Torrentology

DI Leopold Stepanek
Sektion Tirol
Wilhelm Greil Straße 9
6020 Innsbruck
Leopold.stepanek@die-wildbach

Innsbruck, 08.11.2024

Content:

- ~~Precipitation~~
- ~~Hydraulics~~
- ~~Formulas~~
- (Definitions)
- **Run-Off**
- **Geomorphology (basics)**
- **Torrential processes**

Words to look up/think about:

- Natural event (phenomenon)
- Natural hazard (menacing event)
- Torrential event (phenomenon)
- Torrential hazard (menacing event)
- Extreme (high intensity)
- Danger (for whom?)
- Risk (damage [= exposition x vulnerability] x probability)
- Disaster = catastrophe (impact, magnitude)

Definition: "torrent"

A torrent

is a steep mountain stream that sometimes swells strongly and carries large quantities of rock debris, boulders, soil, wood or whole tree trunks.

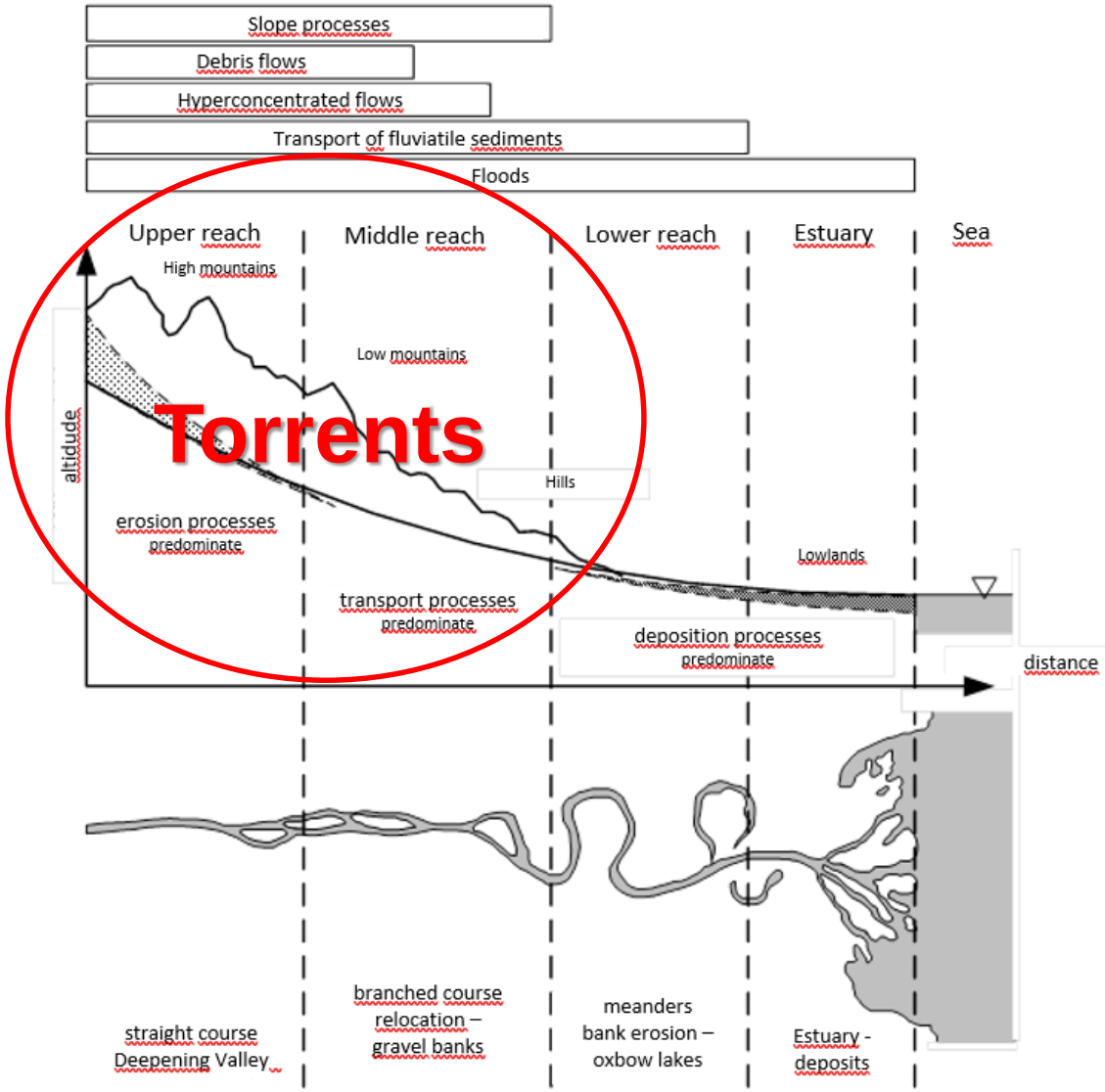
The main characteristics of torrents in the Alps are their steep gradients and the fact that their flow rates vary strongly within a short period of time due to snowmelt and heavy thunderstorms. Torrents also exist less frequently in the hilly lowlands on steep slopes. They typically do not have great differences in altitude, but often have a larger catchment area than mountain streams.

WATER

+

DEBRIS

Watercourse continuum:



Three typical forms occur in the mountain rivers, depending on the water and bedload flow and the width of the valley floor:

- Branched river
- Meandering river
- Straight flow

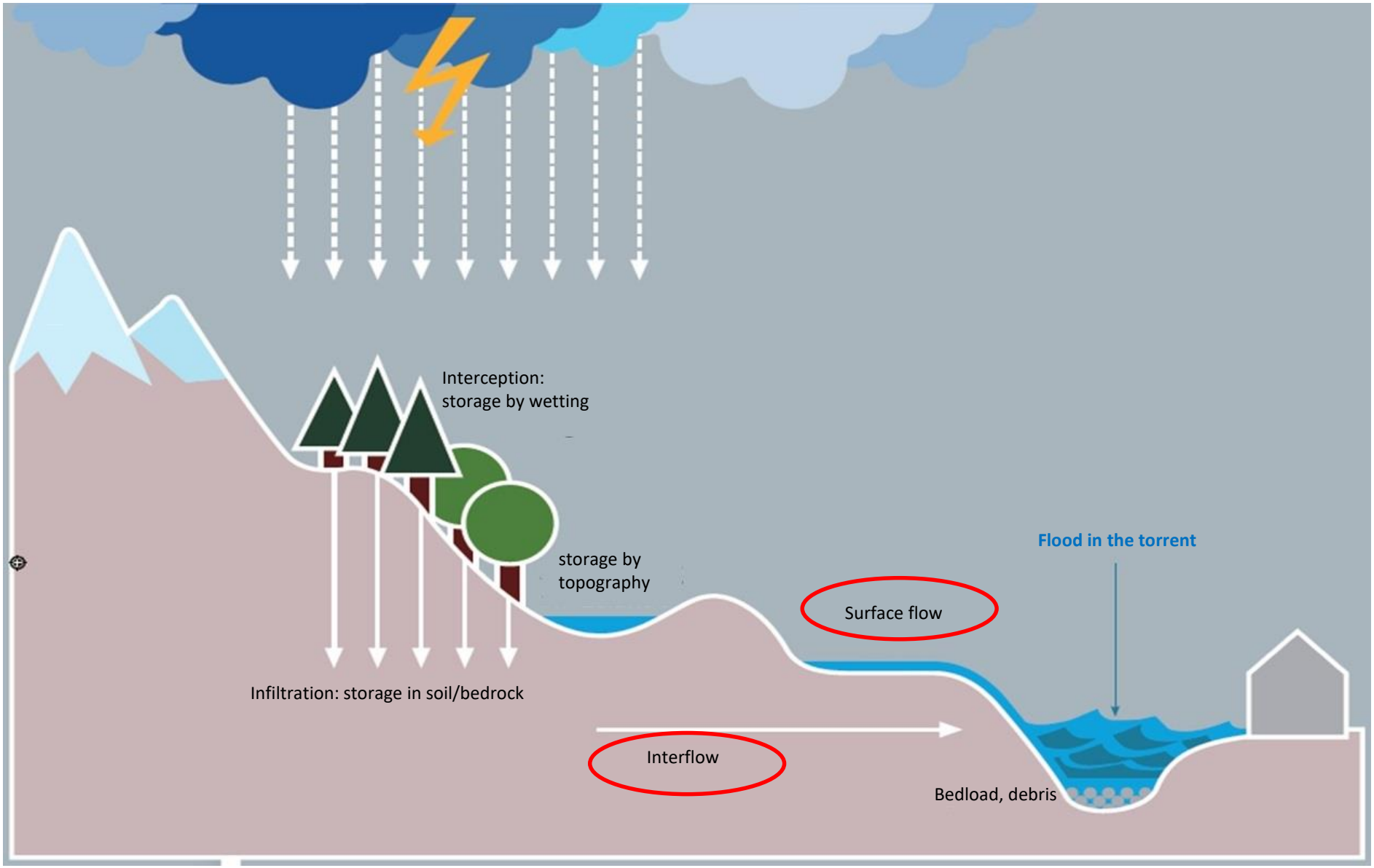
Torrents and rivers in mountainous regions are mainly characterised by floods and the transport of solids.

Torrents: Runoff

CONTENT:

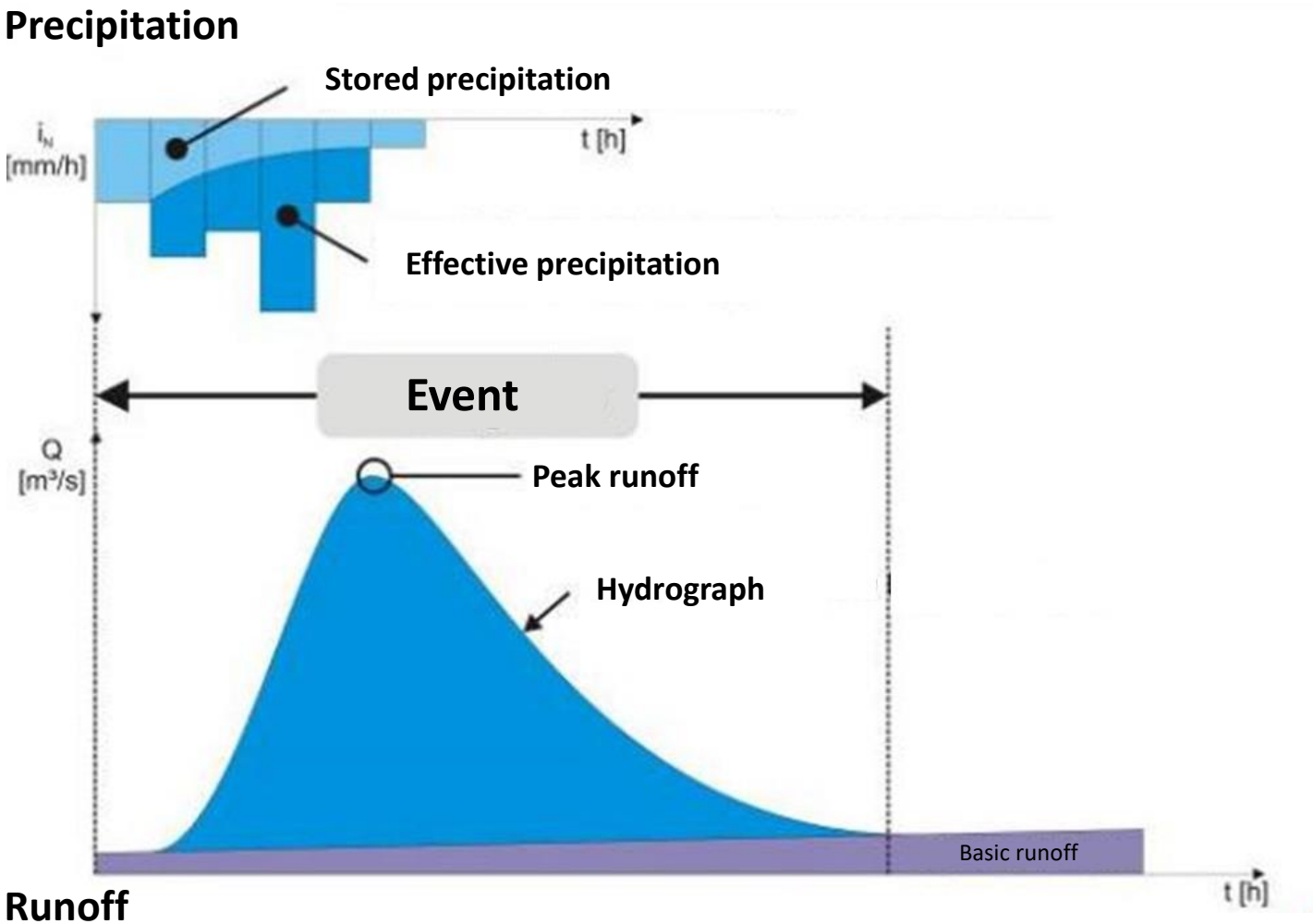
- Formation
- Discharge
- Catchment area characteristics

Runoff: Formation

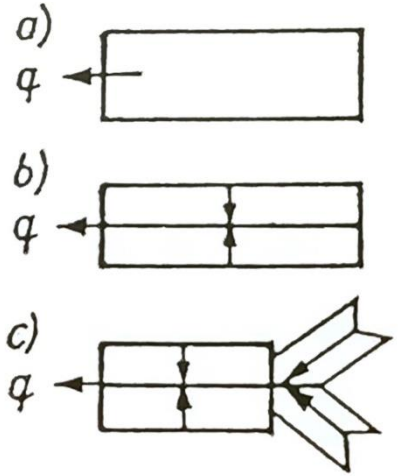


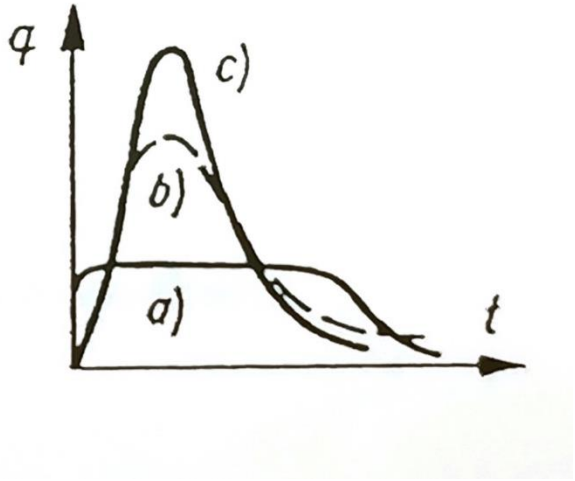
Runoff: Discharge

The graphical representation of a flood in a diagram is called a **flood hydrograph**.

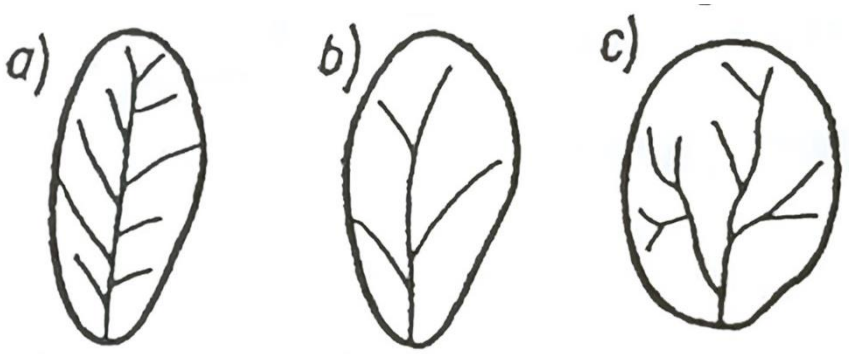


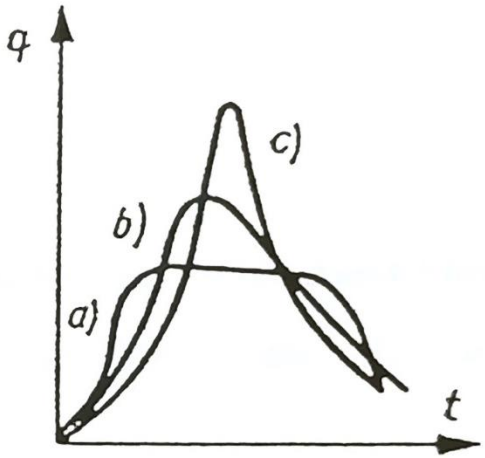
Runoff: Influence of drainage density





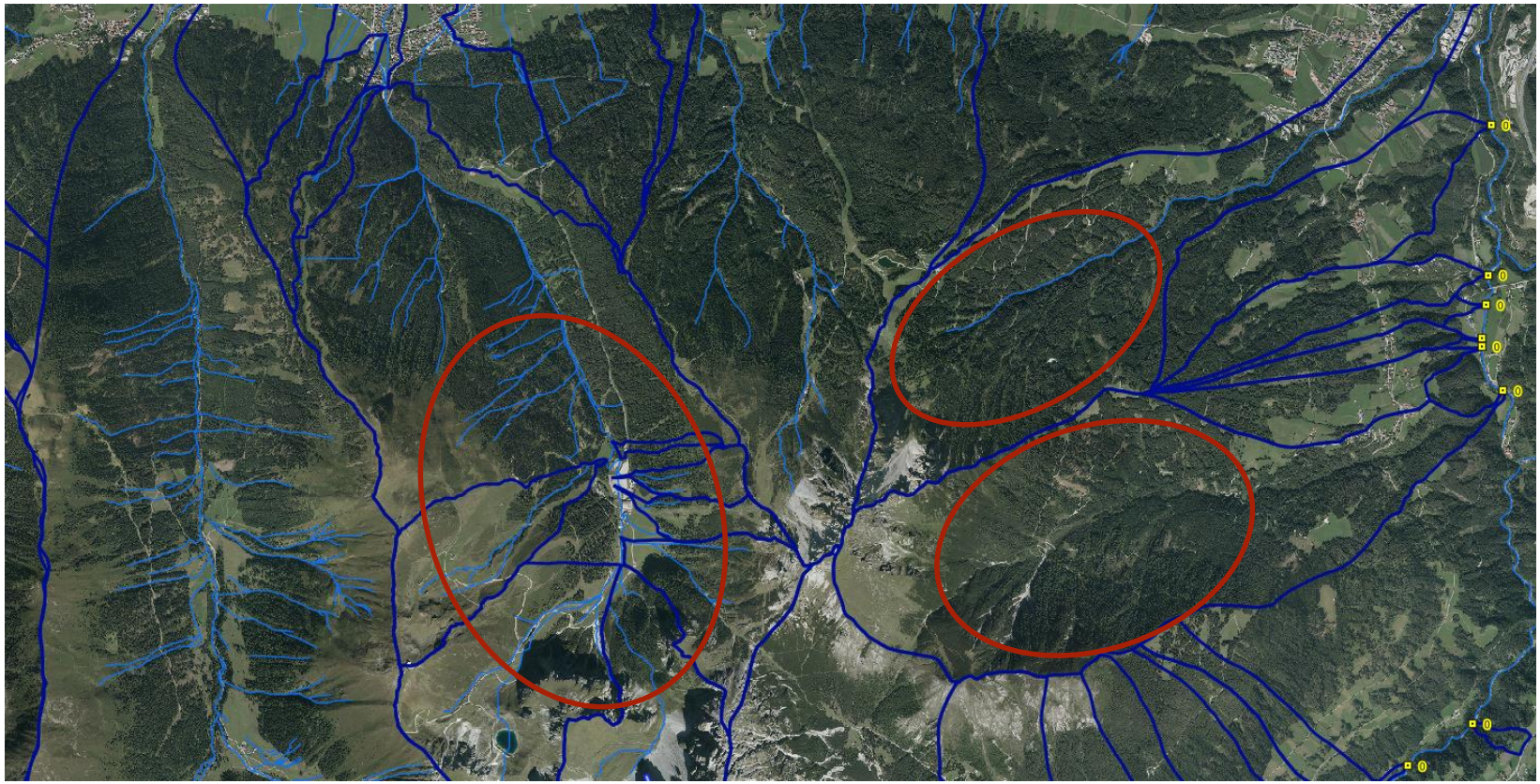
Runoff: Influence of drainage structure





Runoff: Catchment area characteristics

Differences in infiltration due to vegetation cover, management, soil and geology



Different drainage density causes different reaction to precipitation (duration, intensity)

Torrents: Geomorphology (basics)

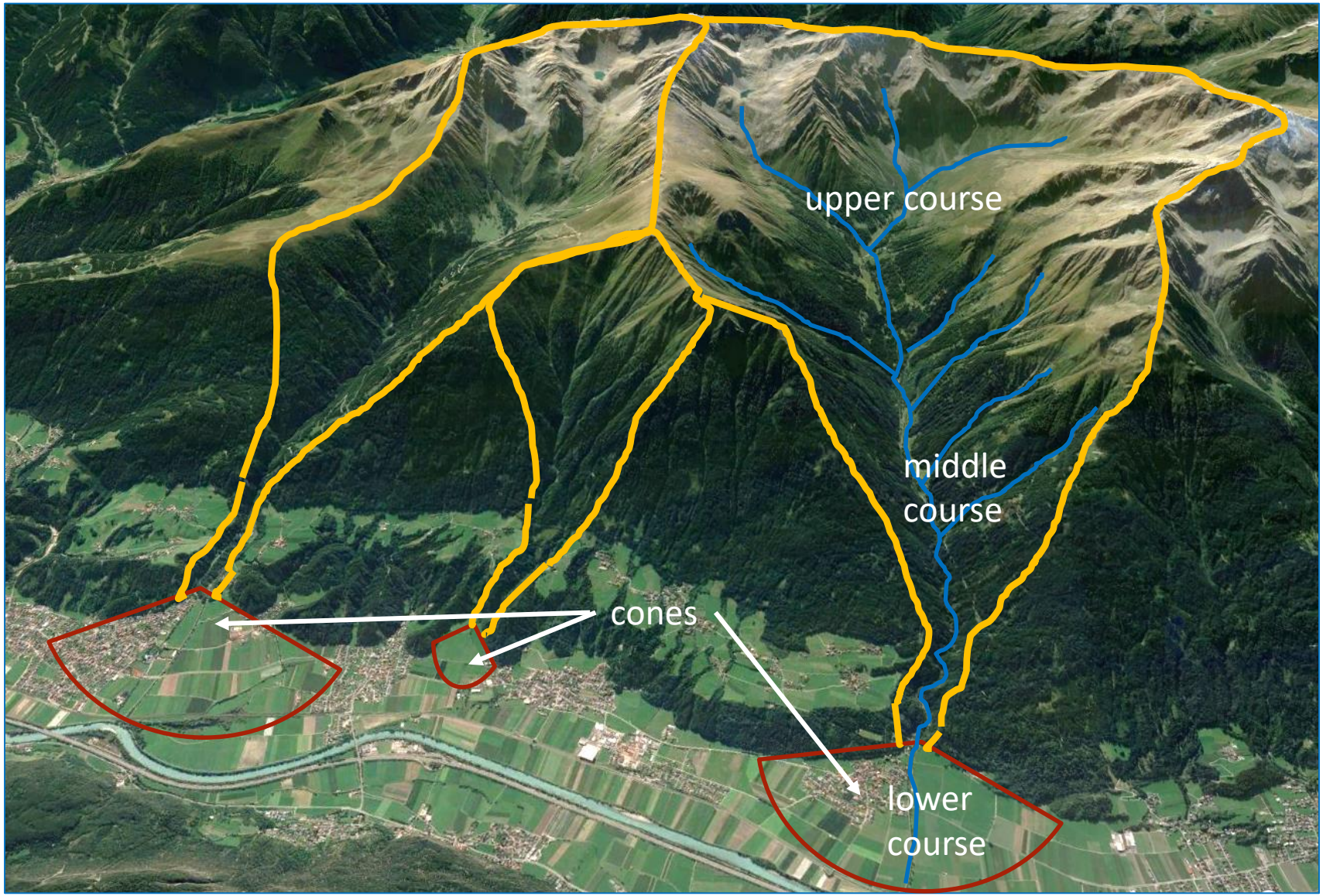
CONTENT:

- Catchment area
- erosion forms, ice age
- alluvial fan

Catchment area:

The catchment area of a torrent is part of the river basin. In terms of bedload transport, the torrent is divided into an upper course (erosion area), middle course (transport area) and lower course (deposition area).

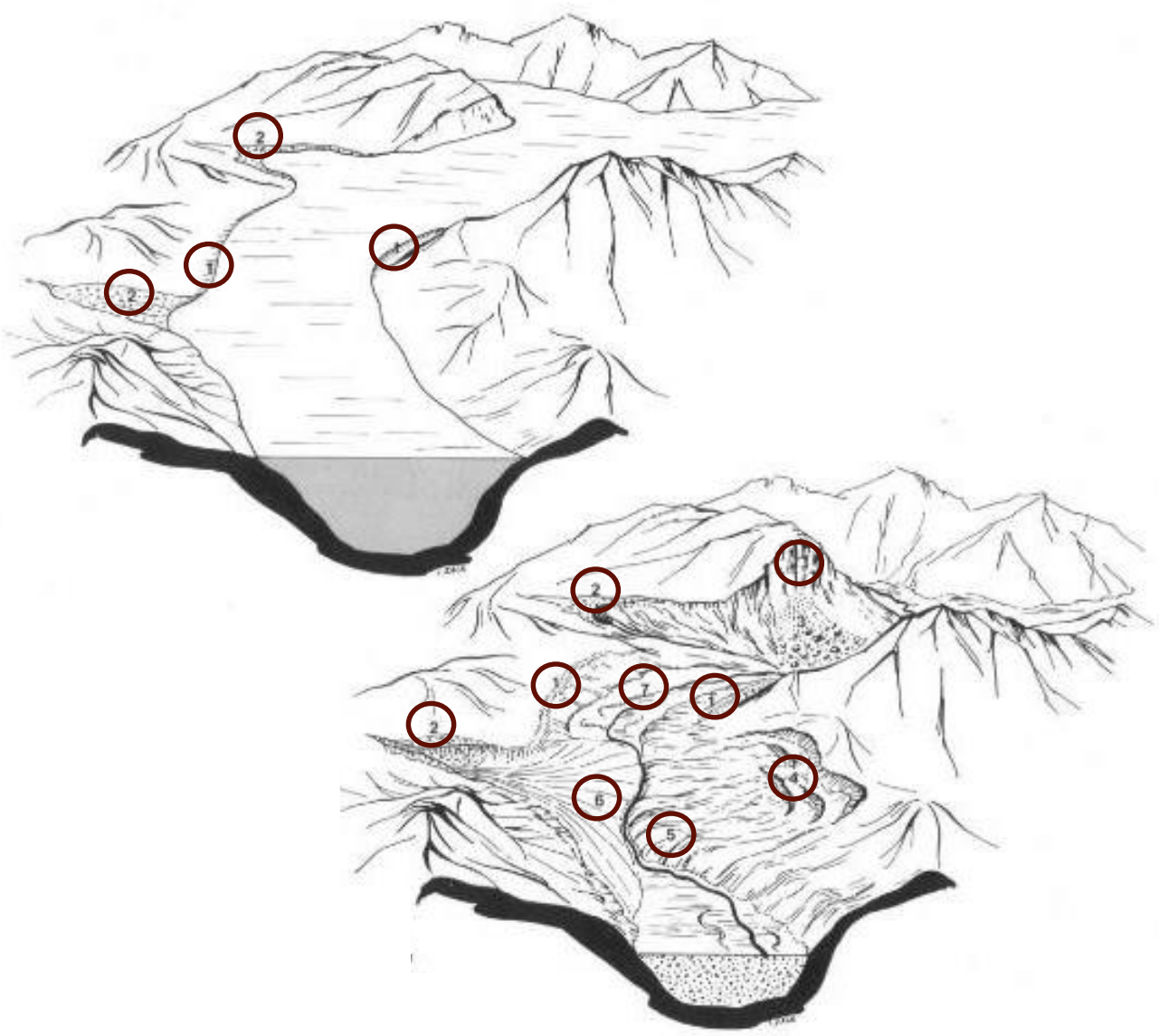
The steep upper reaches generally contain the largest bedloads and slope failures, while the middle reaches are often narrow valleys or gorges. In the lower reaches (at the end of the valley), torrents often form alluvial cones on which debris flows and debris from flood events are deposited.


upper course
middle course
cones
lower course

Alpine Morphology: Ice Age in Slovenia

Alpine Morphology: Ice Age in the Alps

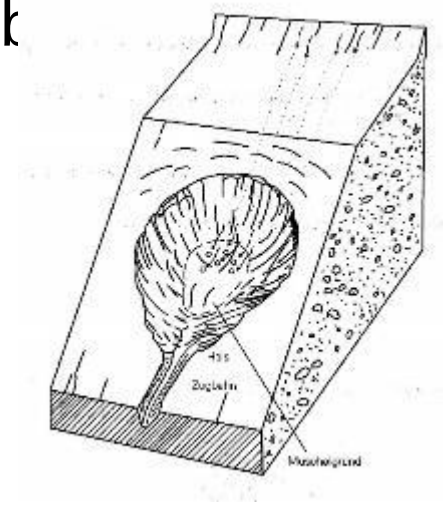
Alpine Morphology: Influence of Ice Age



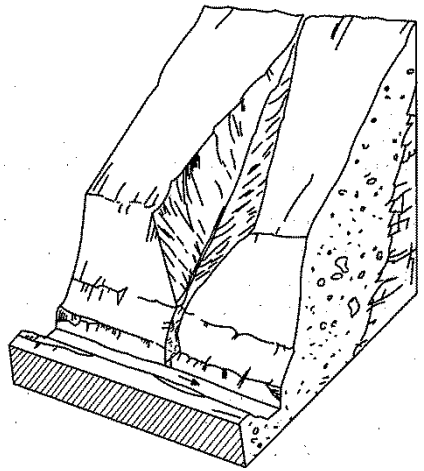
(1) Moraines
(2) Kame (Ice edge deposits)
(3) Rock avalanche
(4) Rock failure
(5) Rock flow
(6) Alluvial/debris cone
(7) Backlog zone with fine sediments, often swamps and mires

Torrents: Erosion

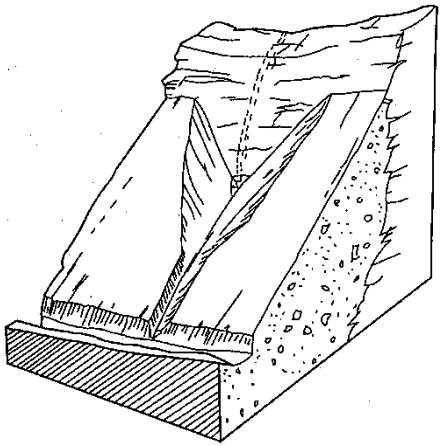
In torrents, the most productive bedload sources are located in the large erosion centres of the loose masses (slope debris, moraines, landslide dumps). The assessment of these erosion foci is based on a categorisation according to Stiny (1931), which is primarily oriented towards the type of water attack (surface, sub



Shell breakage



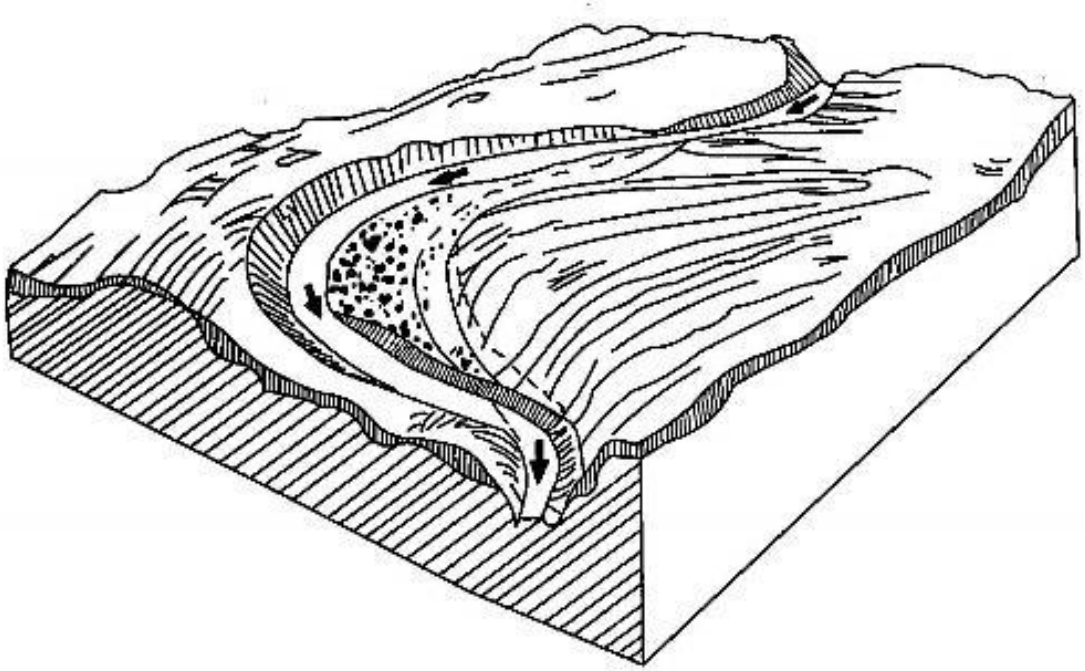
File break



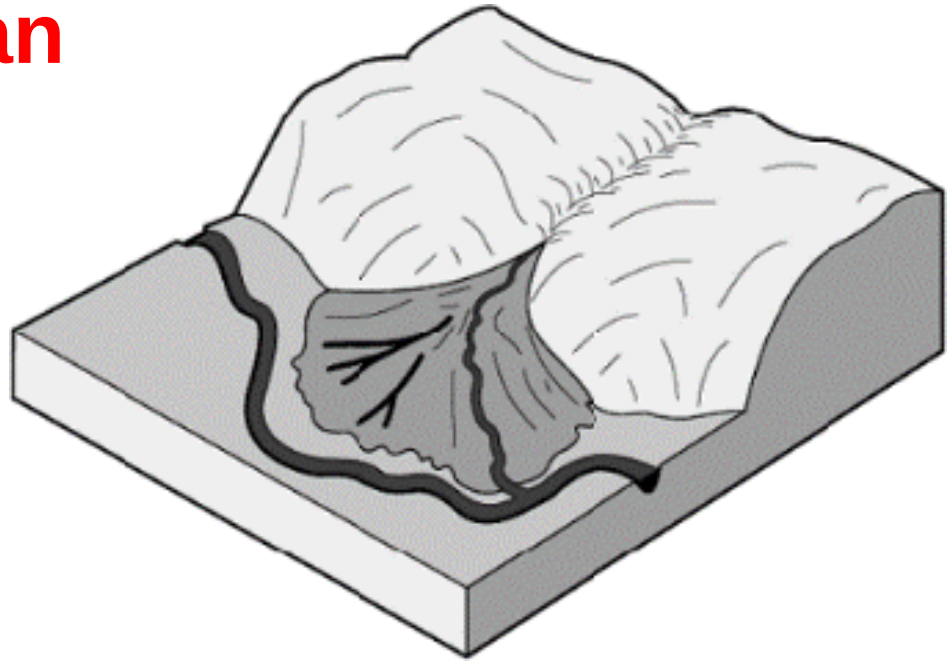
Wedge break

Torrents: bank erosion, bank formation

In streams and rivers, the erosive effect of the flowing water affects both the depth and the sides. Lateral erosion often opens up **bank breaks** on embankments, which are usually located in the outer bend (baffle bank) in winding watercourses, where the flow is directed by centrifugal force. In contrast, bed-load deposits (**banks**) often form in the flow-calmed inner bend.



Torrent: Alluvial Fan



A alluvial fan forms due to the decrease in flow velocity and thus transport capacity. Torrents with active alluvial fans often have several channels, as the water has to avoid the deposits that have already been washed up. In addition, the river (receiving water) of the plain is increasingly displaced by the alluvial fan. The type of debris transported by the river, the size of the river and the surrounding landscape determine the appearance of the fan.

Torrents: Alluvial fan

An **alluvial** fan (also called alluvial fan or alluvial fan),

is the accumulation area (deposition area) of fluvial sediments at a point where a torrent loses gradient, for example when crossing from the mountains into a plain.

A triangular or cone-shaped alluvial fan forms due to the decrease in flow velocity and thus transport capacity. Torrents with active alluvial fans often have several channels, as the water has to avoid the deposits that have already been washed up. In addition, the river (receiving water) of the plain is increasingly displaced by the alluvial fan. The type of debris transported by the river, the size of the river and the surrounding landscape determine the appearance of the fan.

Torrents: Debris cone

A **debris cone**

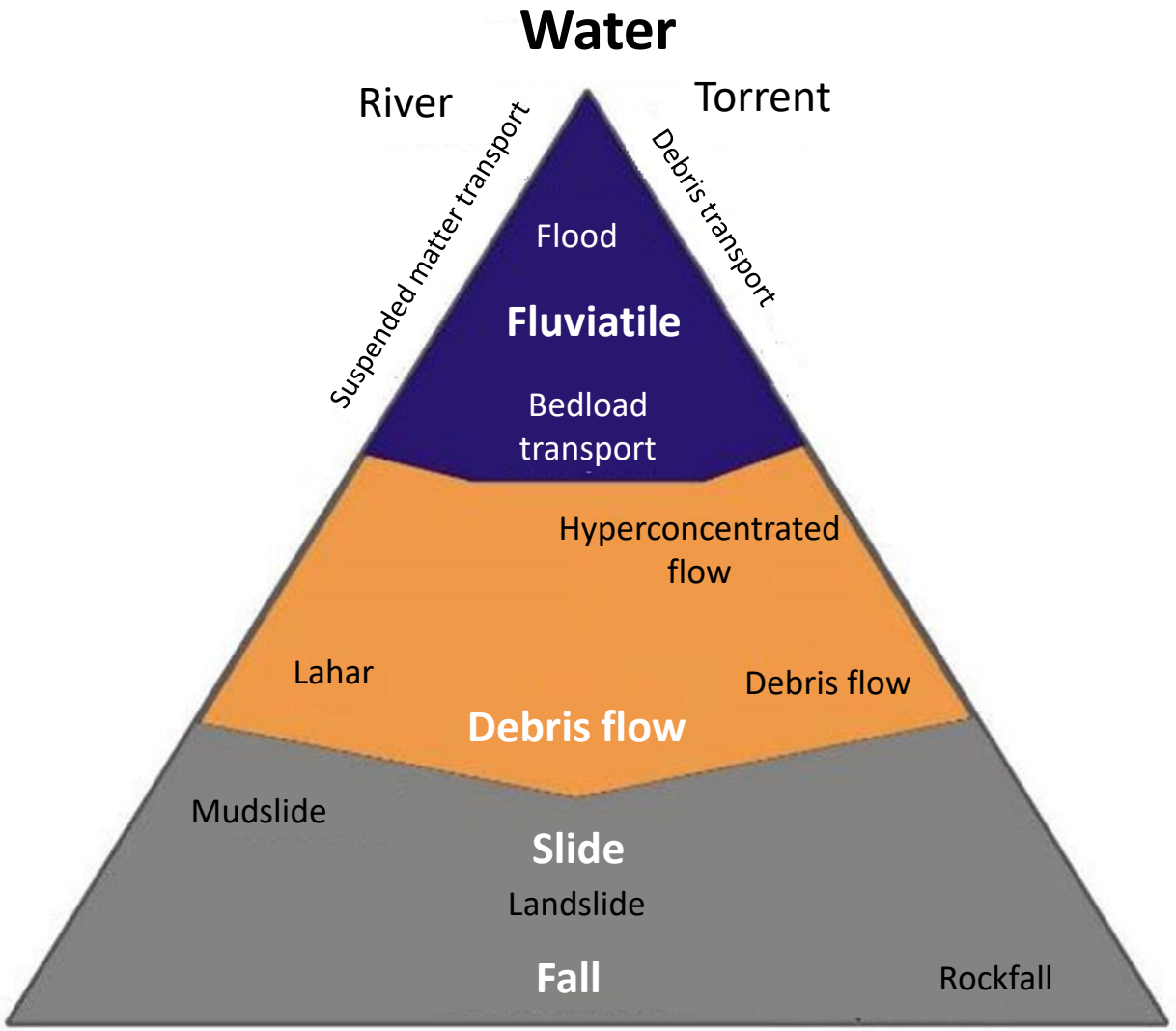
is a semi-cone-shaped deposit of barely sorted coarse and fine material from debris flows, which usually consists of several debris flow tongues.

Torrential processes:

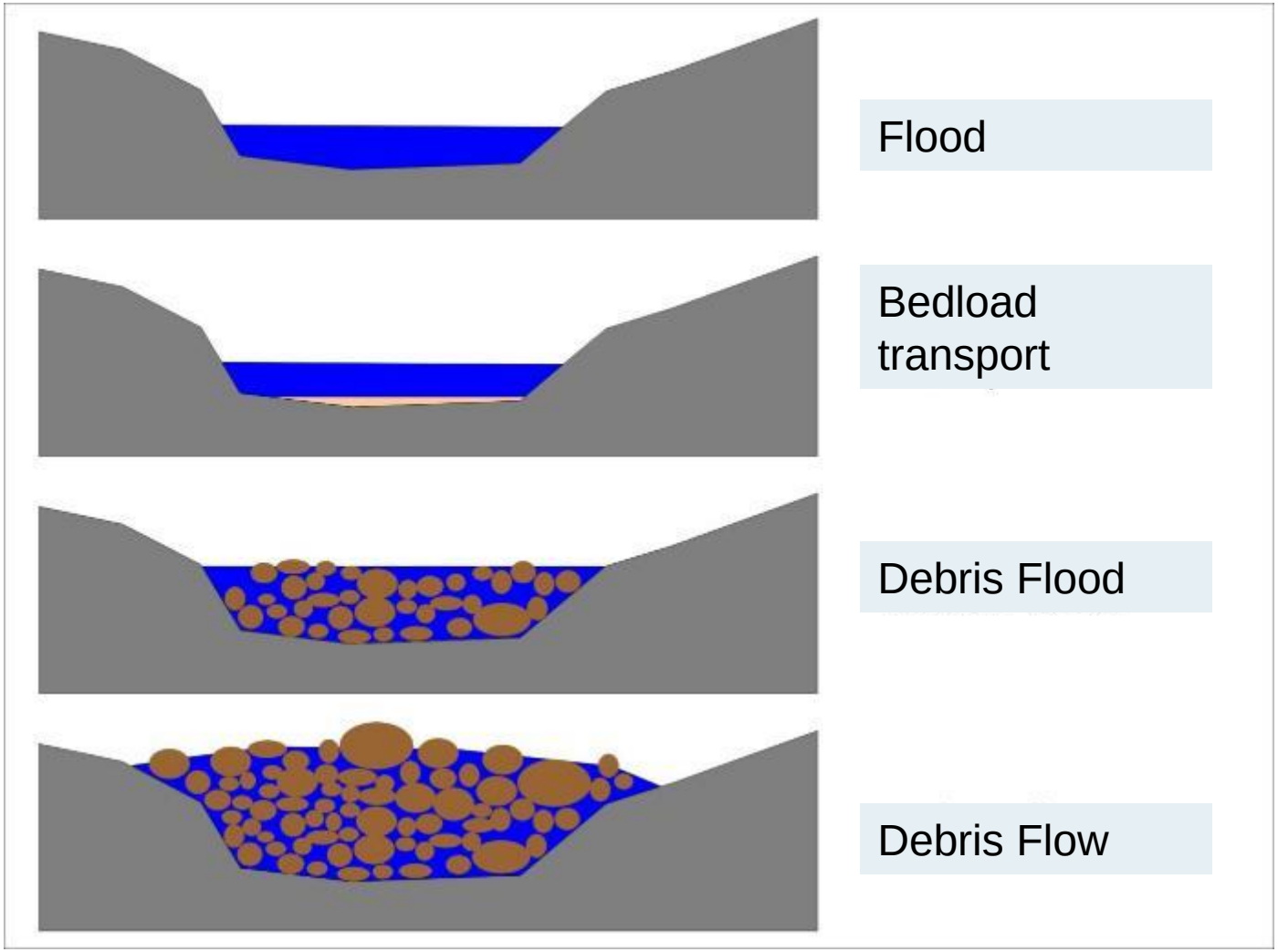
CONTENT:

- Overview
- Floods
- Sediment transport
- Hyperconcentrated flow
- Debris flow
- Woody debris

Torrential Processes: scheme



Torrential Processes



Torrent process: Bed load transport

In torrents, bedload transport accounts for a significant proportion of the discharge during floods, whereby the proportion of bedload in the flood discharge can increase more and more if the gradient is steep and sufficient erodible material is available. Above a certain bedload proportion, the flow properties of the water/bedload mixture change and the bedload transport turns into debris flow and finally into a debris flow.

Debris flows: Hyperconcentrated flow

Hyperconcentrated flows or **debris floods** comprises torrent processes in which solids are distributed across the entire flow cross-section, regardless of grain size. This occurs very frequently in steep catchment areas. Unsorted and grain-supported debris banks and lobes are found as forms of deposition, the fine material is washed out.

Debris Flood

Torrent process: debris flow

Debris flows

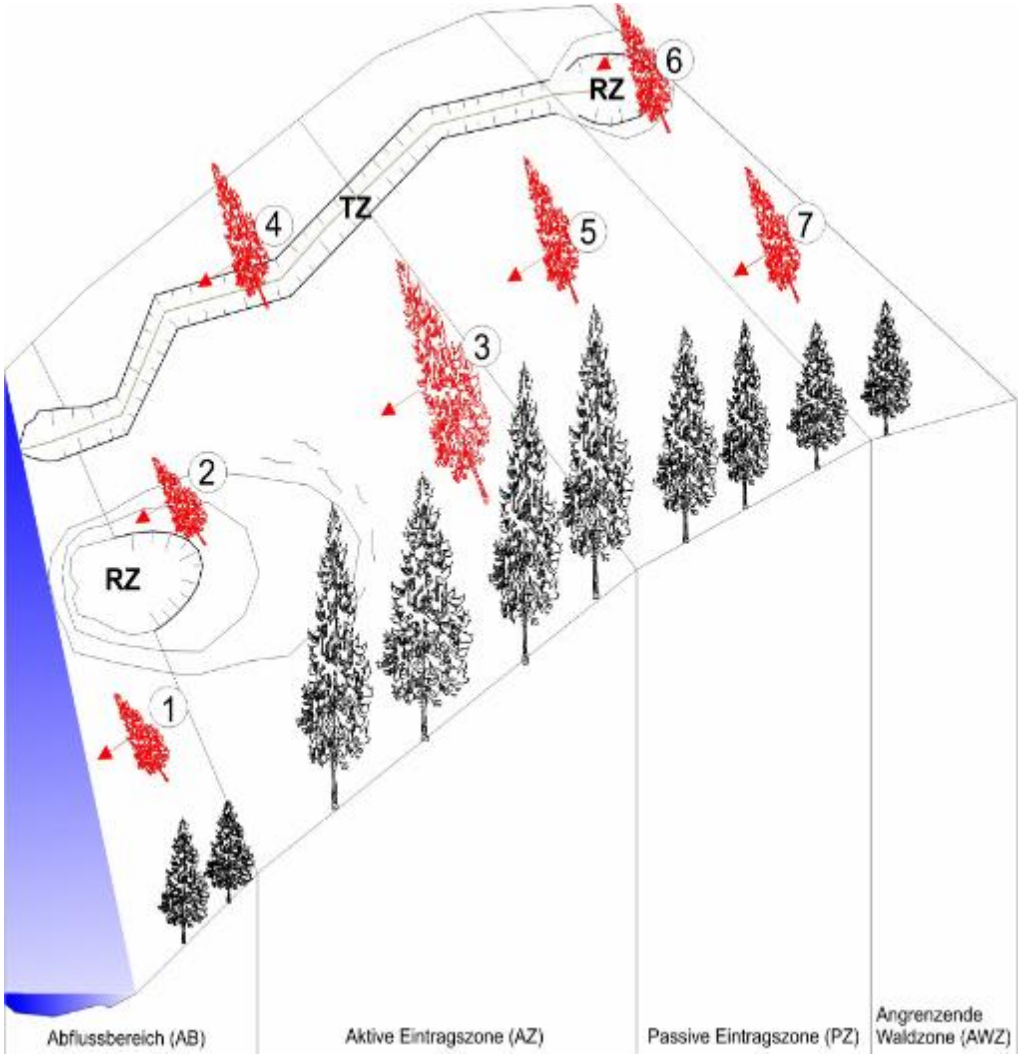
are mass displacements consisting of a mixture of water, fine material and blocks weighing up to several tonnes.

Debris flows include all transport processes in torrents in which the solids make up a significant proportion of the transport volume and whose flow characteristics are strongly determined by the concentration of the water/mud mixture.

Debris Flow: Deposition

Process of sedimentation of solids transported by debris flows outside the channel.

Woody debris: types of sources



(1) Tree in channel

(2) Tree on river bank

(3) Tree on channel slope

(4) Tree in transport zone

(5) Tree can reach channel slope

(6) Tree on landslide

(7) Tree out of reach

Driftwood: Clogging

During flood events, wildwood often causes problems due to **blockages** at narrow points. The most important effects are

1. Blockages or temporary obstructions or obstructions to the flow of water and debris can favour the formation of debris flows.
2. Blockages at bridges, culverts and hydraulic bottlenecks.
3. The breakout of the runoff from the channel area with subsequent deposits and debris flows, in particular on the torrent alluvial cone.
4. Partial or complete clogging of open-crown bedload retention barriers and flood retension systems, whereby an intended effect with regard to bedload transport/flood discharge is impaired or completely prevented.

Woody debris: Breakage due to jamming

Trees that slide down the slope or fall into the channel due to windthrow can dam up water during heavy rainfall, break open and trigger a runoff surge that far exceeds the normal flood discharge.

Boulders sliding in from the slope can also form blockages. The main problem is the risk of lateral bypassing of the drainage obstacle, which causes lateral erosion.


Thanks for your attention!