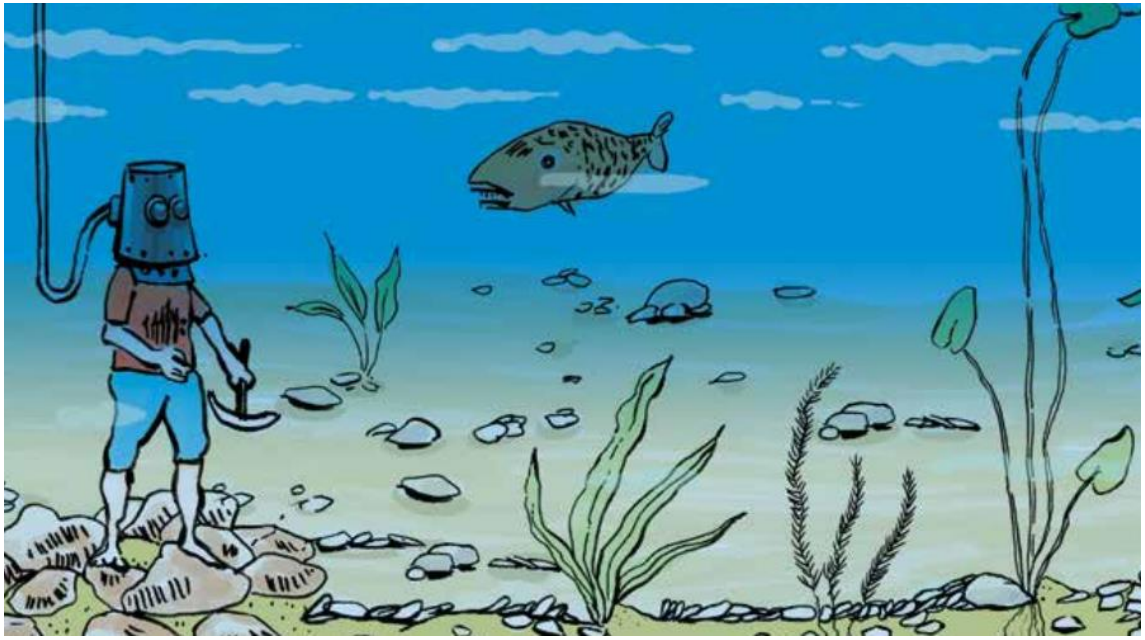
Grundlagen zur Gewässermorphologie

The World of River Morphology



Dr. Roy Frings

Rijkswaterstaat
Ministry of Infrastructure and Water Management
The Netherlands

RWTH Aachen University
Germany

Objective

To explain the basics of the field of river morphology, providing a basis for the upcoming presentations

Outline

1. Introduction
2. Geology
3. Sediment transport
4. Bed level change
5. Human impact
6. Relevance
7. Conclusions

Definition

River morphology is the science that studies the shaping of the Earth's surface by running water

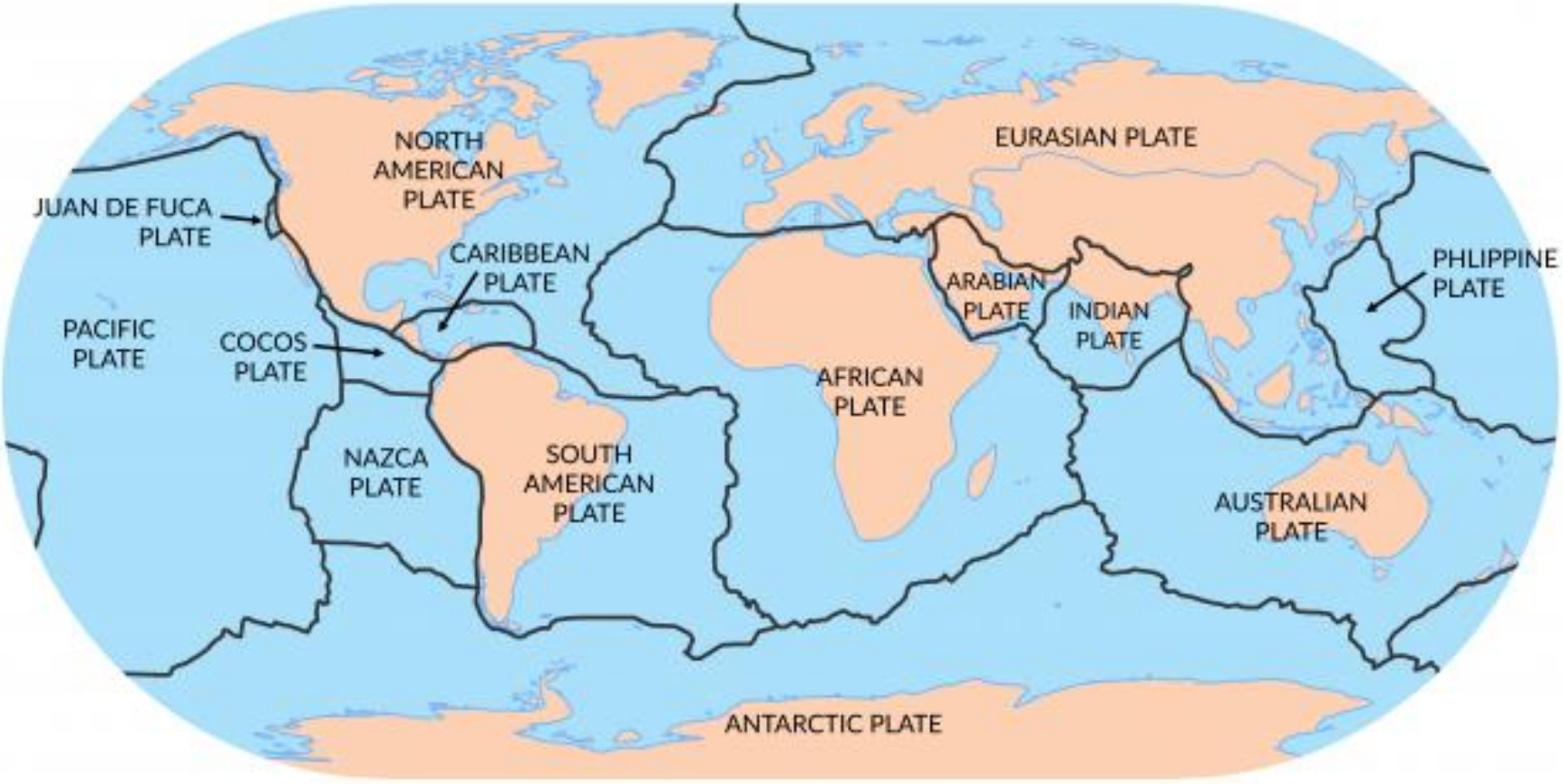
Importance

- Societal
- Ecological

Aims

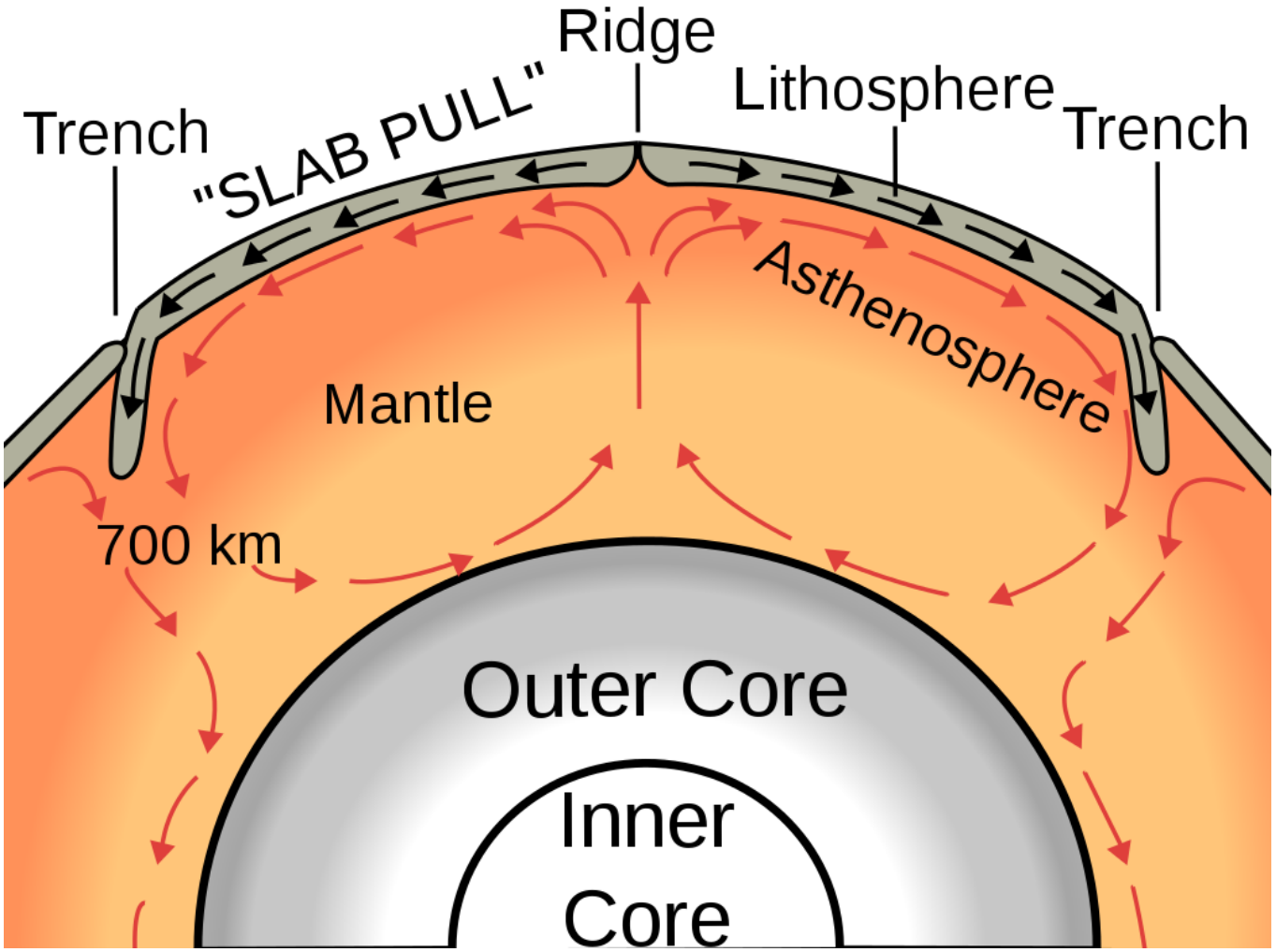
1. To describe
2. To reconstruct
3. To explain
4. To prognosticate

The Earth's tectonic plates



Earth How

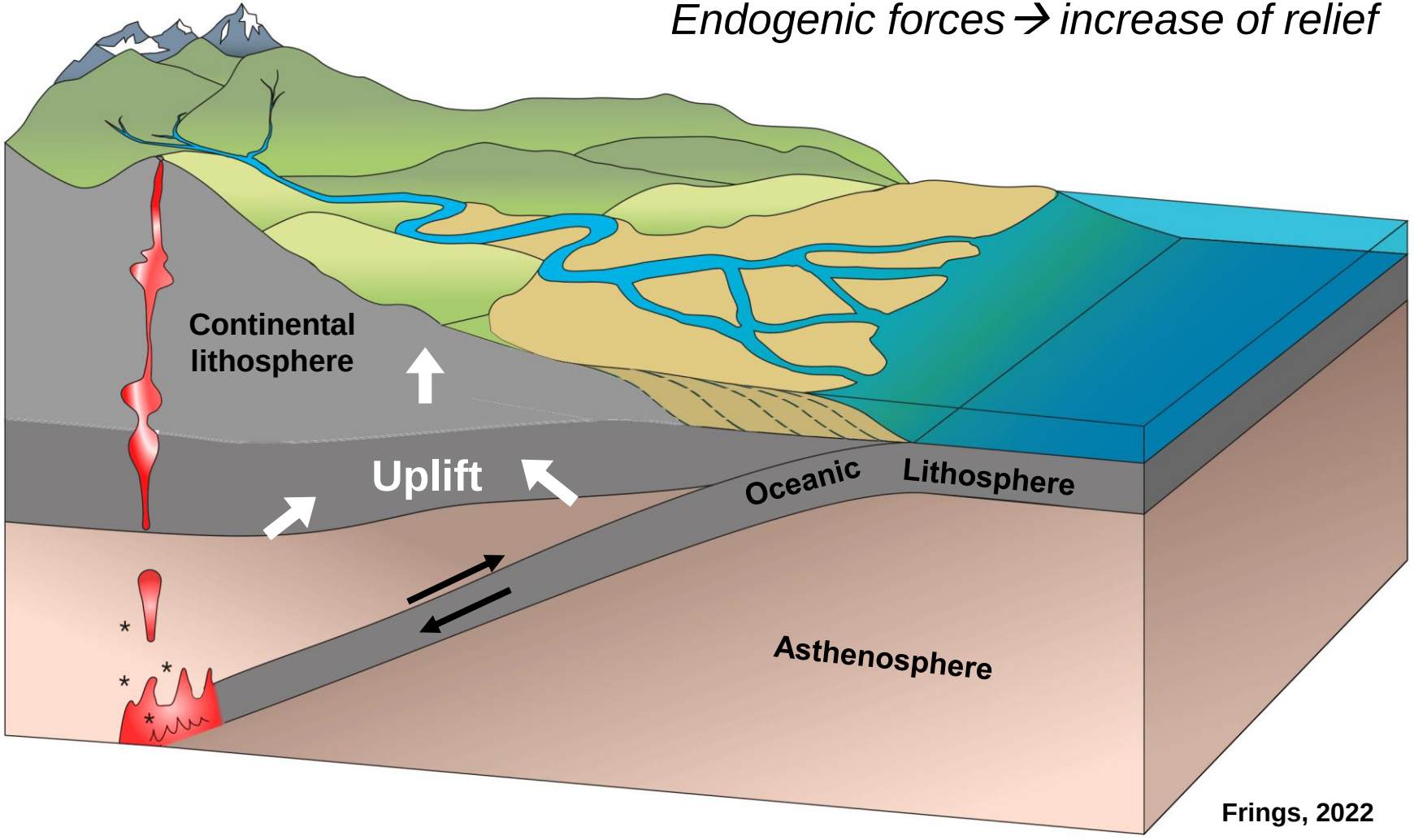
Convection processes



USGS/SVG

Mountain building

Endogenic forces → increase of relief

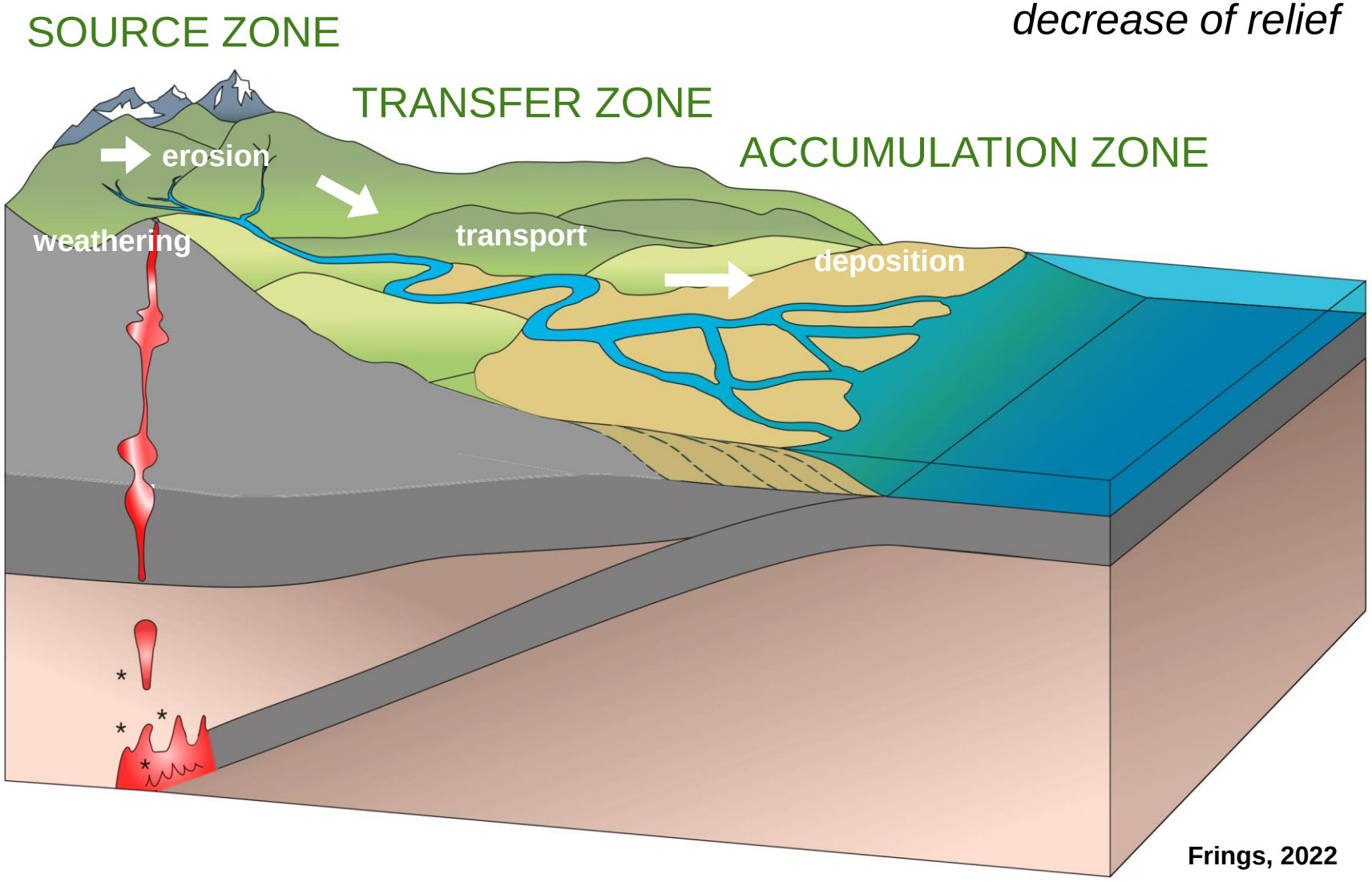


Frings, 2022

Geology

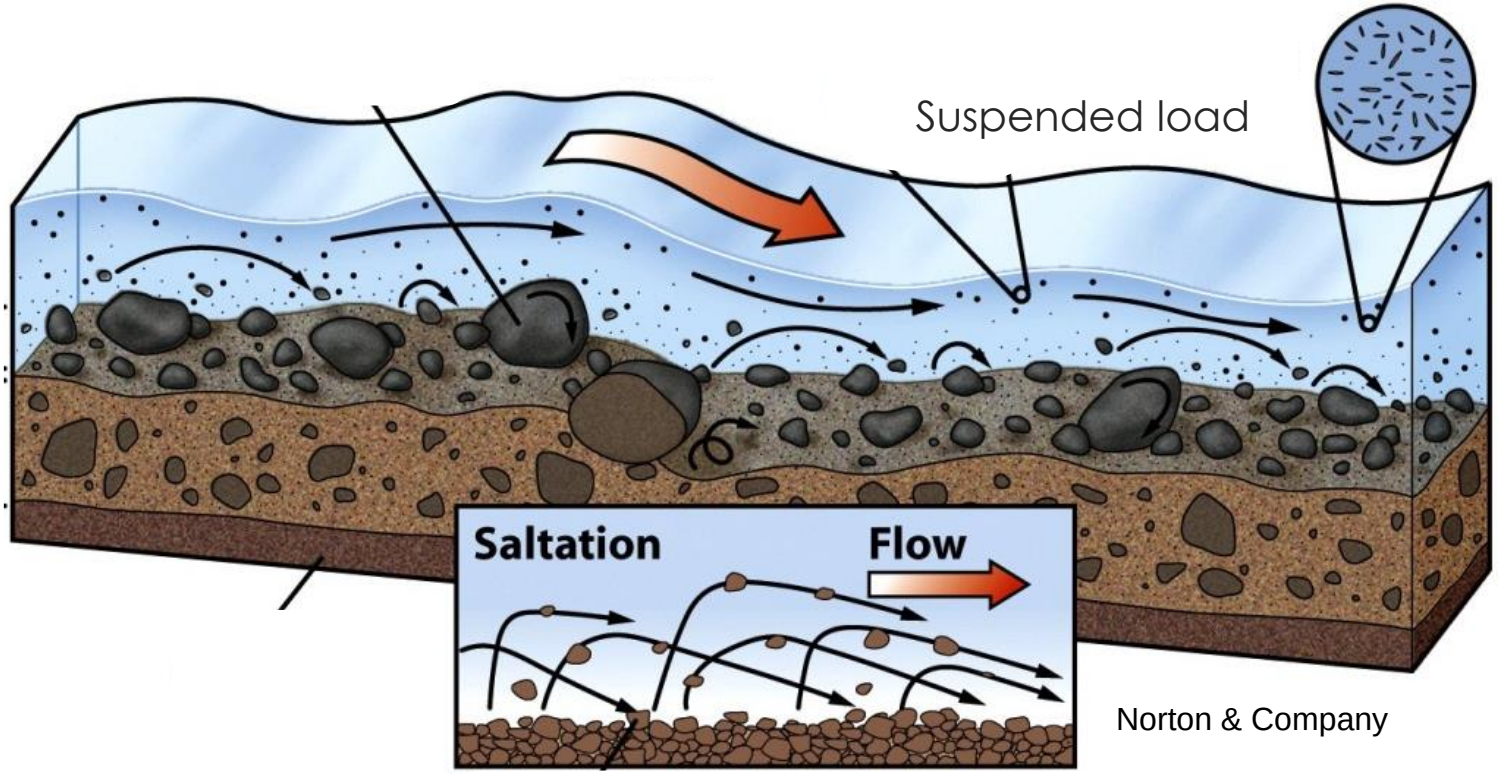
Denudation

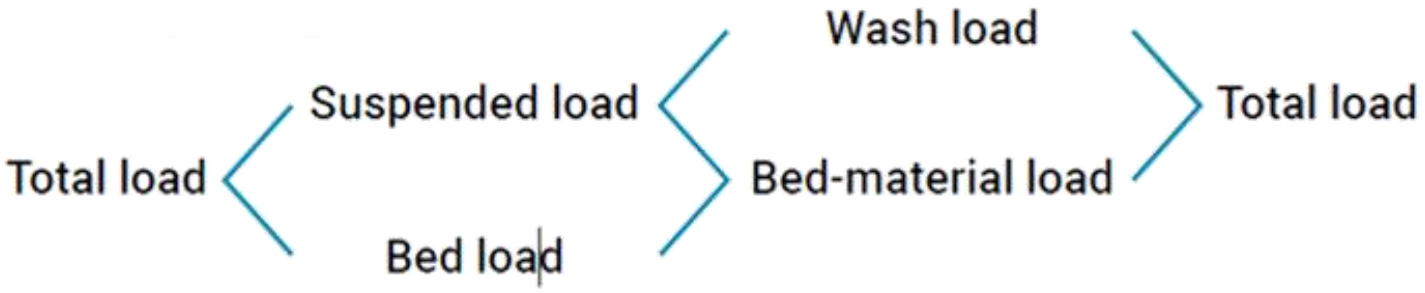
decrease of relief



Frings, 2022

Sediment transport





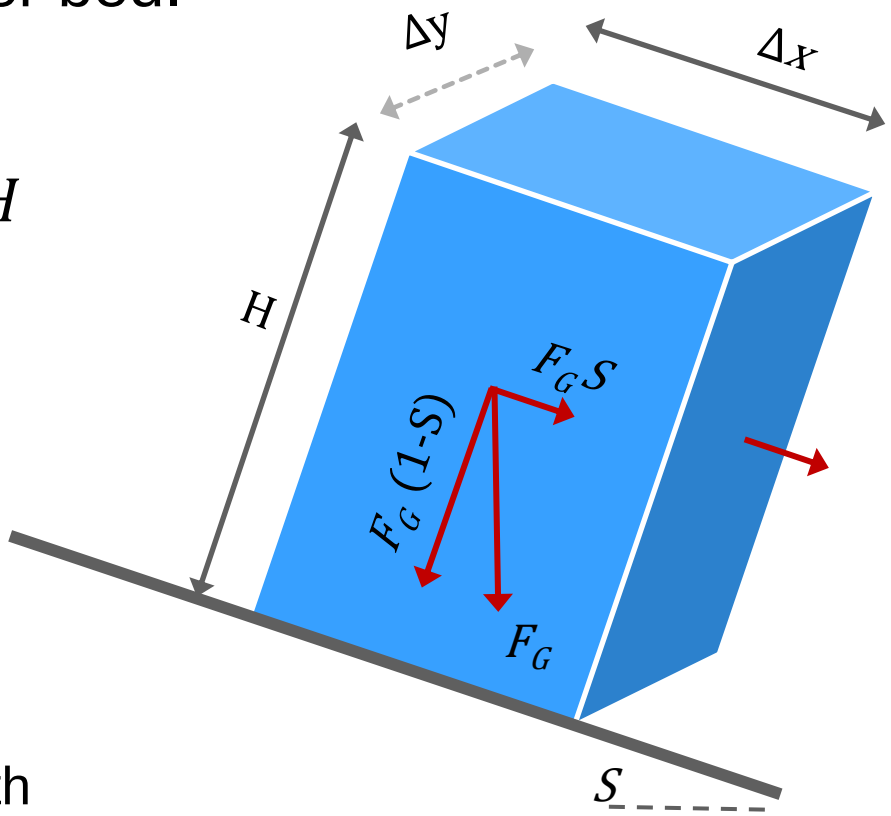
Forces

Governing the motion of sediment is the downstream force exerted by the fluid on the river bed.

$$F_0 = F_G S$$

$$F_G = mg = (\rho V)g = \rho g \Delta x \Delta y H$$

$$F_0 = \rho g H S \ \ \Delta x \Delta y$$



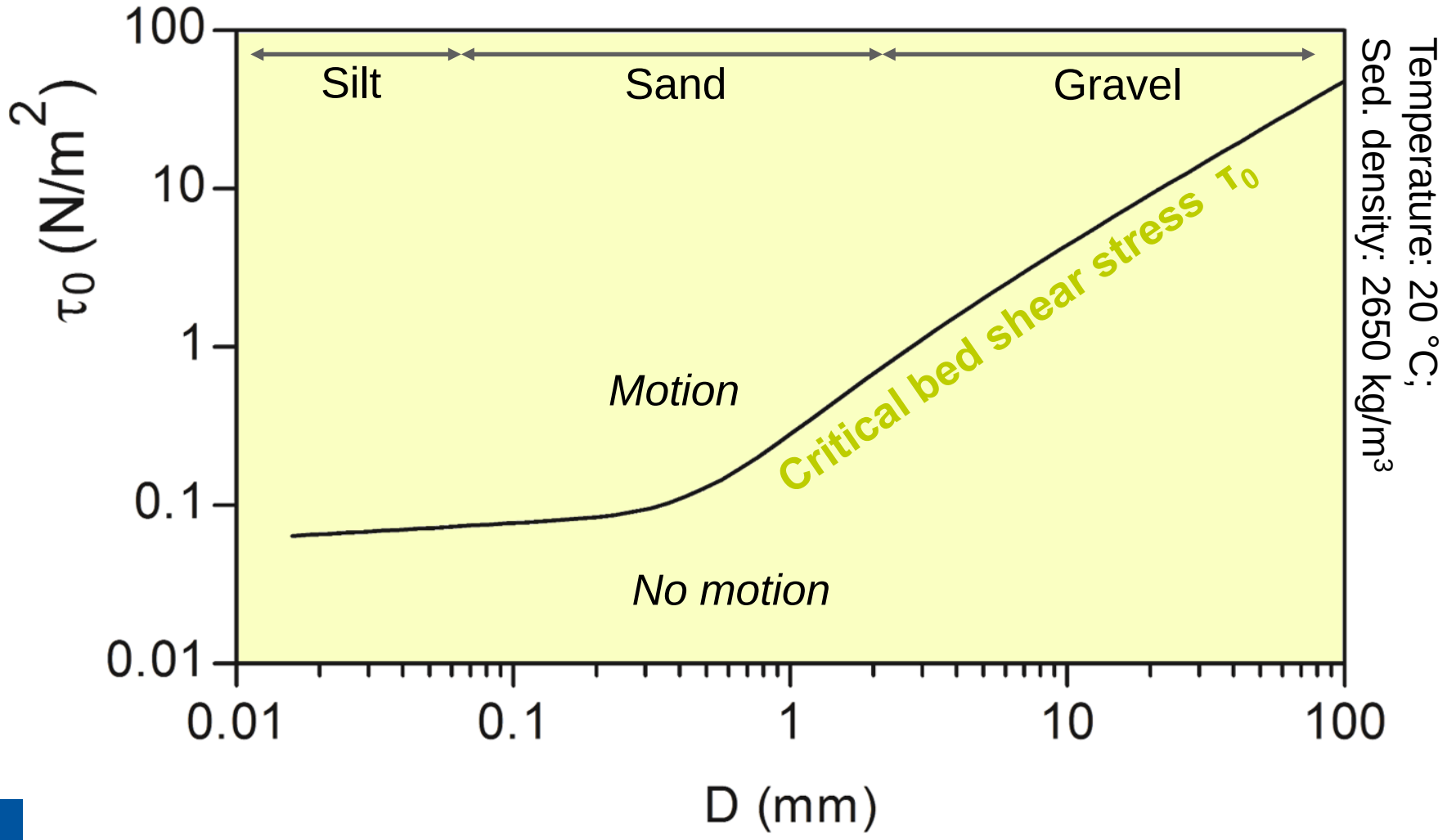
Shear stress

Force per unit area (Δx Δy)

$$\tau_0 = \rho g H S$$

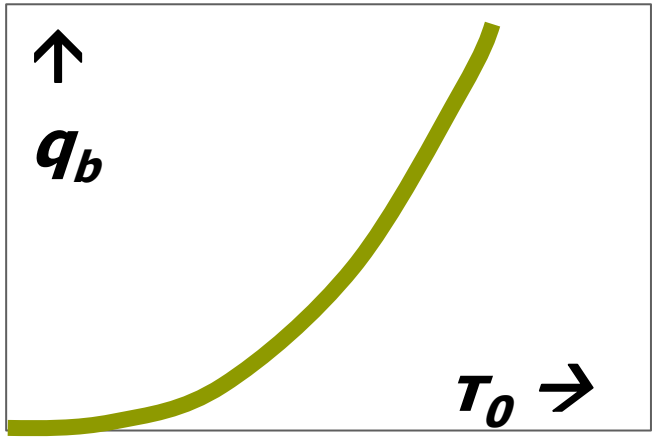
S = slope
H = water depth
g = gravitational acceleration
ρ = density

Initiation of motion



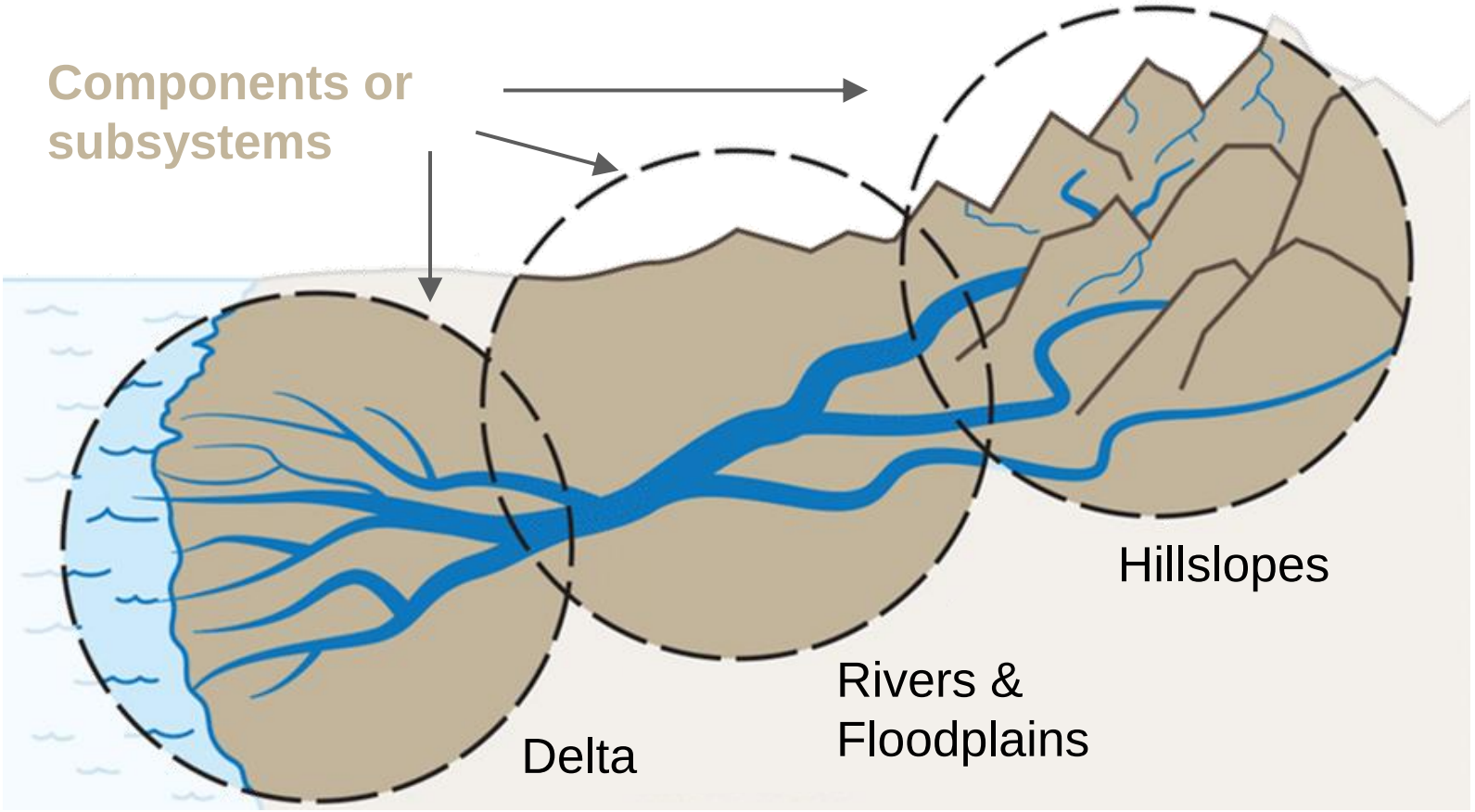
Transport capacity

$$q_b = f(\tau_0 - \tau_c)^n$$



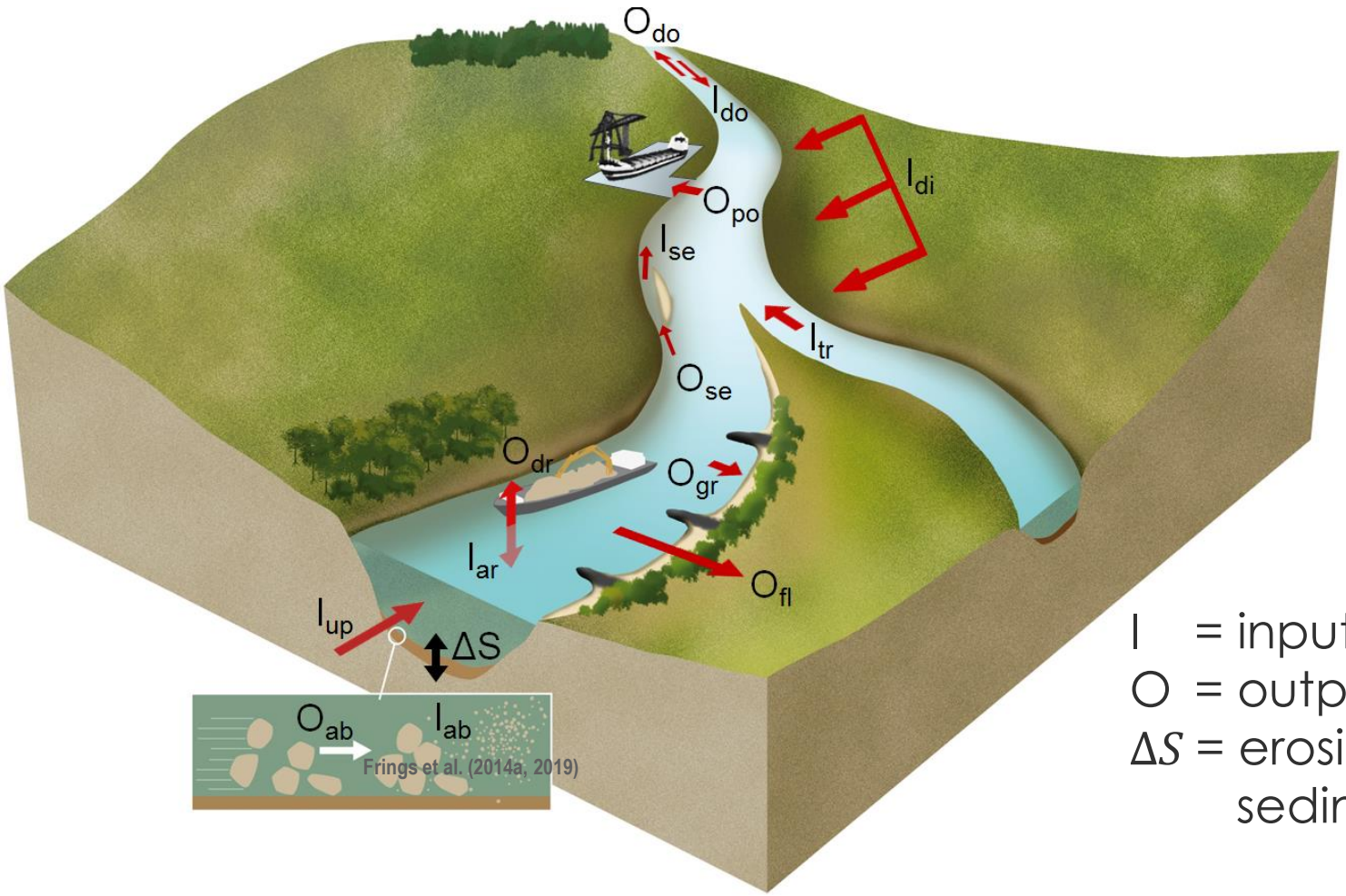
- Sediment transport only takes place if $\tau_0 > \tau_c$
- Small increase of τ_0 → strong increase of transport q_b

The sediment cascade



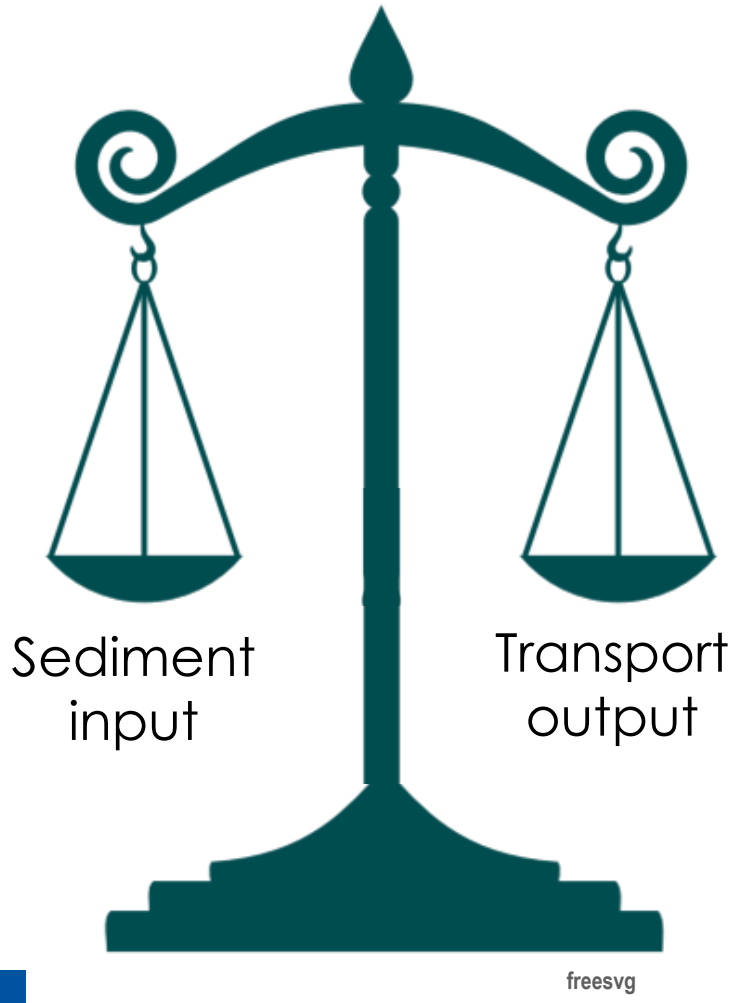
Sediment transport

There are many sediment fluxes



I = input
O = output
ΔS = erosion & sedimentation

The sediment budget



Input = output: no change
Input > output: sedimentation
Input < output: erosion

Erosion and sedimentation result in a change of the shape (morphology) of the river bed.

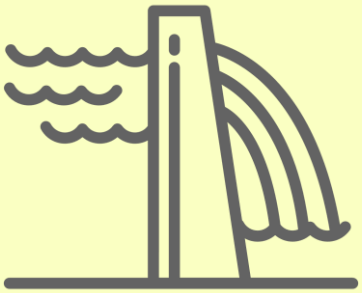
Human impact

freesvg.com

Humans have strongly disrupted the natural sediment dynamics of the Earth's rivers.

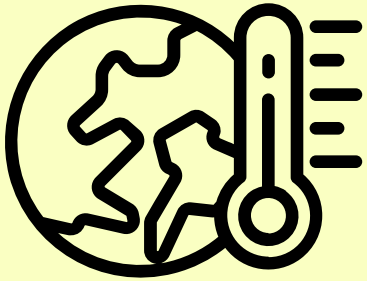
Human impact

1. Land use change

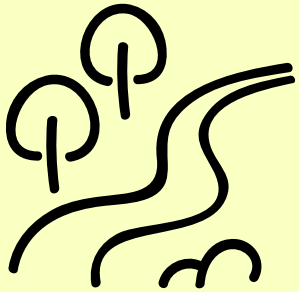


2. River regulation

3. Sediment mining



4. Climate change

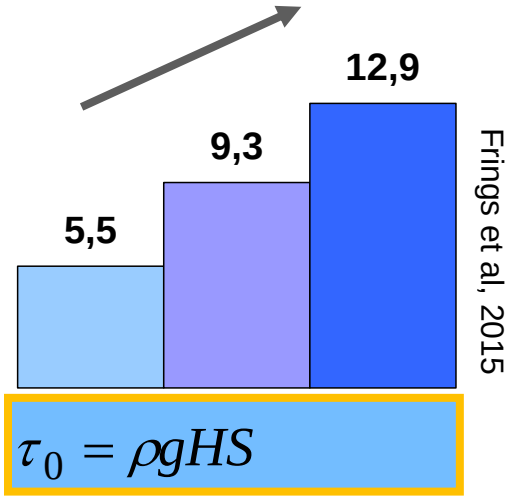


5. River restoration

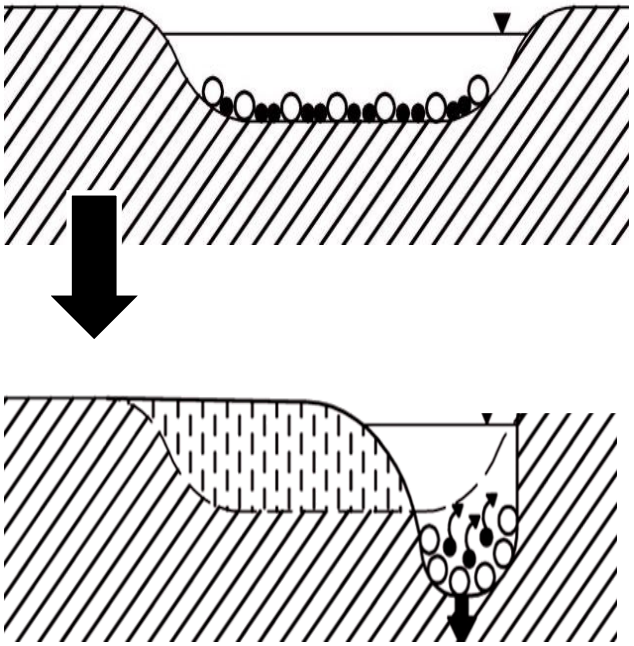
Human impact

River narrowing

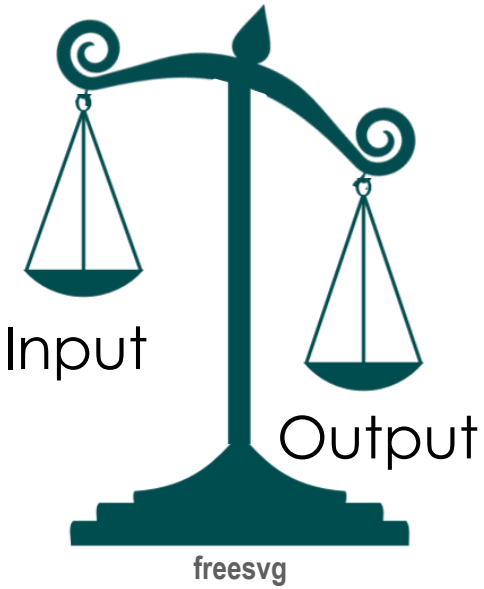
- Increased depth
- Increased bed shear stress
- Increased transport capacity
- Disequilibrium → erosion



Frings et al, 2015



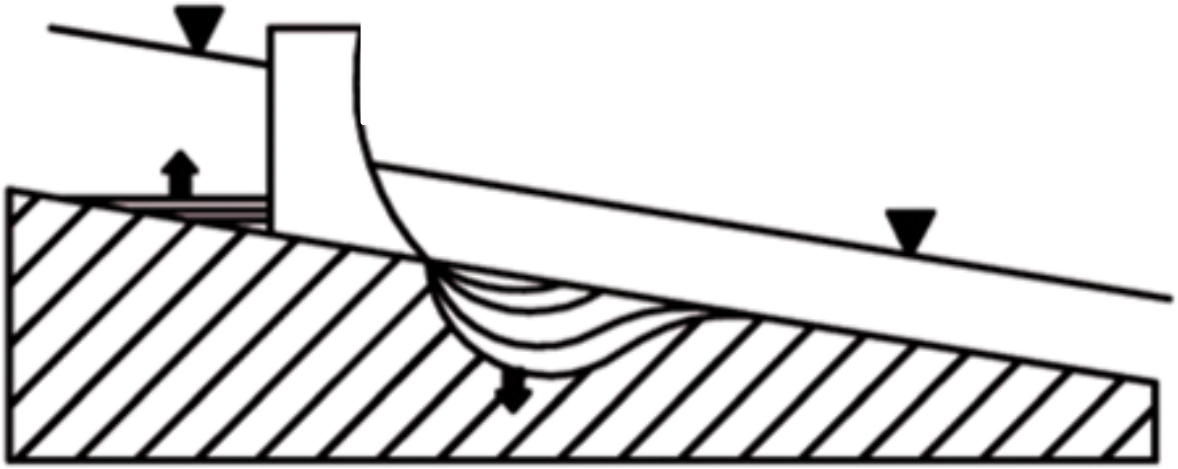
Frings et al, 2015



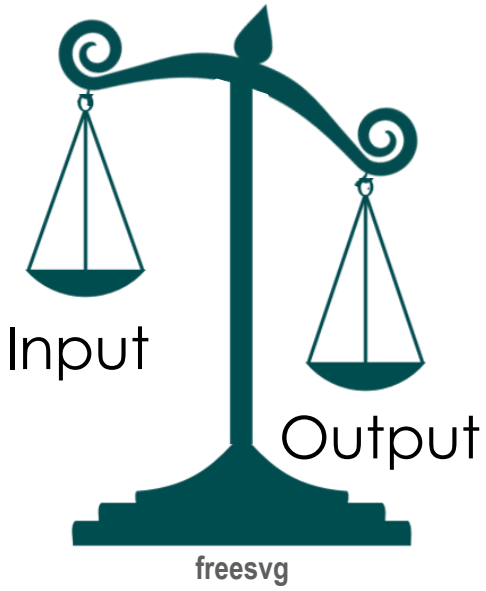
Human impact

Dam building

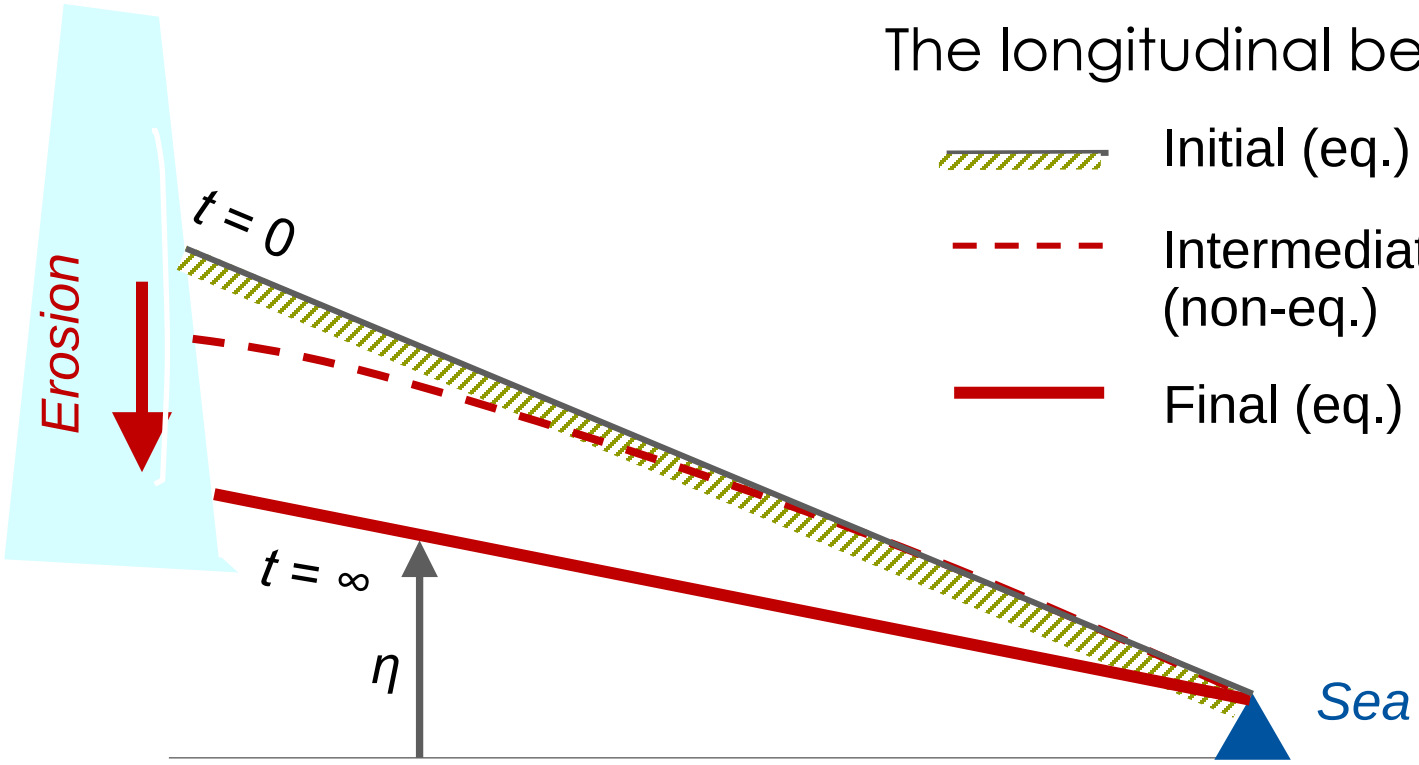
- Upstream: deposition
- Downstream: decreased sediment supply → erosion



Frings et al, 2015



Human impact

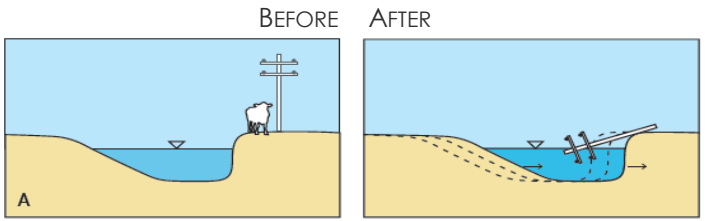


Very interesting:

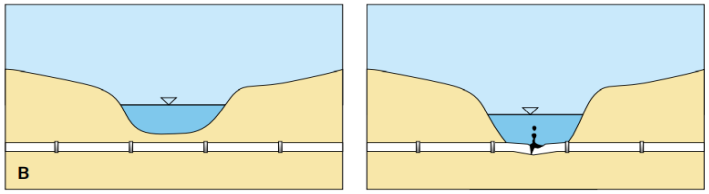
Due to erosion the bed slope decreases, which decreases the bed shear stress and reduces the erosion rate. The river tries to find new equilibrium.

Erosion and sedimentation from a human perspective

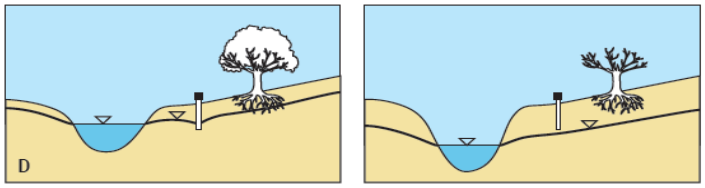
Erosion



Infrastructure (bank erosion)

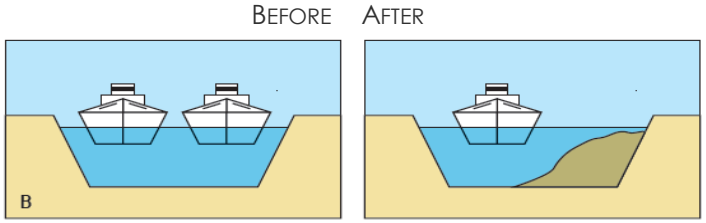


Infrastructure (bed erosion)

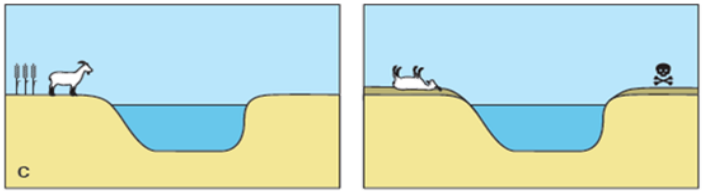


Water availability

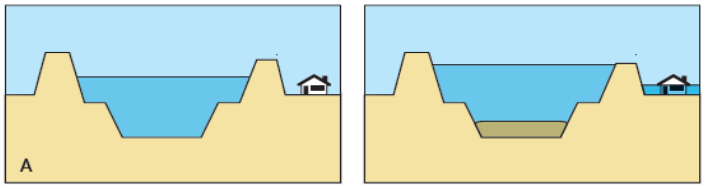
Sedimentation



Shipping



Water and soil quality



Flood safety

R.M. Frings, 2022

Relevance

Erosion and sedimentation from an ecological perspective

- Plants and animals in rivers have specifically adapted to life in dynamic environments.
- Each species has its own special habitat requirements:
- More diversity of habitats → more different species → richer biodiversity.

Erosion and sedimentation create habitats and are essential to river ecosystems

Conclusions

Sediment transport is governed by bed shear stress (H and S)

Humans have strongly disrupted the world's sediment fluxes

A disbalance between sediment in- and output causes erosion or sedimentation

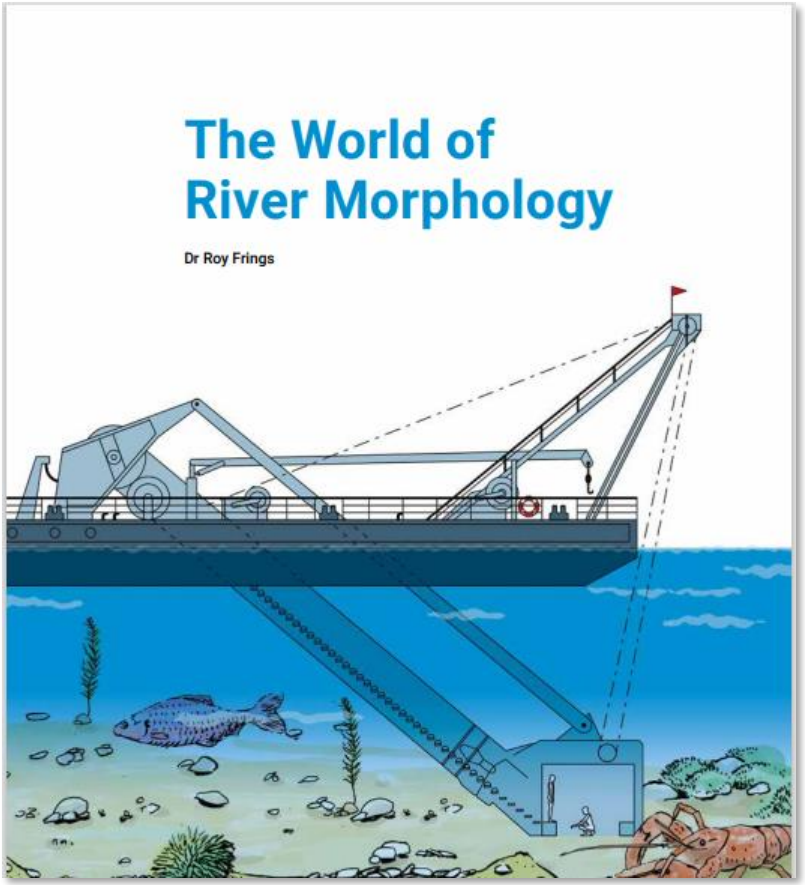
River strive towards equilibrium, but seldom achieve one.

Erosion and sedimentation are often problematic from a human point of view, but (in natural amounts) necessary from an ecological point of view

Sediment is the basis below all human and ecological river functions

"Flumen sanum in corpore sano"

Thank you for your attention!



Dr. Roy Frings