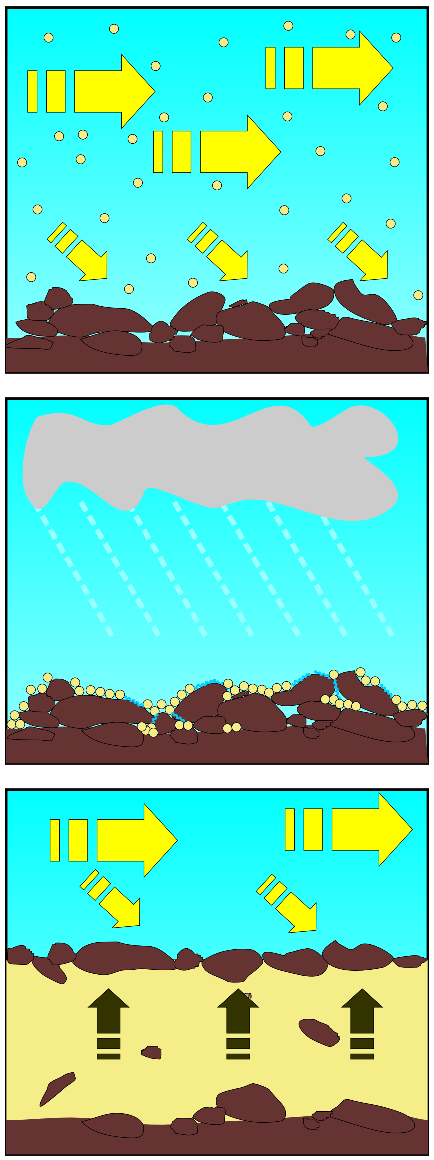
dust emission

The accretionary evolution model

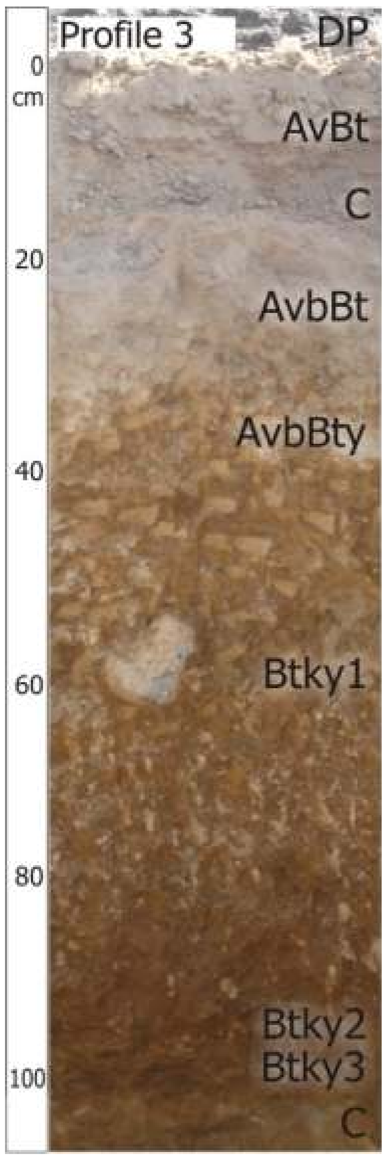


McFadden et al. (1986)

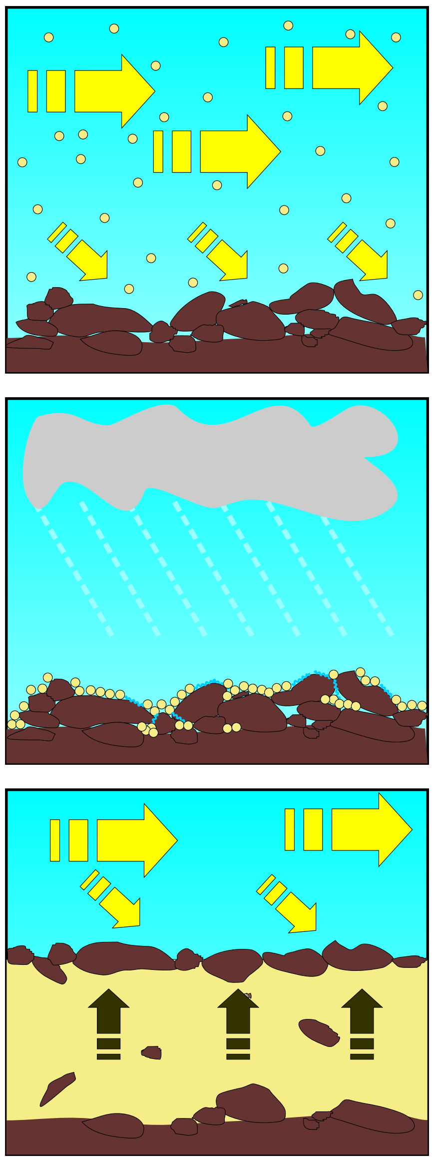
The accretionary evolution model



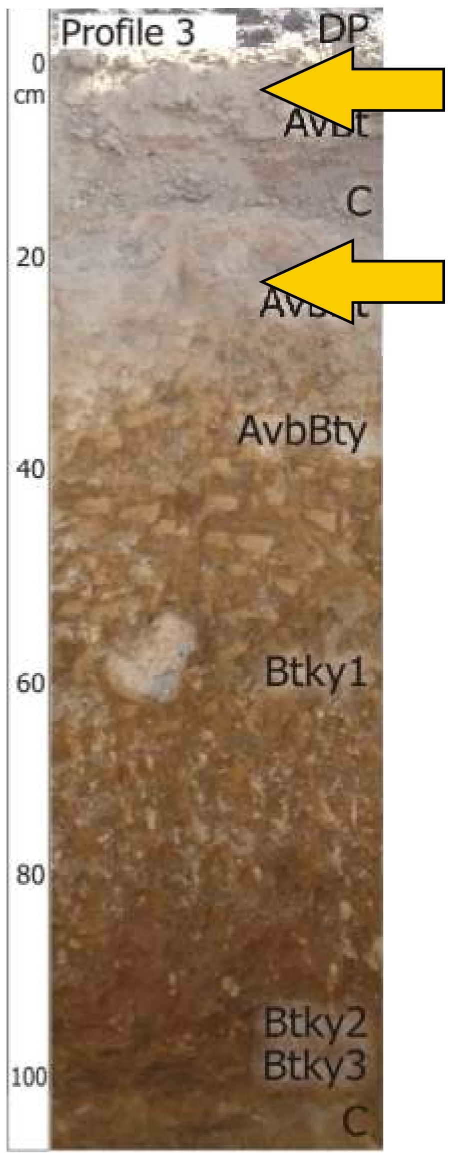
McFadden et al. (1986)



The accretionary evolution model

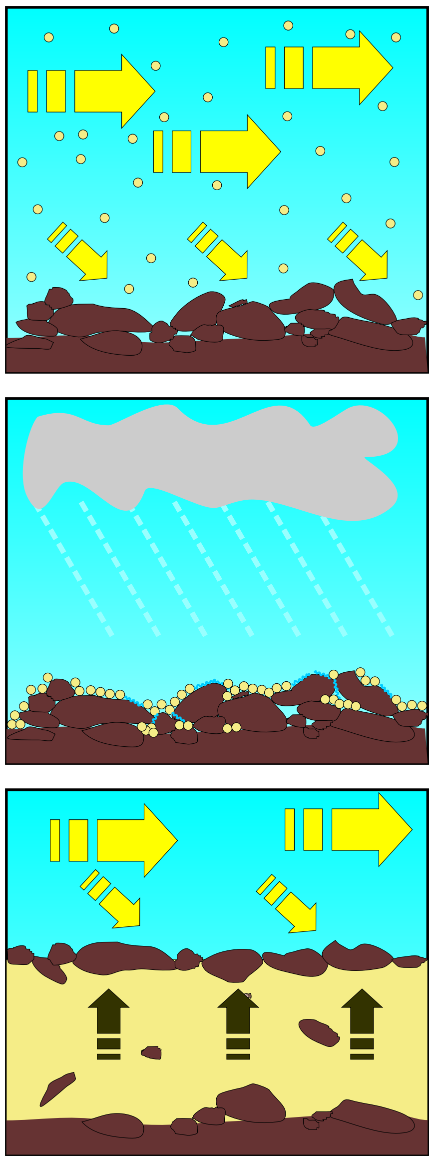


McFadden et al. (1986)

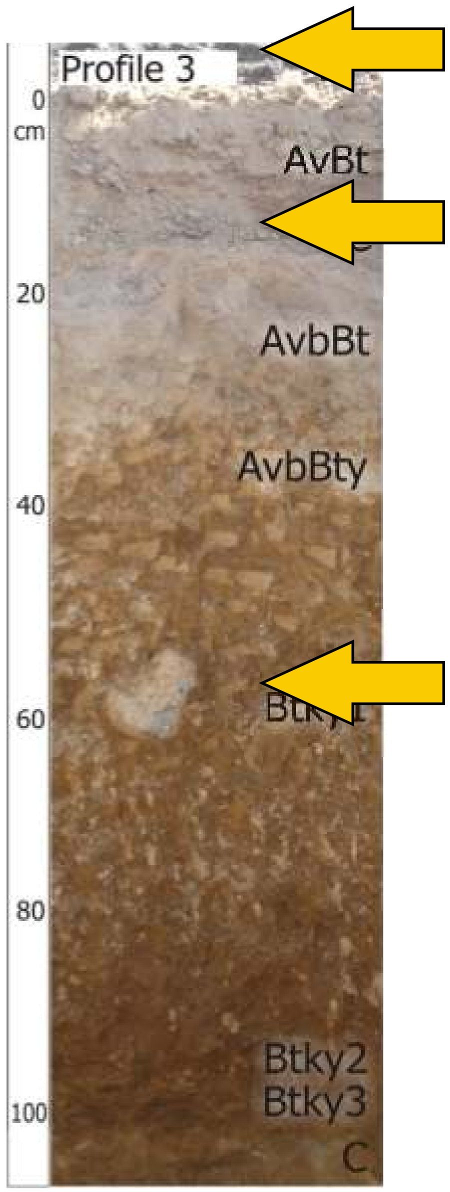


Modern and buried vesicular horizons

The accretionary evolution model

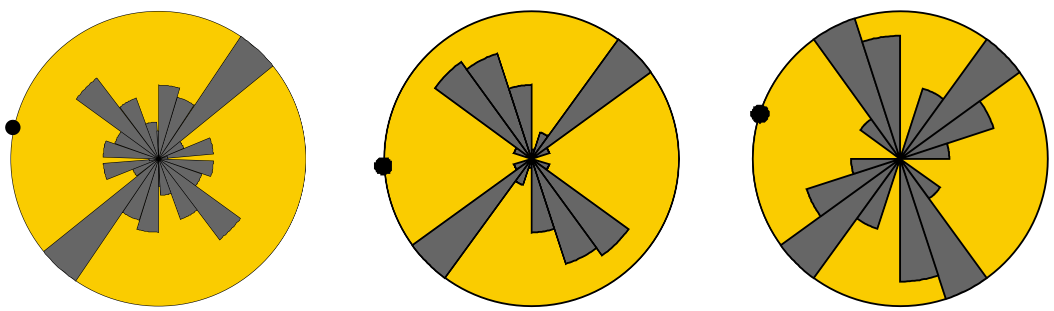


McFadden et al. (1986)



Modern and buried vesicular horizons

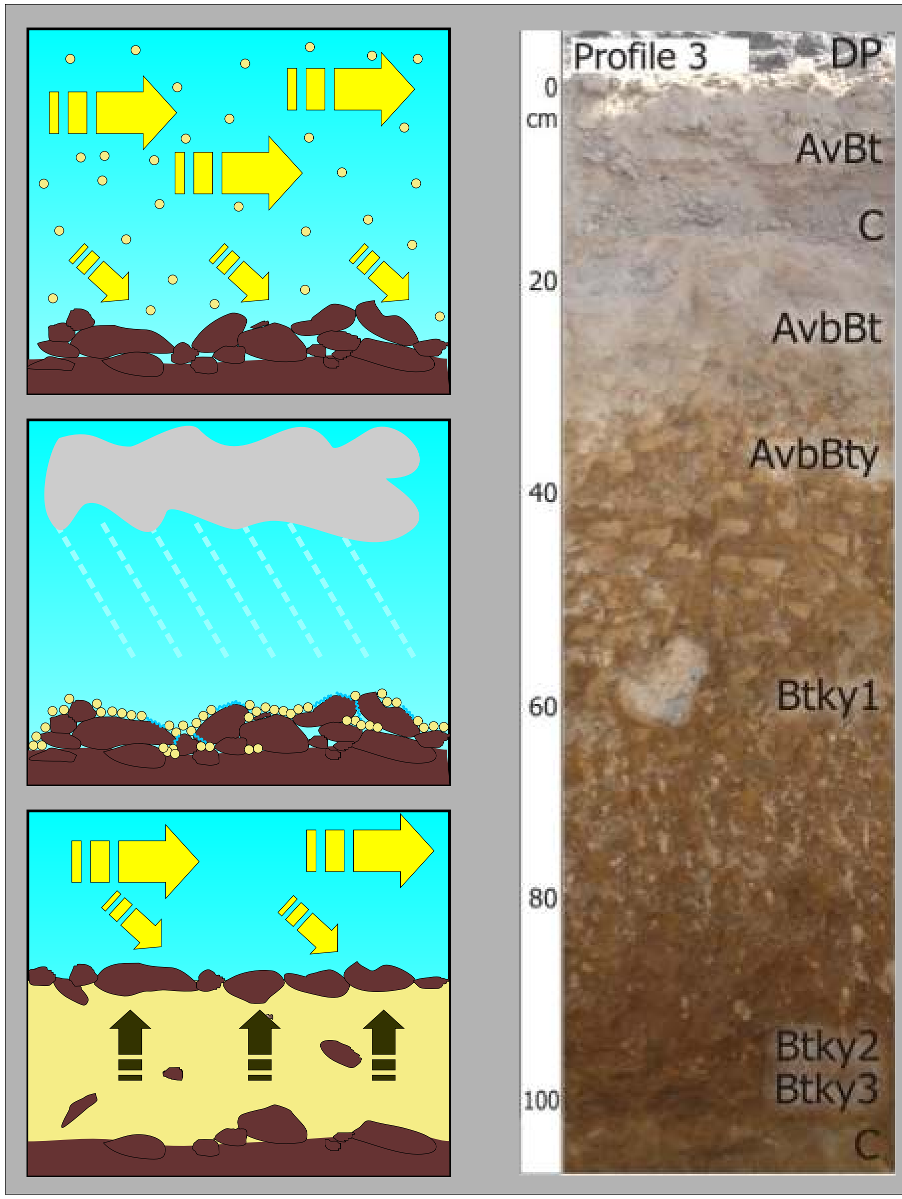
Modern and buried stone pavements



$\phi = 40 \pm 14\ °$

with preferred clast orientation patterns

The accretionary evolution model - challenges and goals



Explanation for burial and reformation

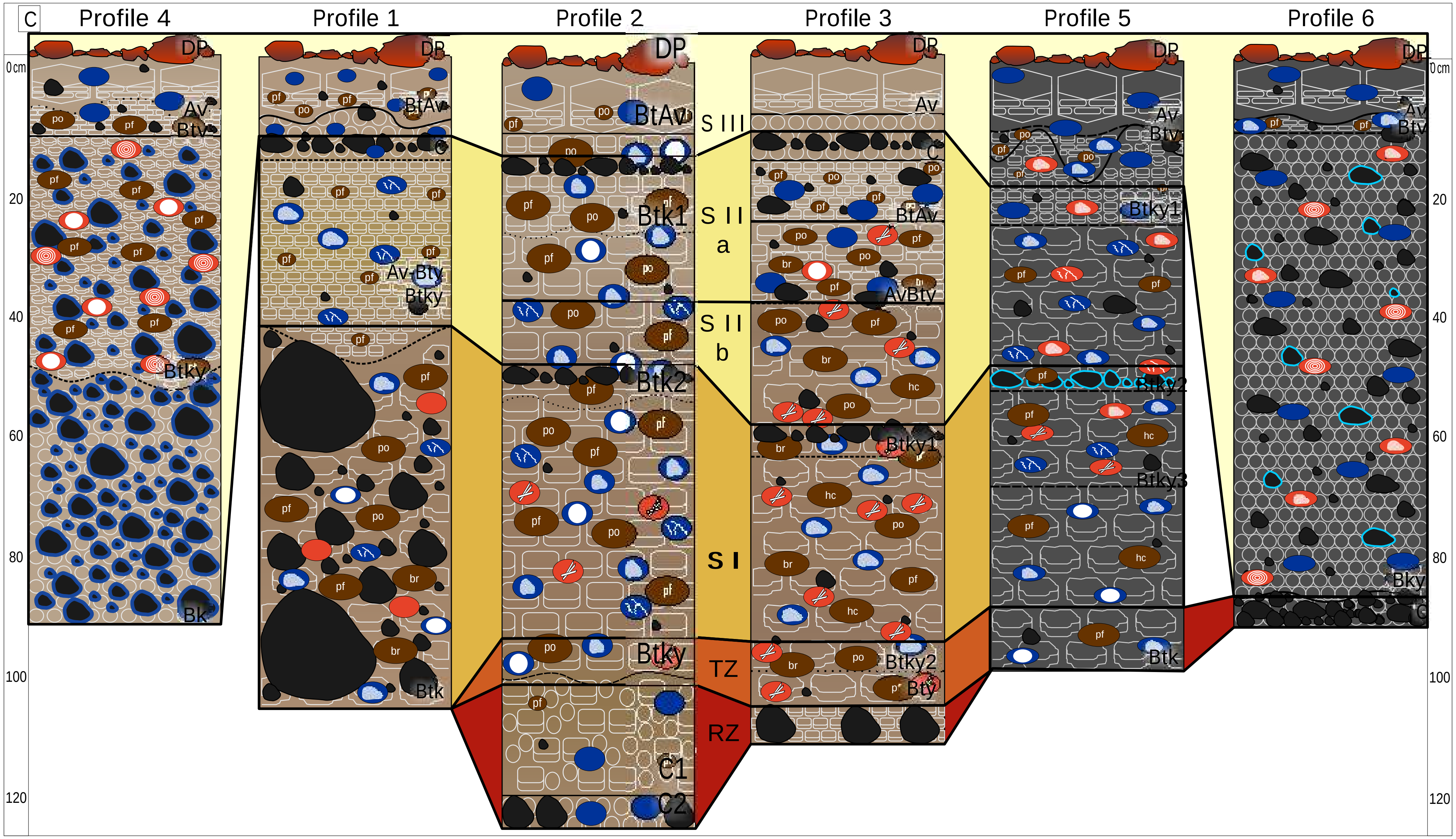
Explanation for orientation pattern formation

Modern and buried vesicular horizons

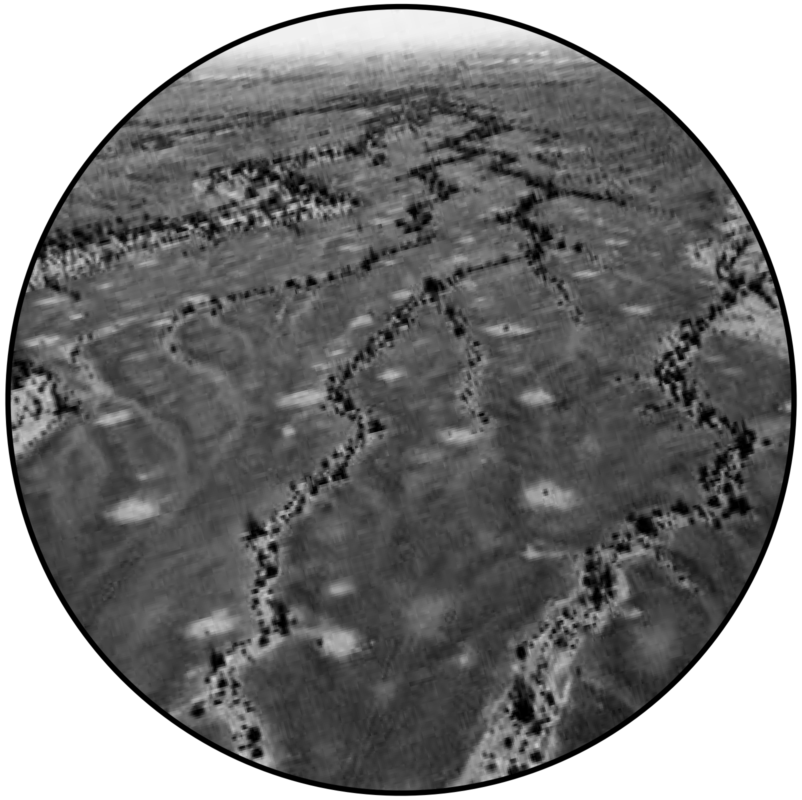
Modern and buried stone pavements

with preferred clast orientation patterns

Nota bene - systematic properties



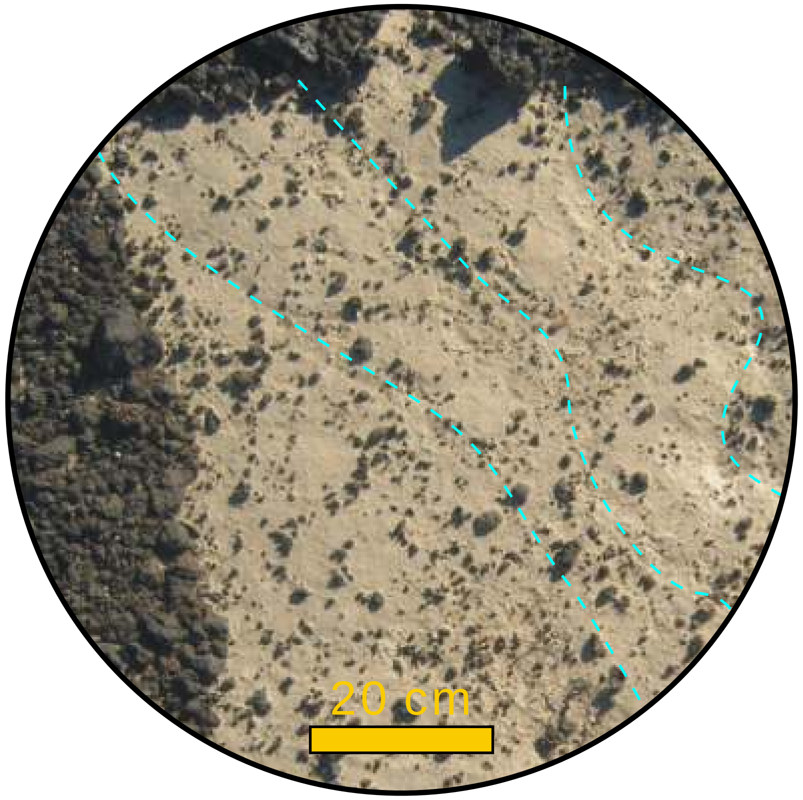
Surface activity - disturbance and triggered processes



McAuliffe & McDonald (2006)

Pavement scars from perennial plants

Pavement scar with fresh deposits

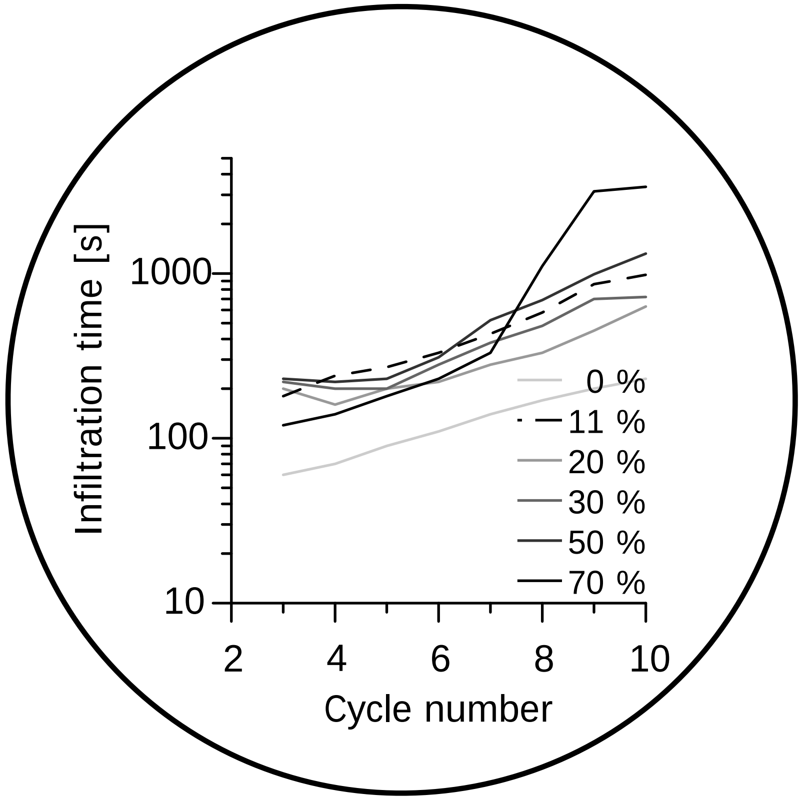


Fresh clasts and drainage lines

The key feature: the vesicular horizon

Dietze & Kleber (2012)

Flat, fine-grained surface



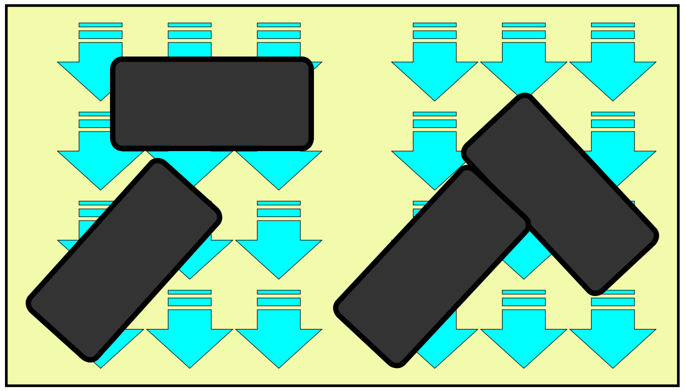
Dietze et al. (2012)

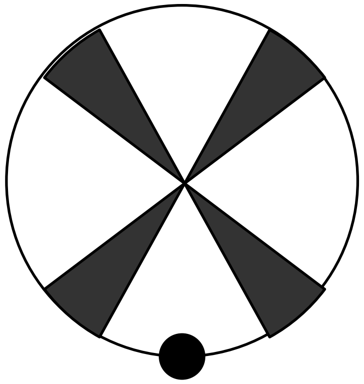
Limited infiltration

Dietze et al. (2013)

Resistive to erosion

Model proposition: clast drag by surface runoff

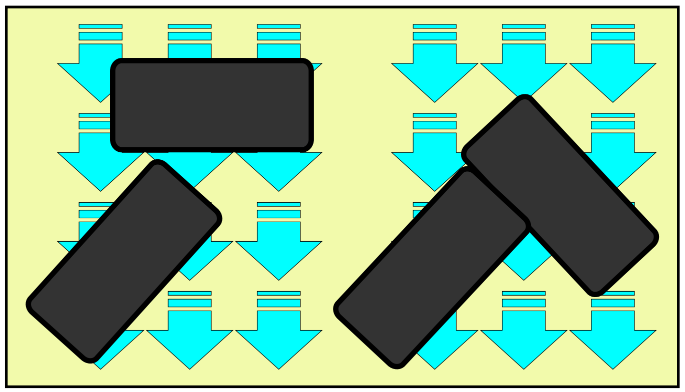


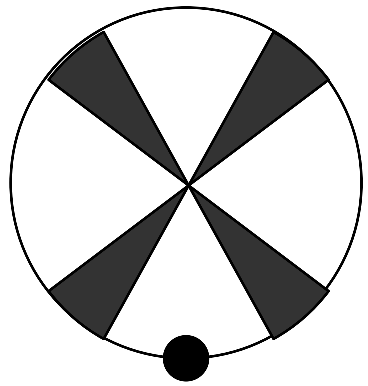


Boundary conditions

- Flat, finegrained, resistive surface
- Transport by drag
- Rotation upon collision

Model proposition: clast drag by surface runoff



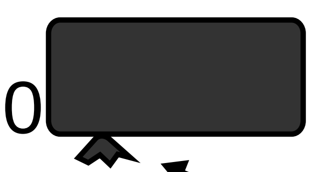


Boundary conditions

- Flat, finegrained, resistive surface
- Transport by drag
- Rotation upon collision

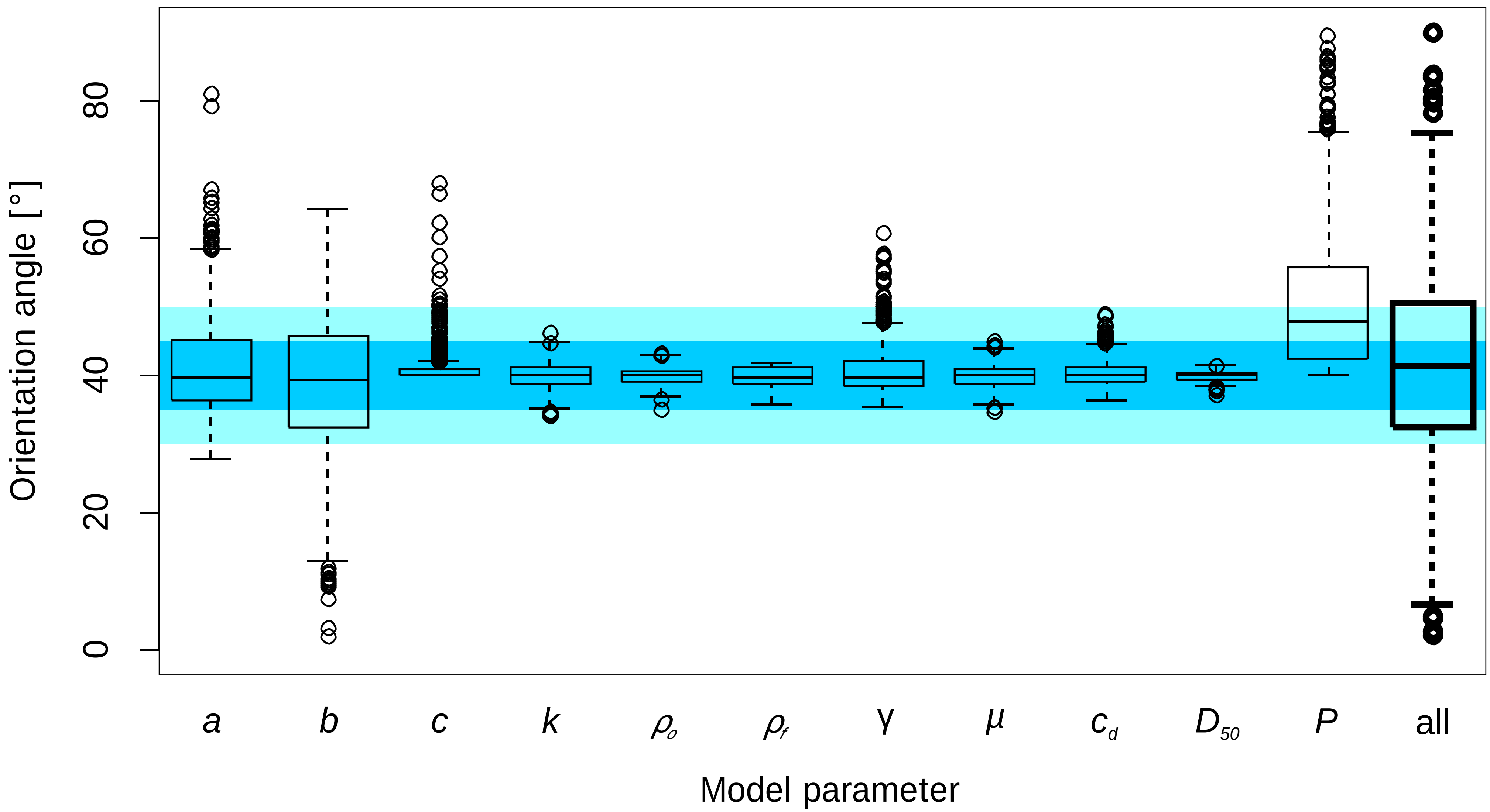
rotation angle • water drag force = friction force clast - underground

$$\phi = \arccos\left(\frac{2\cdot V_o\cdot g\cdot(\rho_o-\rho_w)\cdot\cos(\gamma)\cdot\mu}{\rho_w\cdot\bar{v}^2\cdot C_w\cdot c\cdot\sqrt{a^2+b^2}}\right)-\arctan\left(\frac{b}{a}\right)$$

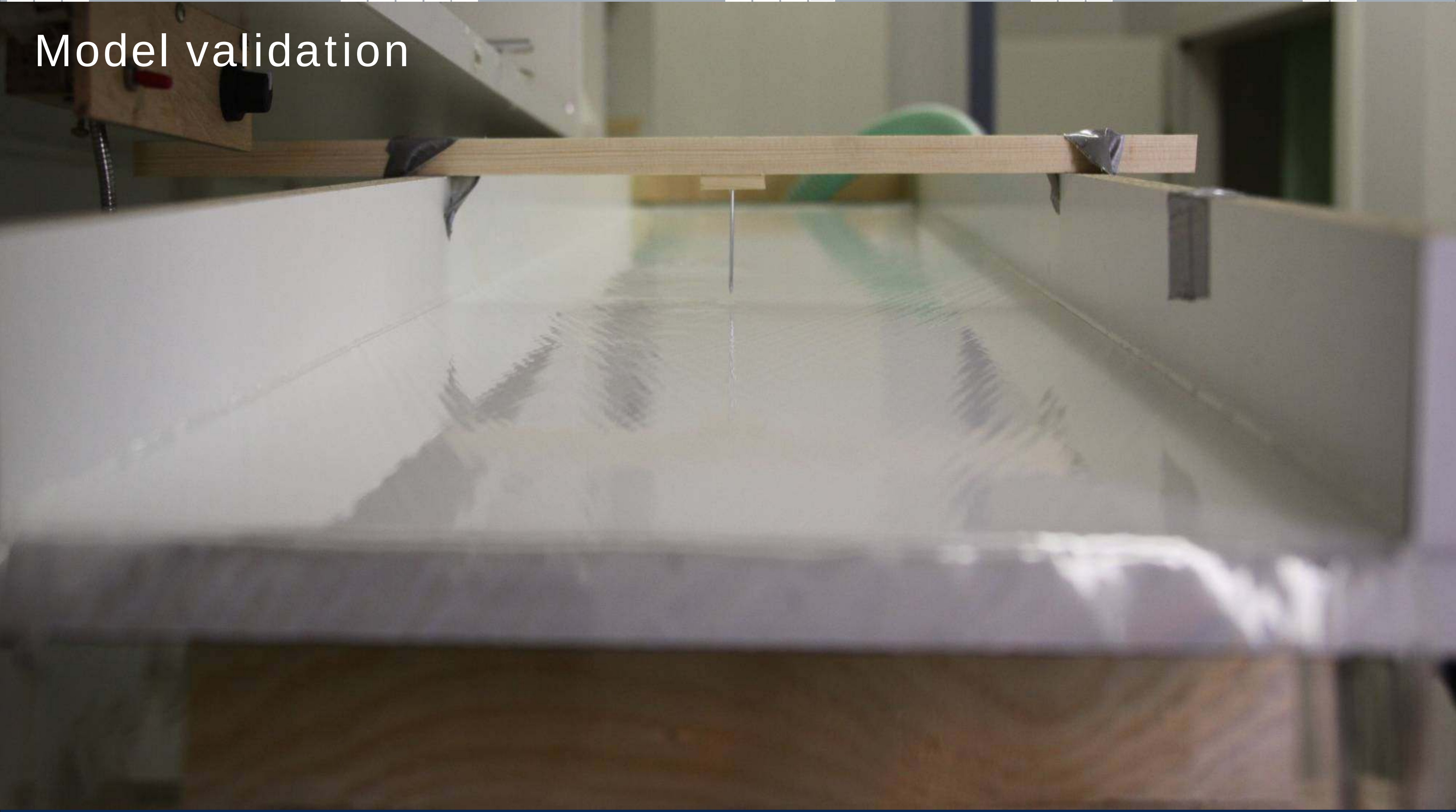


ϕ = **40 ± 14 °**

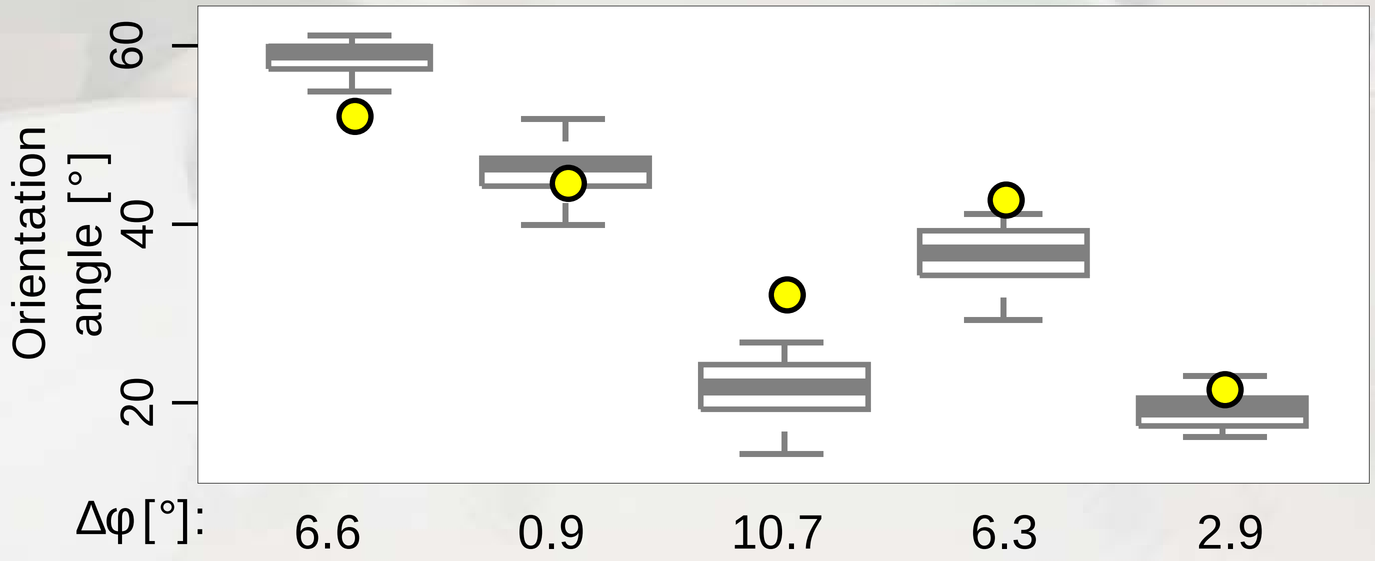
Model parameter sensitivity

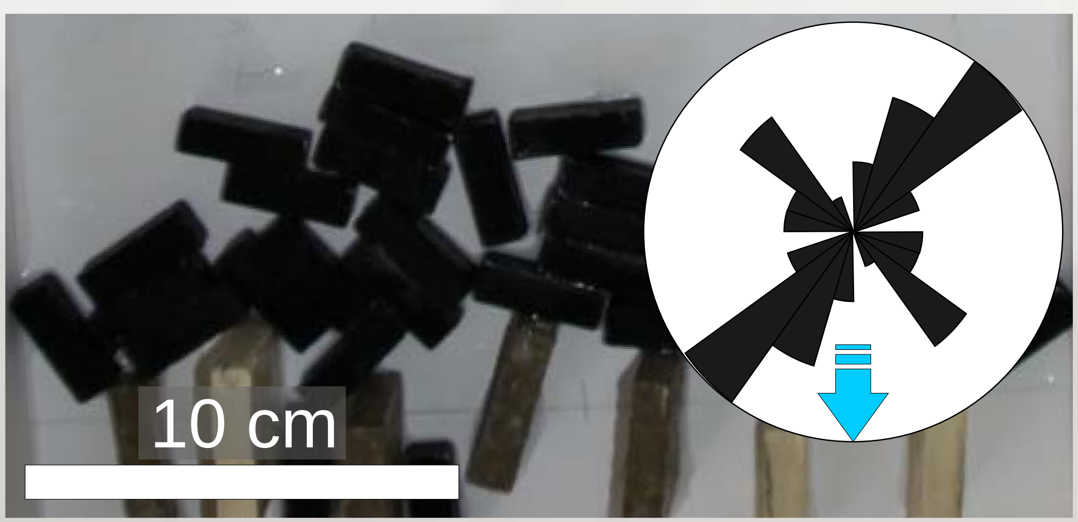


Model validation

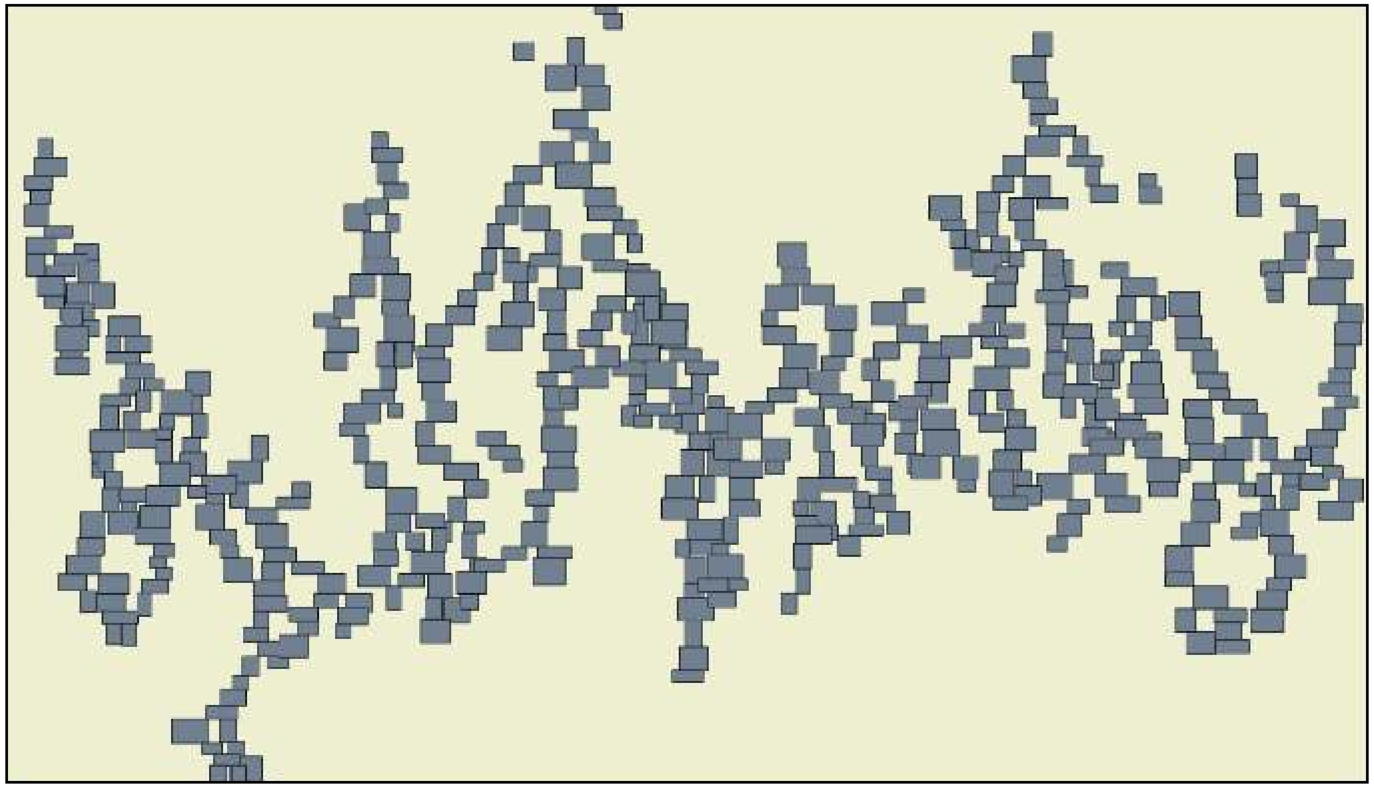


Model validation





Towards multi-object modelling



Boundary conditions

Flat, finegrained, resistive surface

Transport by drag

Rotation upon collision

$n_{clasts} = 10^2 - 10^5$

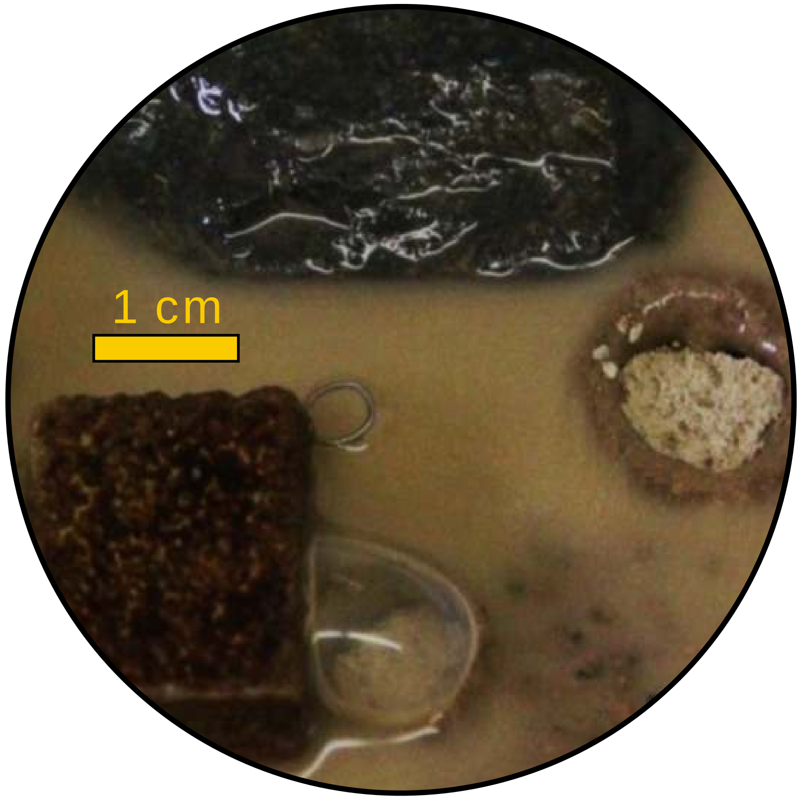
superimposed generators

kinetics not implemented

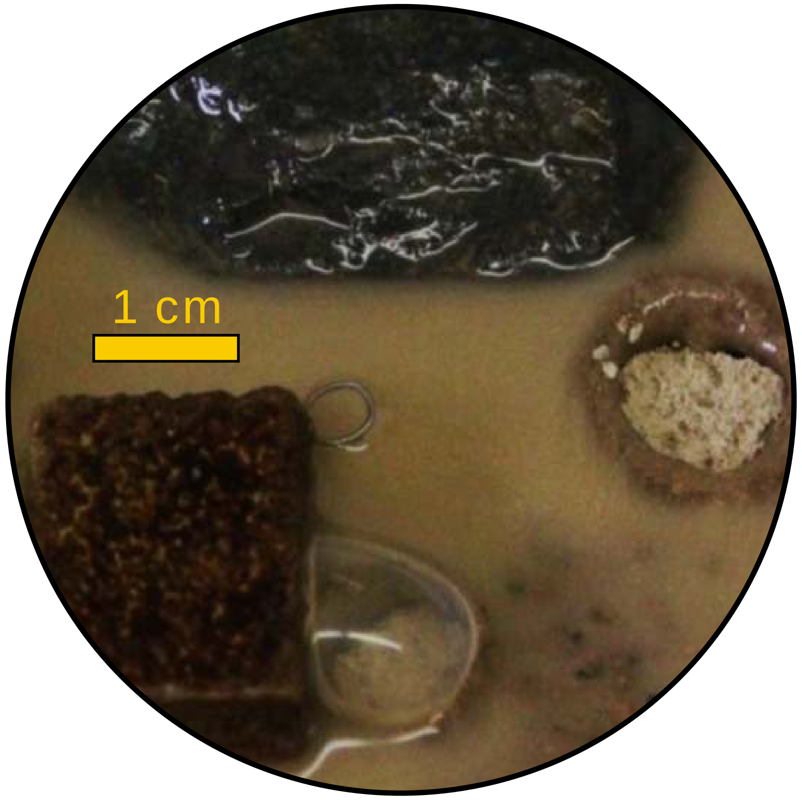
Limits from the model-perspective

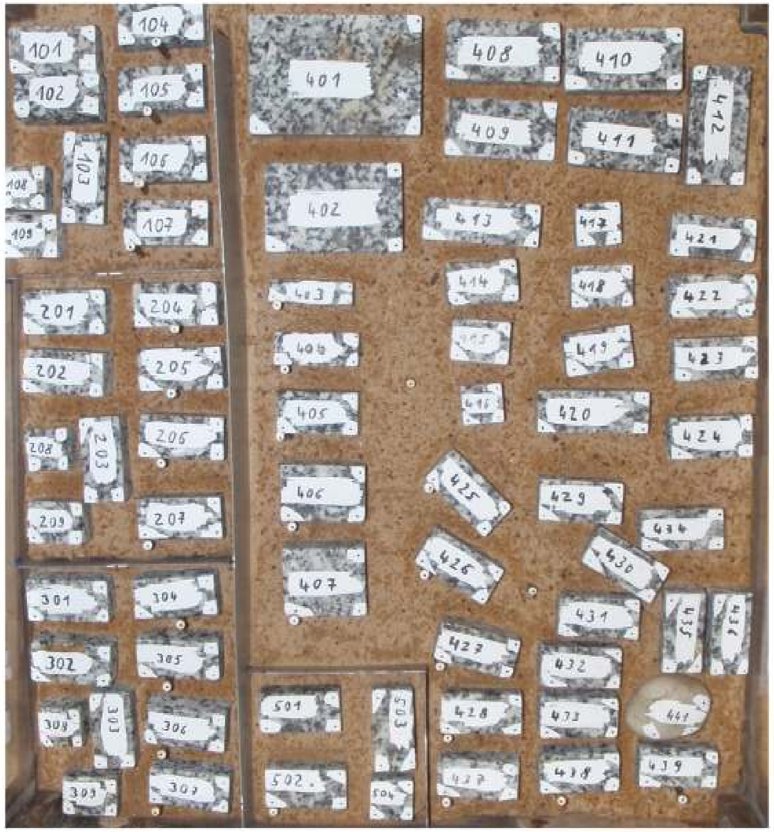
1. No further coverage with increasing clast cover
2. Clast transport only for sufficiently large drainage areas

The key feature: the vesicular horizon



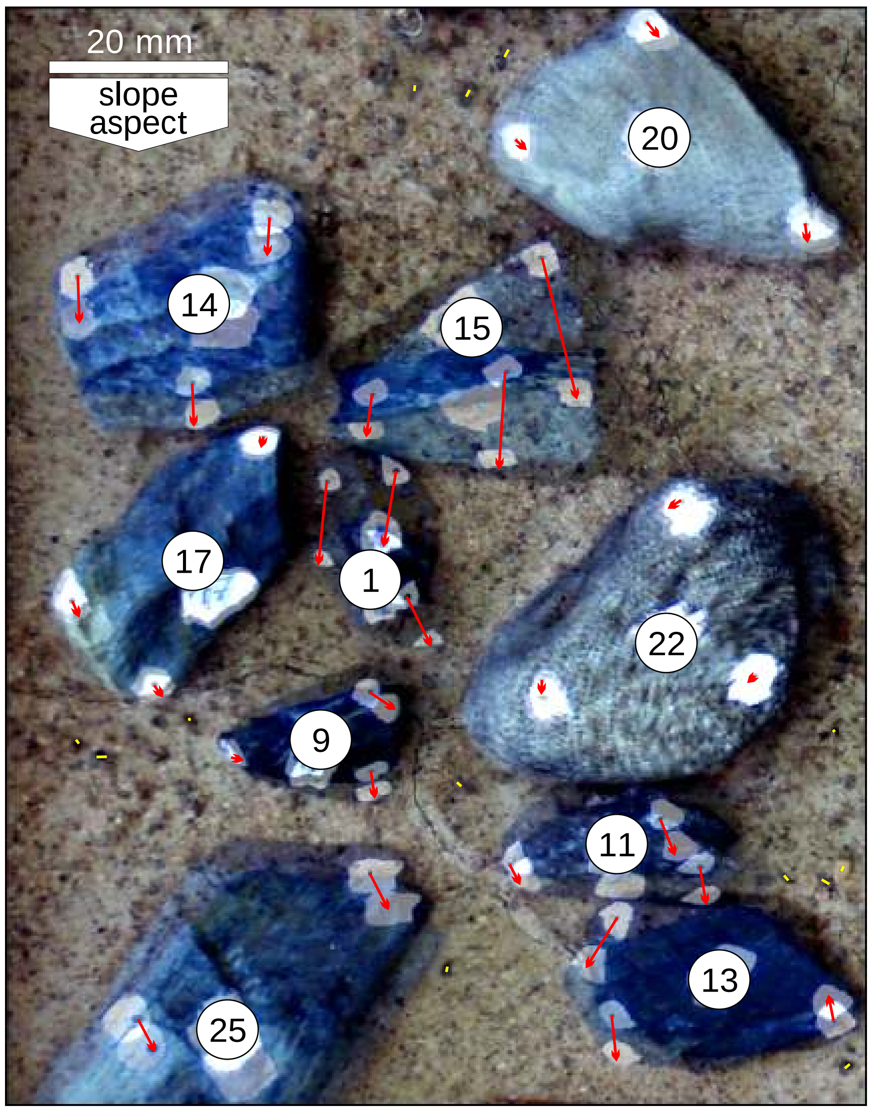
The key feature: the vesicular horizon



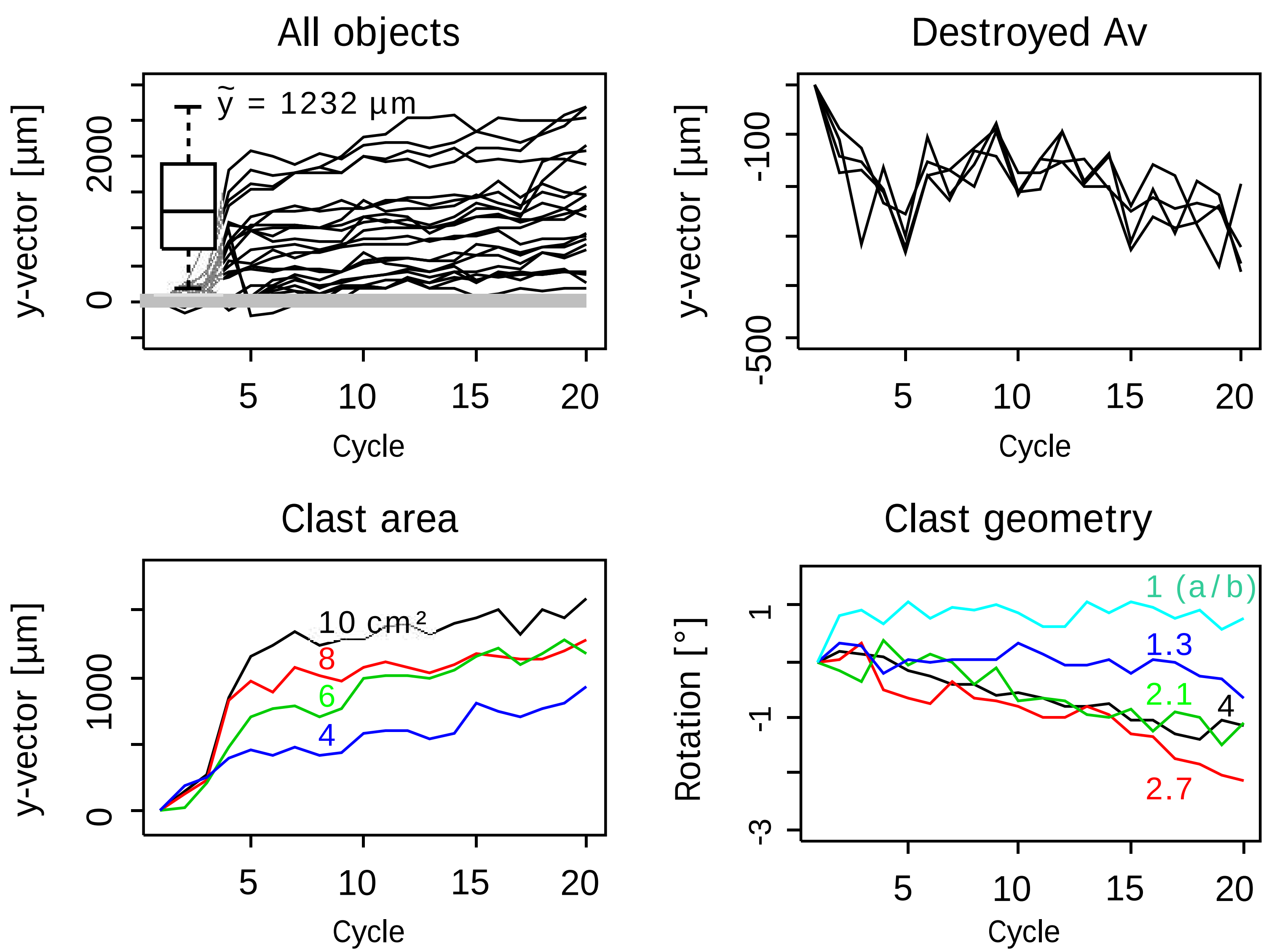


Clast creep by escaping air - experiment results

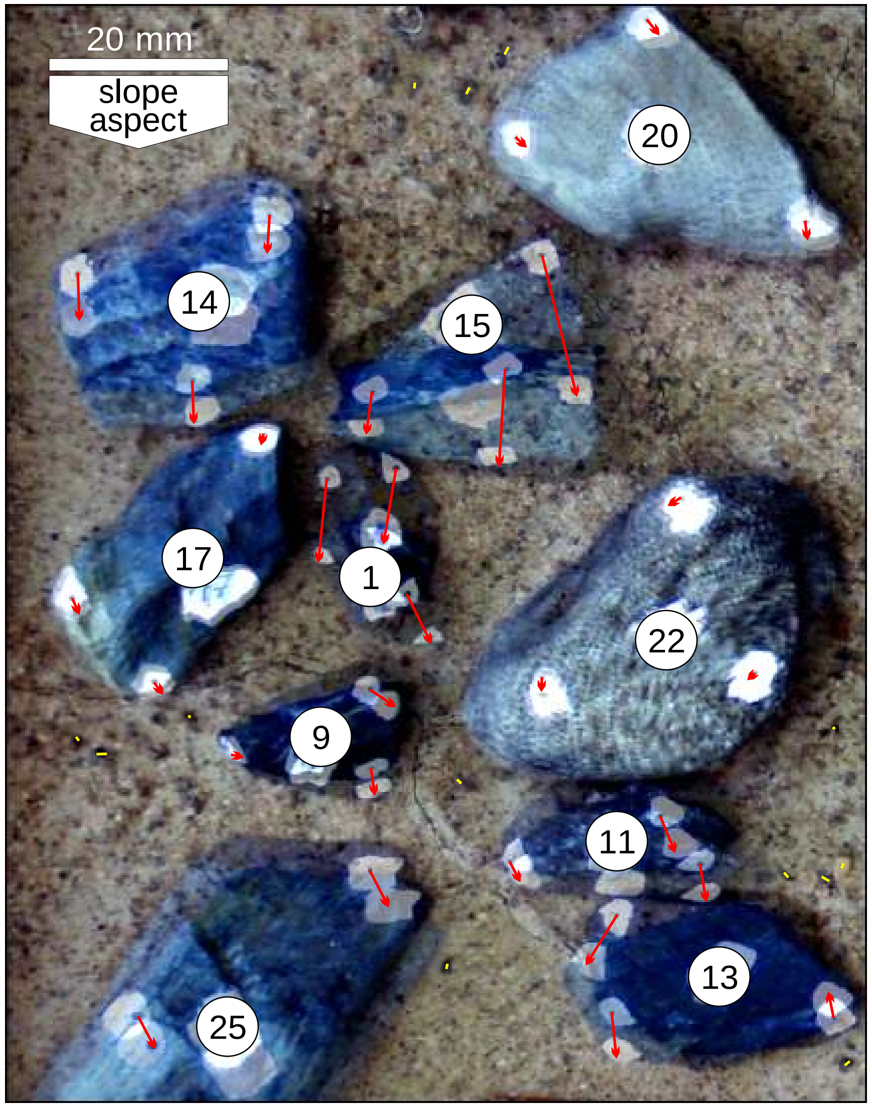
Natural clasts

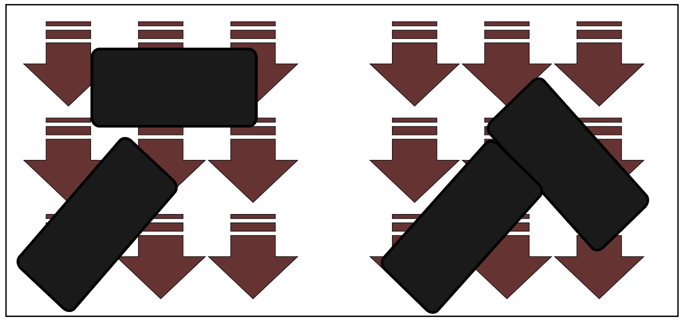


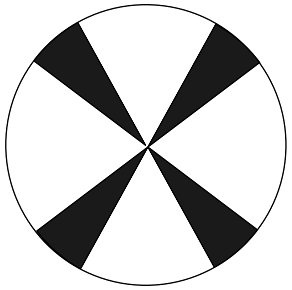
Artificial cuboids



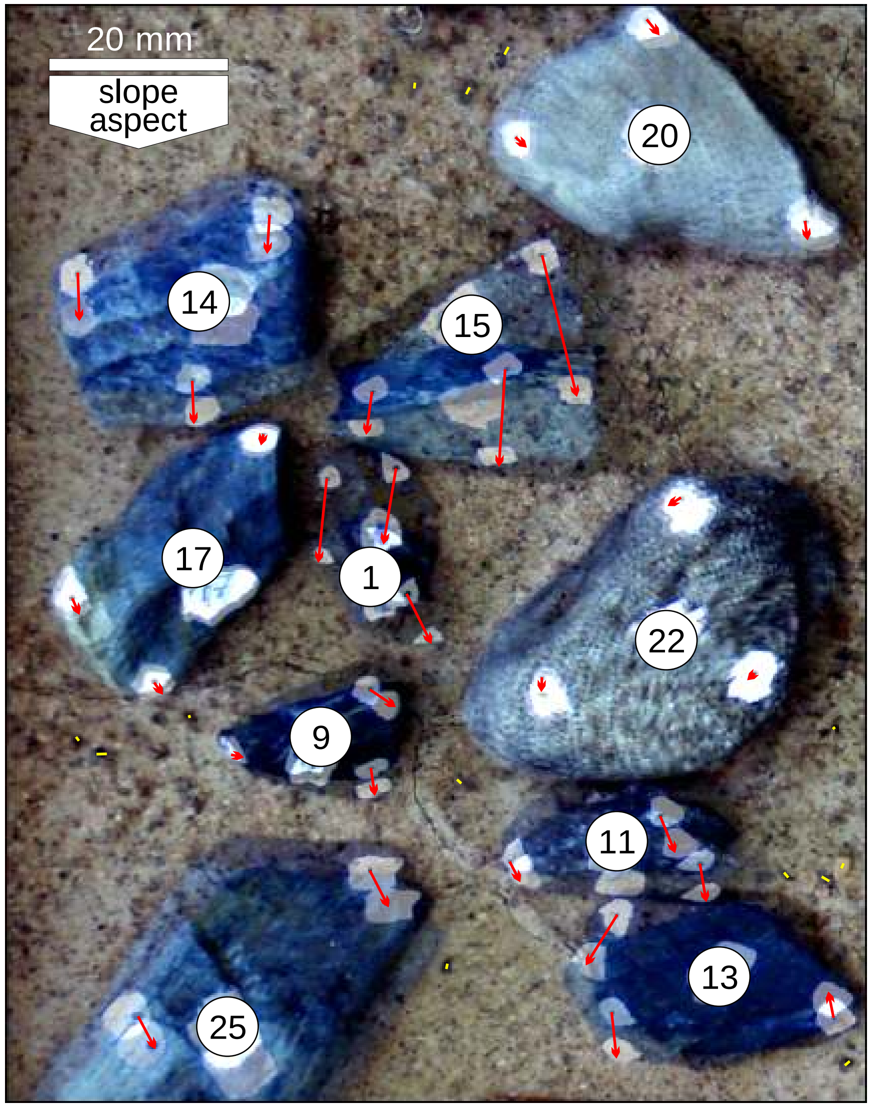
Clast creep by escaping air - model proposition

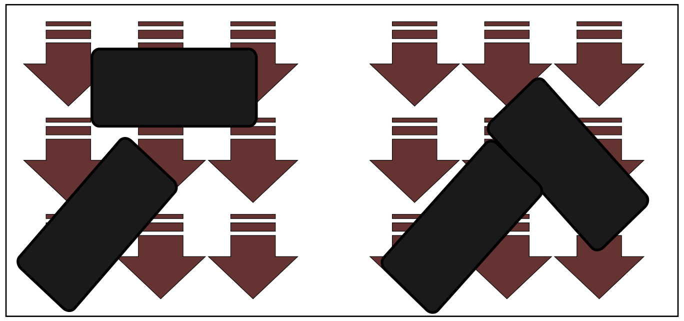


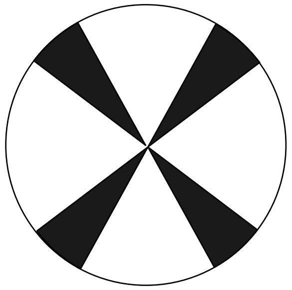




Clast creep by escaping air - model proposition



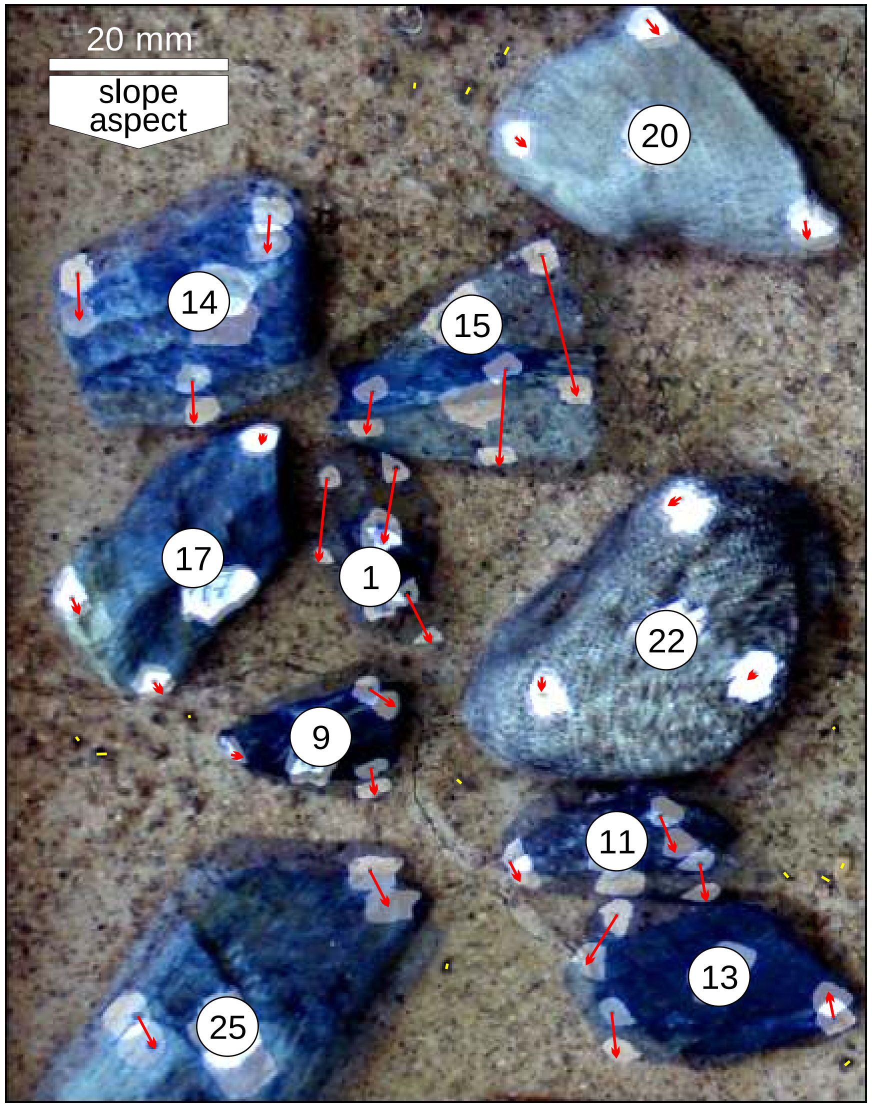


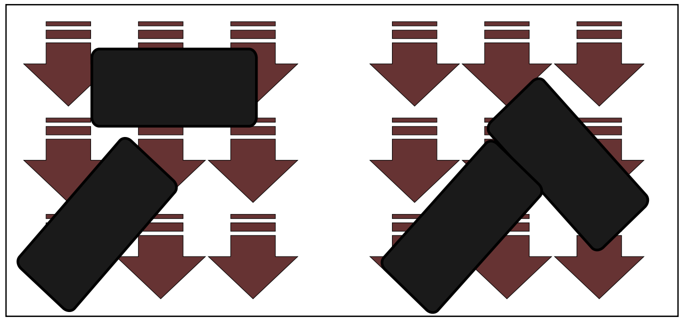


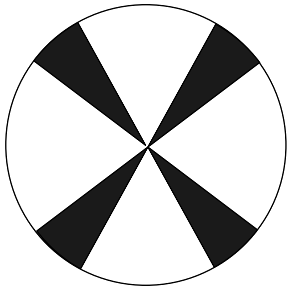
$$\phi = arctan\left(\frac{b}{a}\right)$$

Allen (1982)

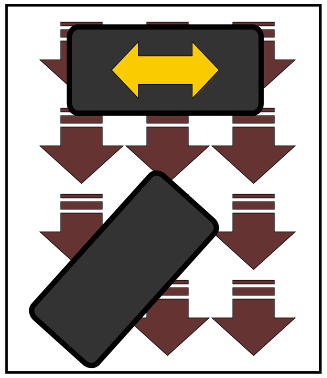
Clast creep by escaping air - model proposition

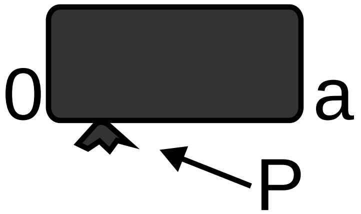






$$\phi = arctan\left(\frac{b}{a}\right)\left(\frac{\frac{a}{2} - P}{\frac{a}{2}}\right)$$





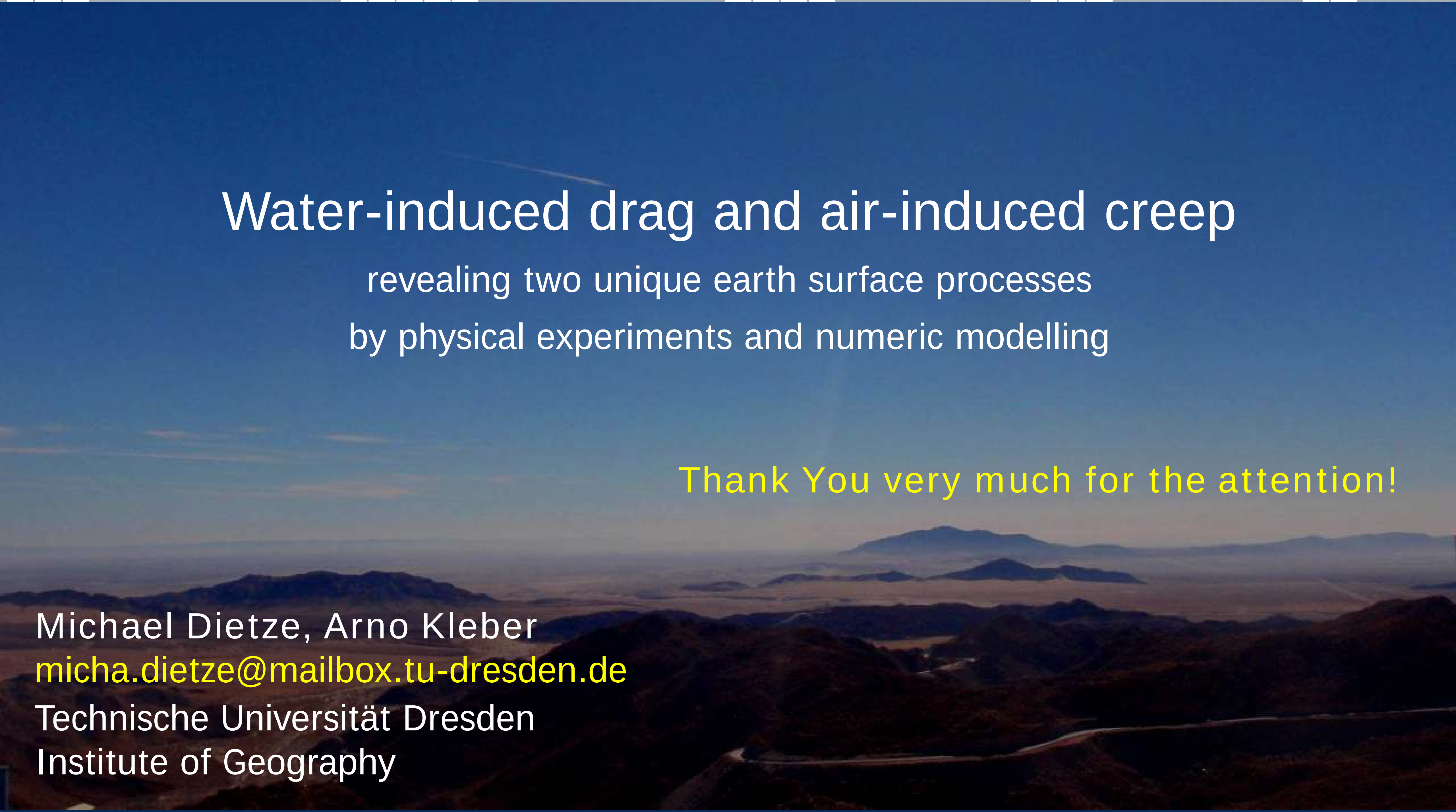
$\phi = 32 \pm 14\ °$

Clasts in motion - a synthesis

Stone pavements are no hallmarks of stability. They can become buried and are able to reform by at least two (new) processes: water-induced drag and air-induced creep; each acting at different spatial and temporal scales.

Accepting lateral processes allows to fully explain accretionary sediment profiles with buried vesicular horizons and stone pavements, generally exhibiting preferred clast orientation patterns.

Vesicular horizons are the actual controlling agents for stone pavement formation, maintenance and recovery.



Water-induced drag and air-induced creep

revealing two unique earth surface processes

by physical experiments and numeric modelling

Thank You very much for the attention!

Michael Dietze, Arno Kleber
micha.dietze@mailbox.tu-dresden.de
Technische Universität Dresden
Institute of Geography