CGEO UNAM 2017

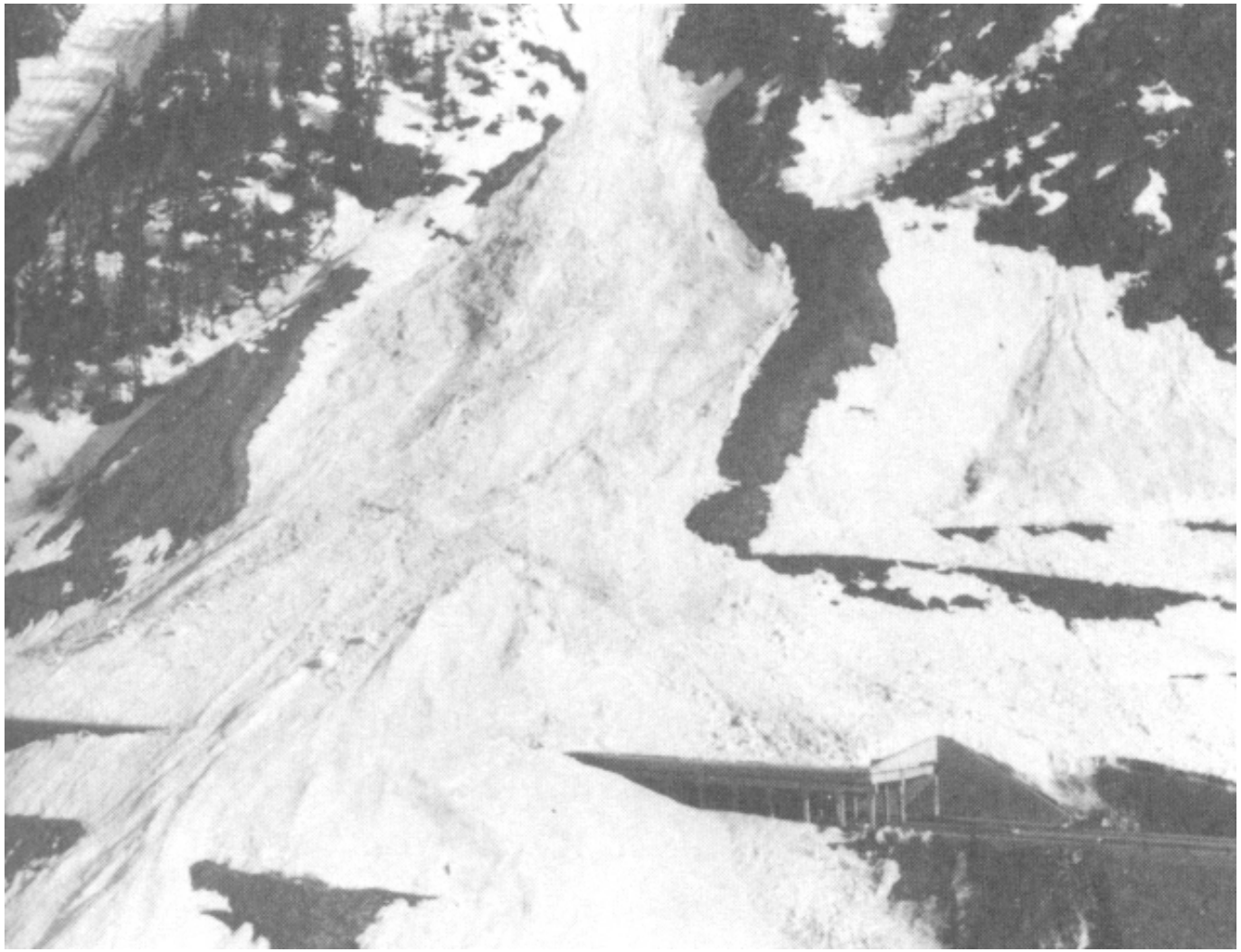
Curso de sismologia ambiental

Características, tipologías e impacto de los Procesos Geológicos Superficiales (PGS)

4 – Snow avalanches

Velio Coviello -
vcoviello@geociencias.unam.mx

Snow avalanches



Avalanches were first imagined as **giant snowballs** which increased in size from accretion of underlying snow

What are avalanches?

- They are **rapid downslope movements of snow, ice, rock, or soil**
- The driving force is Gravity

- They can be **channelized or unconfined**
- They may travel as coherent block or disaggregate into small particles

Avalanche impact

Direct effects:

- impact
- Burial

- Most fatalities were people killed while building railways (e.g., Canadian Pacific Railway, 1886)

- European issue: high population density in the Alpine region

Avalanche impact

Indirect effects:

- Traffic delays and economic losses
- Property damage
- Forests damage: uprooting, breaking trees
- Tsunamis generated if an avalanche enters a lake

Avalanche Triggering

- Naturally: after snow storms or normal daytime heating upper part of the snowpack.
- The person's weight increases the shearing force in the weak layer triggering failure
- Intentionally with explosives, as part of avalanche-control programs

Avalanche Zones

- **Starting zone:** where the snow pack fails
- **Avalanche track:** along which the avalanche accelerates and achieves its highest velocity
- **Runout area:** where the avalanche decelerates and snow is deposited

Starting zone

Gravity and slope gradient controls the avalanche triggering:

- shear strength (stay force)
  internal resistance to movement or force of cohesion and friction

- shear stress (go force)
  force causing movement parallel to slope increases with slope angle

At a certain point, the shear stress (go force) exceeds the shear strength (stay force) and the failure of the mass occurs

Slope Angle

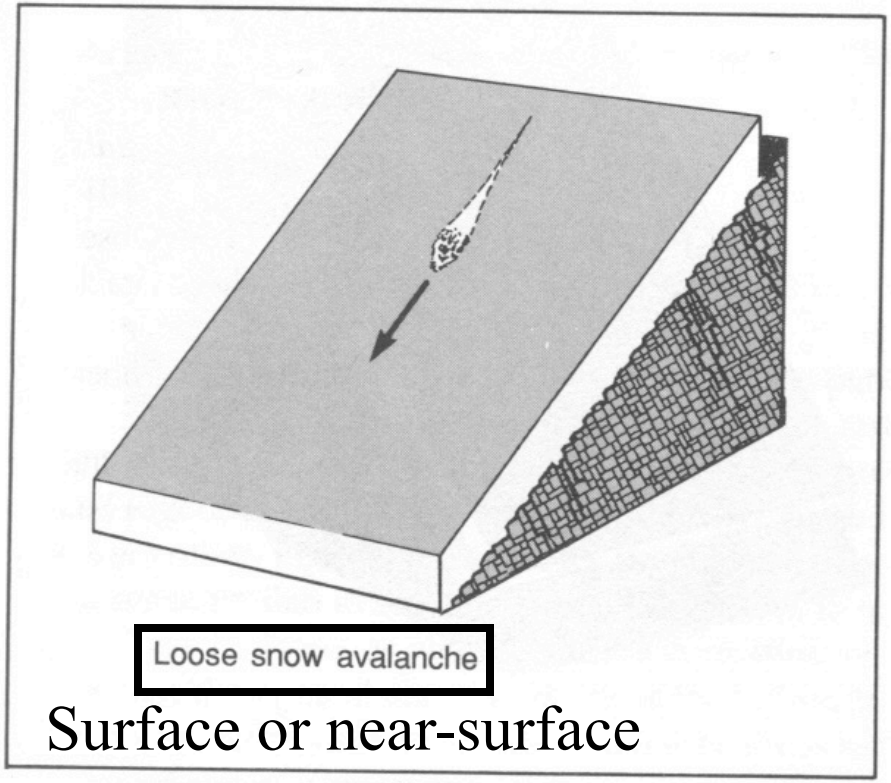
- Most avalanches (slabs) are released from slopes between 30 and 45 degrees
- Slopes less than 25 degrees and steeper than 60 degrees have a very low avalanche risk.
- Wet snow slides, can happen on slopes less than 25 degrees. They contain liquid water between the grains of snow.

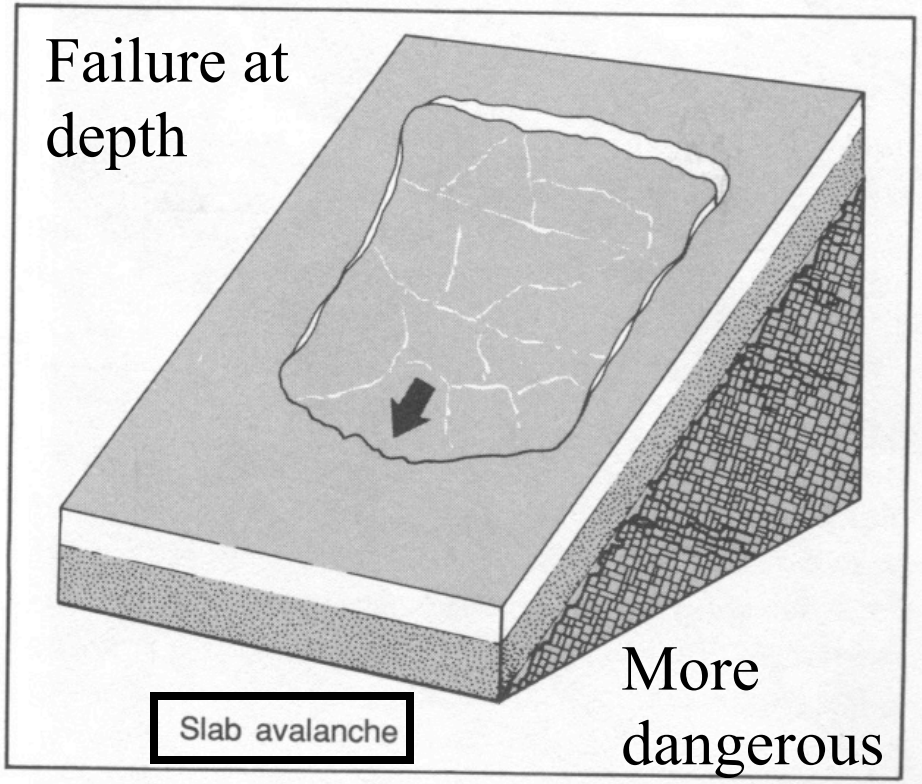
Avalanche Initiation

1 - Point release avalanches (loose snow): initial failure of a small amount of snow. More snow is incorporated into the avalanche as it moves downslope.

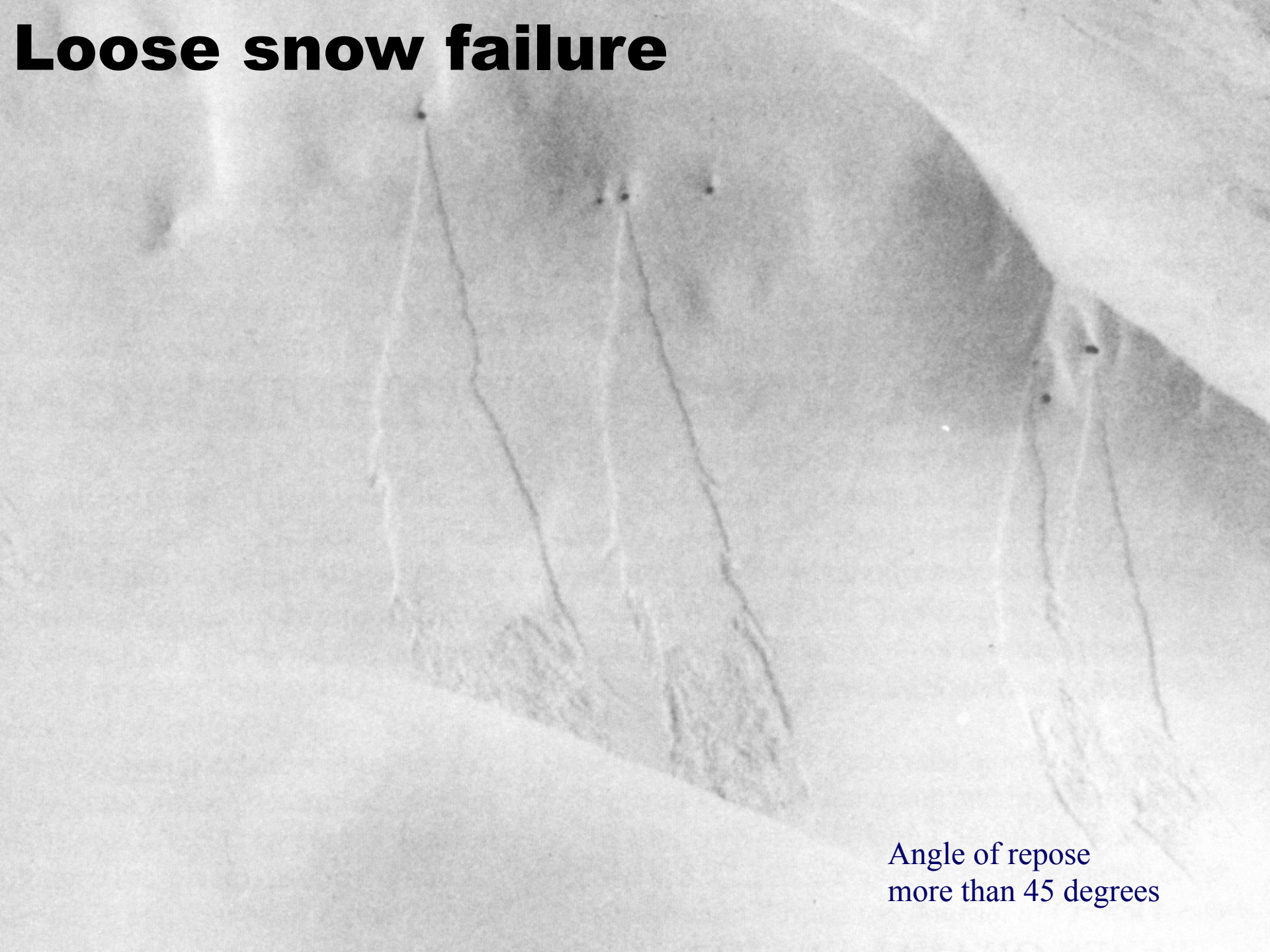
2 - Slab avalanche begins with fracturing of the snowpack along a weak layer at depth. Gravity causes the snowpack to move downslope with the top moving faster than the bottom.

Initial failure - two types





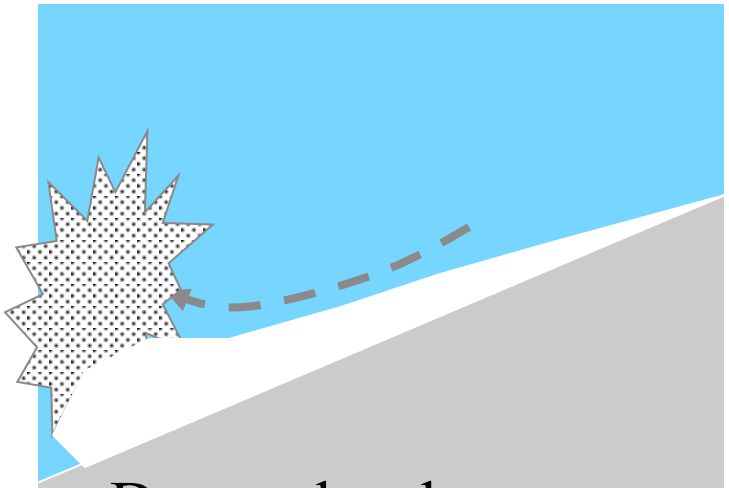
Loose snow failure



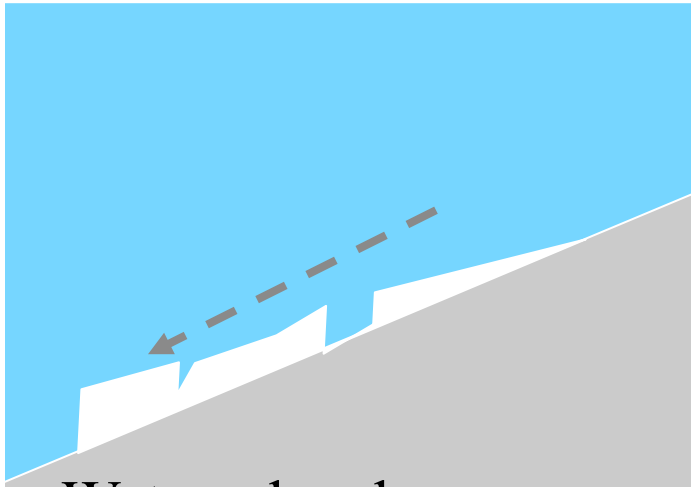
Angle of repose
more than 45 degrees


Slab failure

Slab avalanches: dry and wet

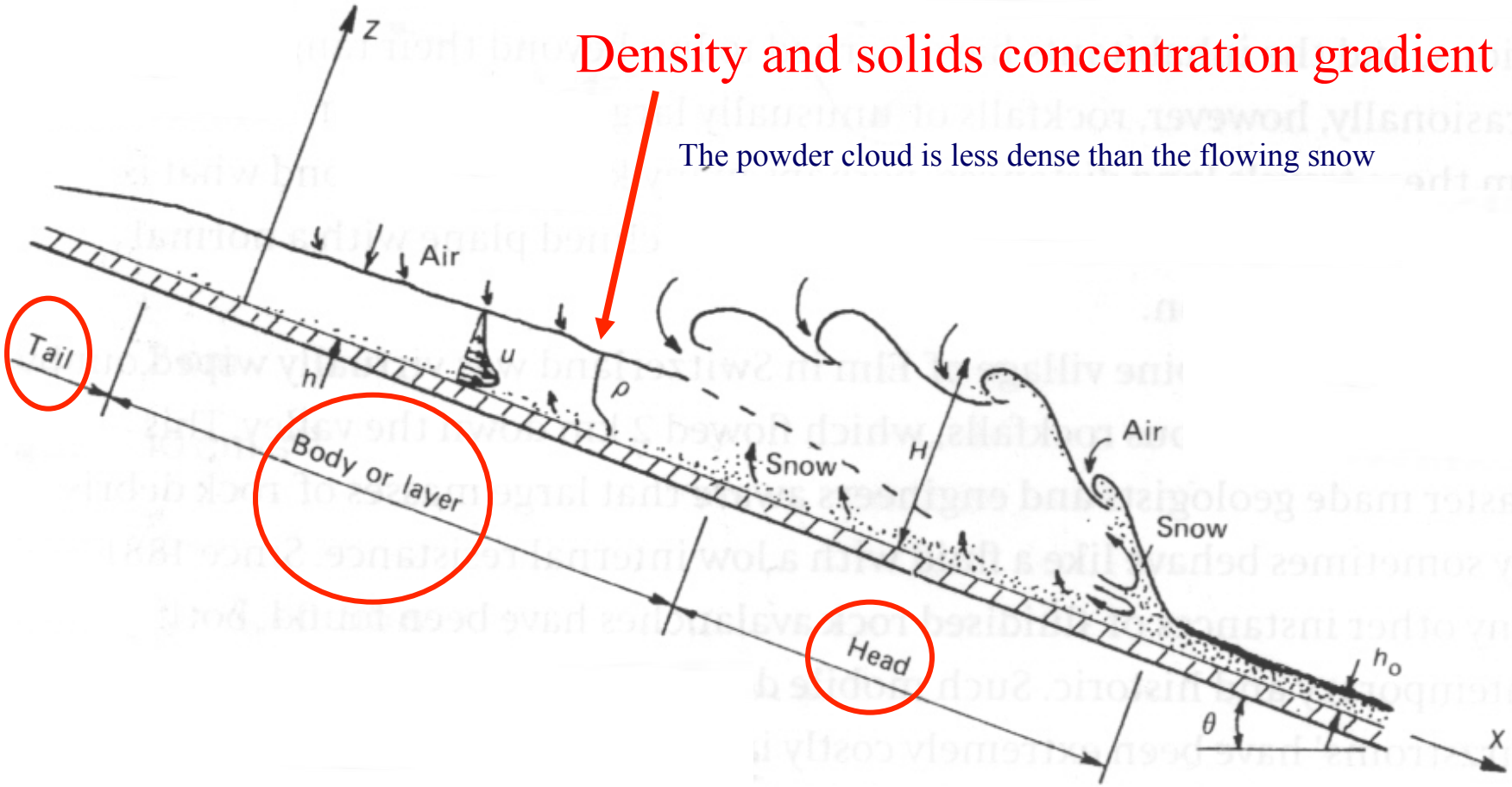


Dry avalanches move
at 100-300 km/h;
develop powder clouds



Wet avalanches move
at 50-100 km/h;
(denser & slower)

Internal structure of the flow



2 types of snow avalanche (a spectrum exists):

- flow avalanches (often constrained by a valley)
- airborne powder snow avalanches

Flow avalanches

- Velocities up to **200 km/h**
- Flow heights up to 10 meters
- Collisions of particles - granular flow

- Initially tends to slide as a **rigid body** (similar to a landslide)…
- …but rapidly breaks up into smaller particles and becomes a granular **flow**

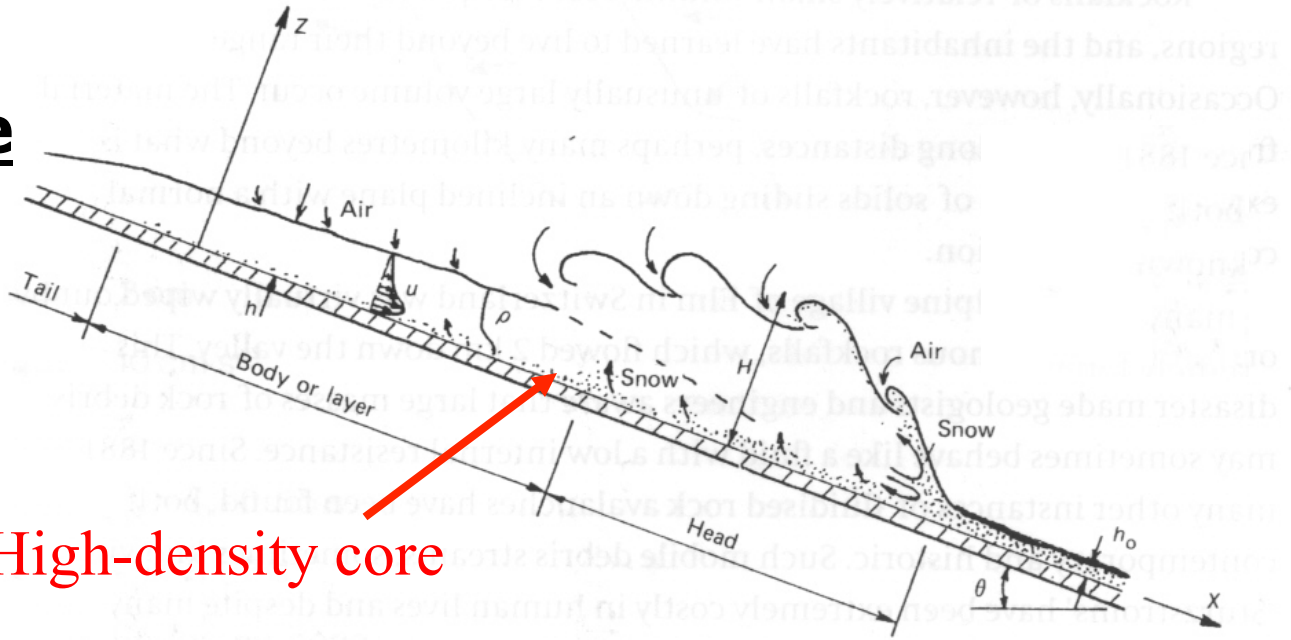
Interior of the flow

- There is a **high-density core** near the base of the flow

- In this zone, particles collide, resulting in friction and producing **heat**

- When the avalanche flow stops, freezing can occur, making the deposit very **hard**

- sets like **concrete**



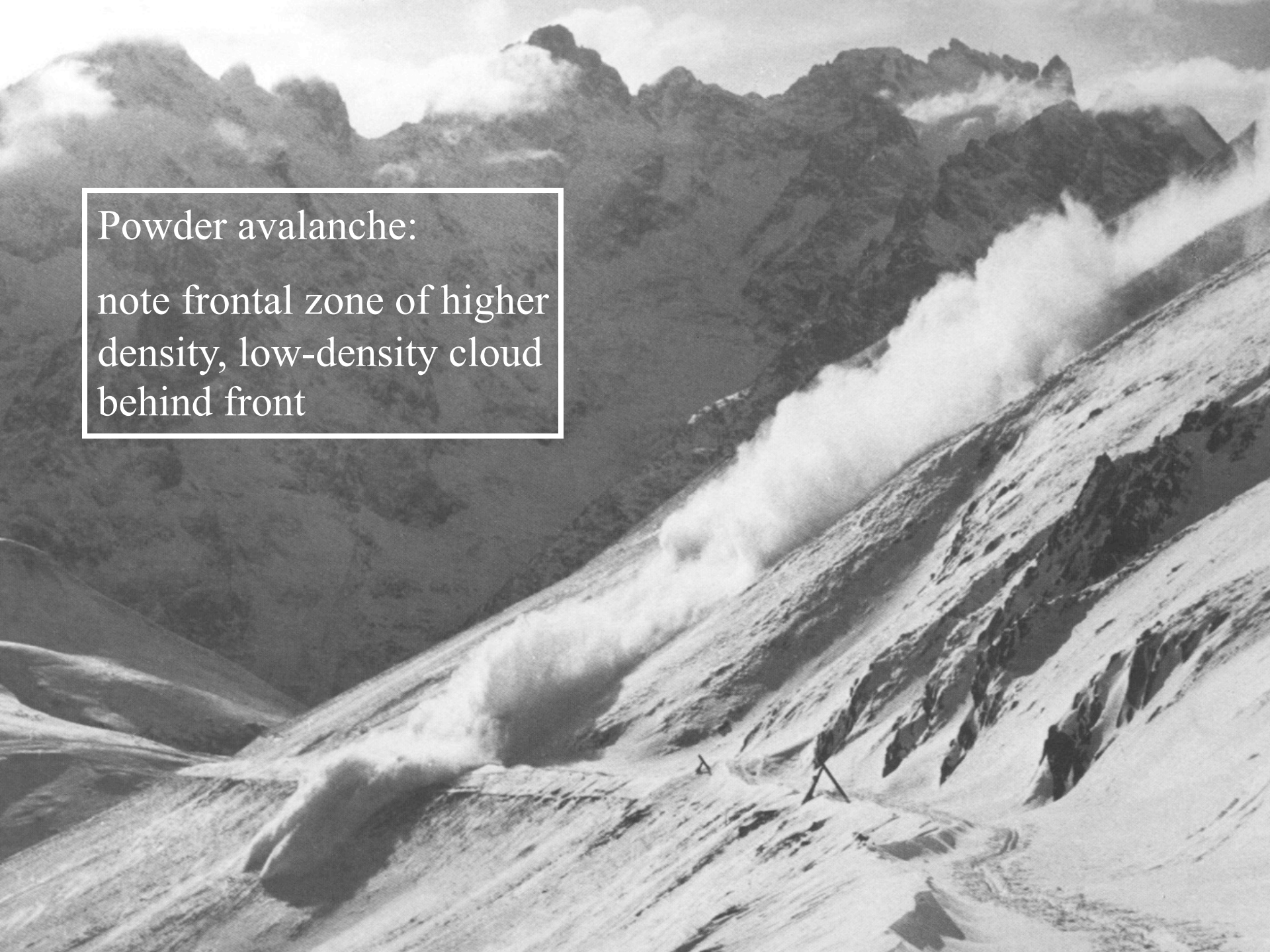
Mixed flow-powder avalanche

Above 35 km/h flow avalanches generate a snow powder cloud, much less dense than the flowing mass.

Powder snow avalanches

- Velocities can exceed **300 km/hr**
- Flow thicknesses may exceed **100 meters**

- Essentially a highly dilute density current flowing down an incline:
  1. partial entrainment of underlying snow by turbulent, erosive flow
  2. dense core small or absent
  3. powder avalanches may develop from flow avalanches, but the mechanisms are not well understood

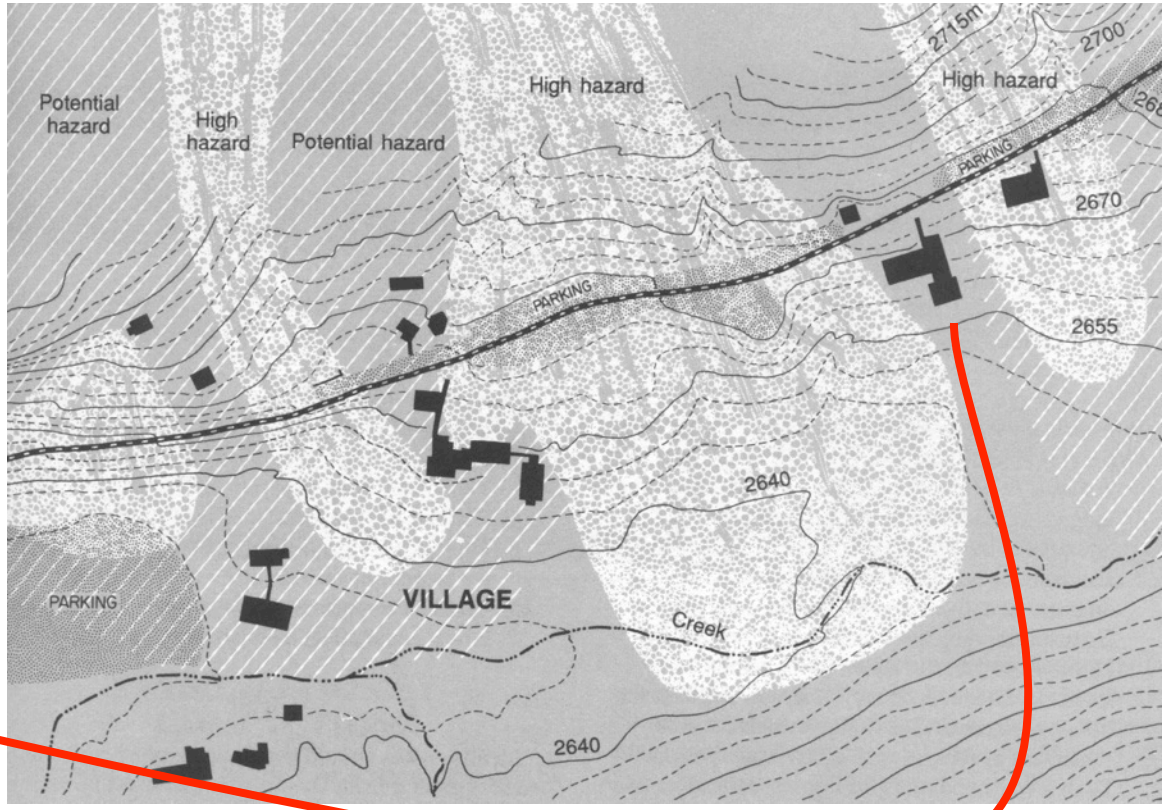

Powder avalanche:
note frontal zone of higher density, low-density cloud behind front

Mitigation measures

- **Avoid** steep slopes, gullies
- **Close** high-hazard areas to reduce risk and vulnerability
- **Set off explosive charges** to artificially induce avalanches and remove the source material (unstable snow)

HAZARD MAPS

Example from Alta, Utah: Avalanche Risk can be estimated by determining the distribution, frequency, and sizes of avalanches in given area.



Engineering works

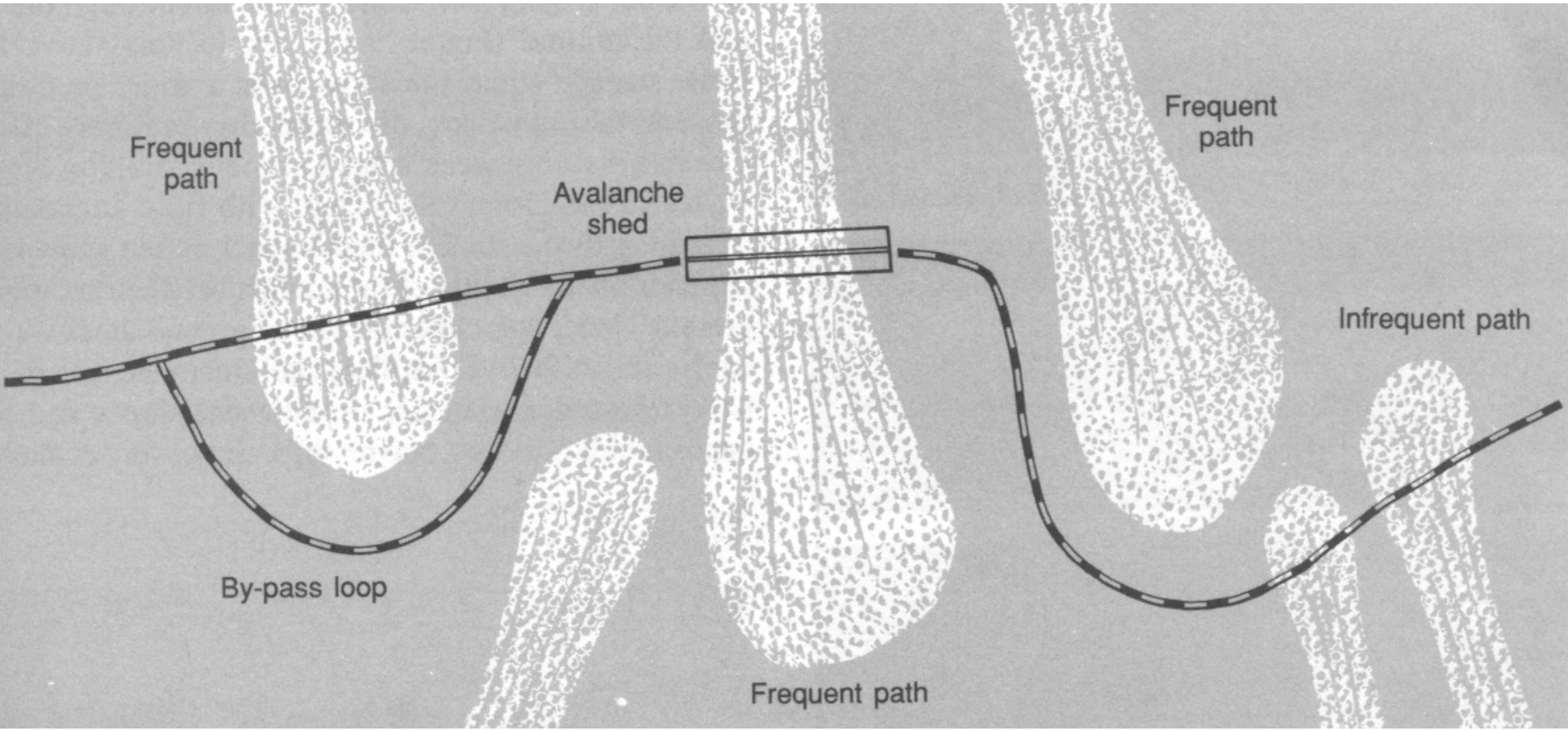
Reforestation:

- to stabilize slopes and snow
- to dissipate avalanche force impact

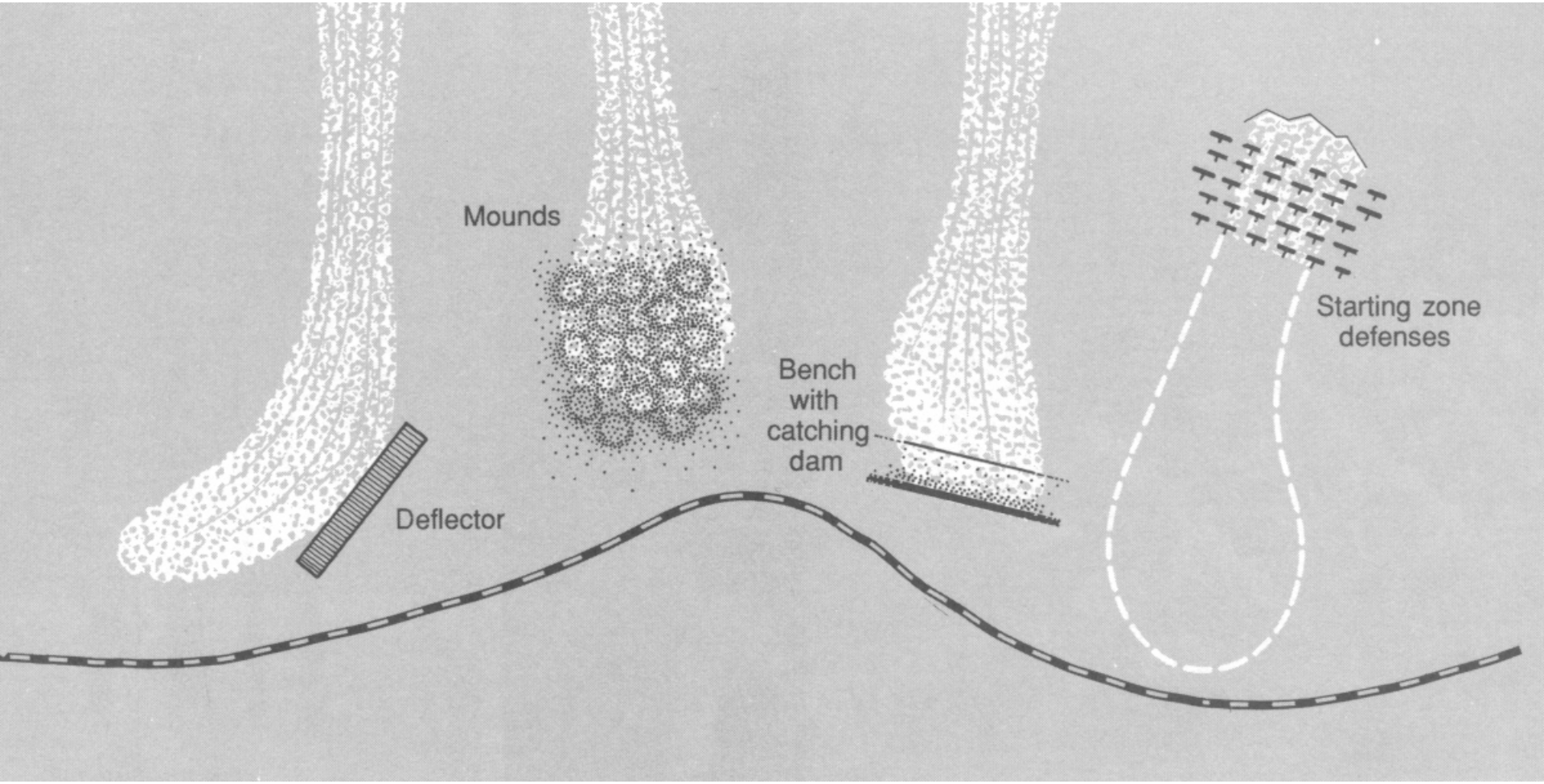
Highways:

- locate to avoid avalanche tracks
- use of defense structures: deflectors, mounds, benches with dams

Avalanche avoidance



Use of defense structures



Starting zone defenses

To help reduce avalanches using:

- terraces
- supporting structures

Starting zone defenses

Only practical for protecting inhabited structures, busy roads and critical infrastructure (not commonly used in America)

To help reduce avalanches using:

- terraces
- supporting structures

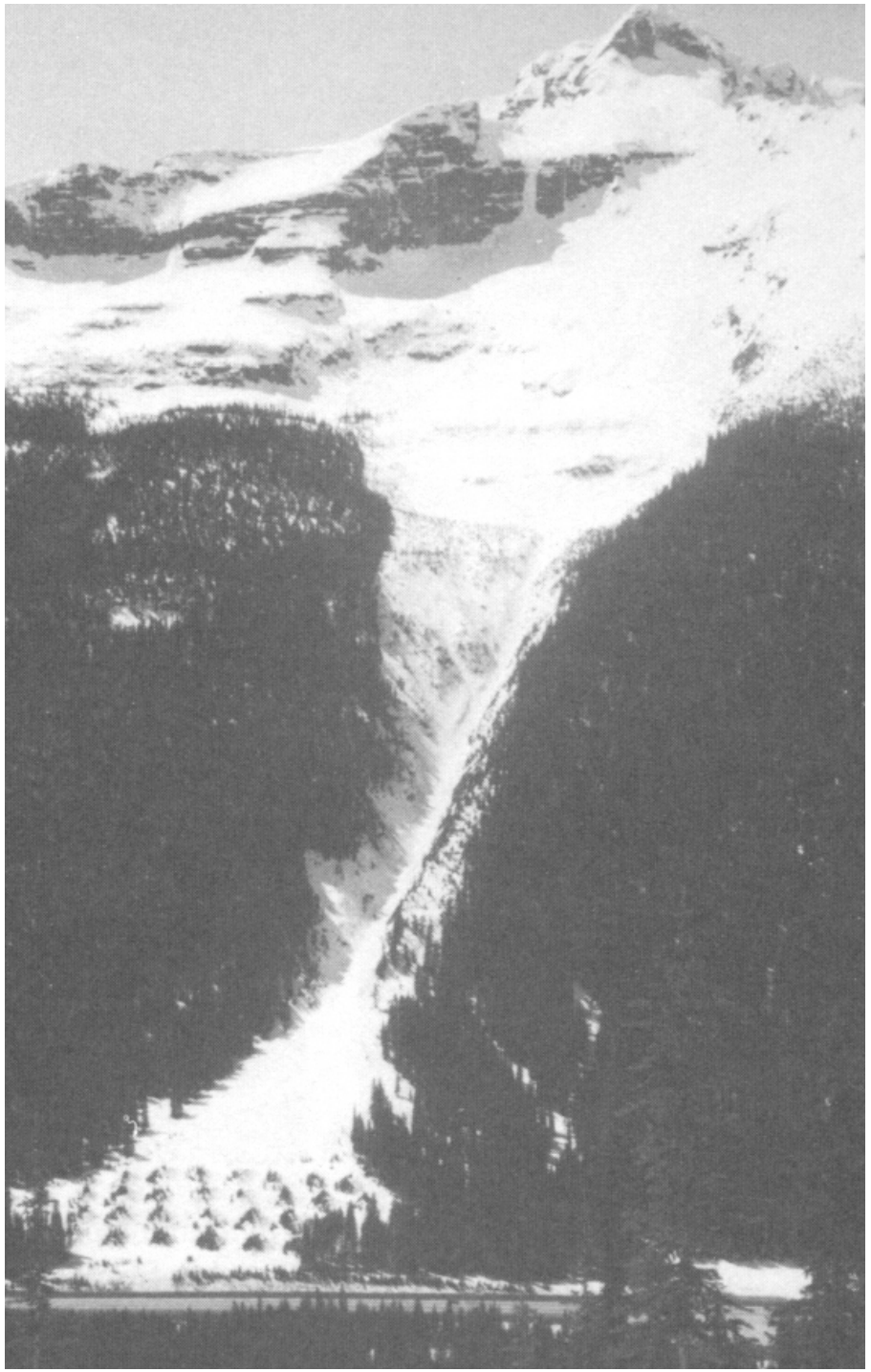

Supporting structures

Arresters

- Arresters are used to slow or stop avalanches
- need adequate height; if too low, flow can **accelerate** above barrier, increasing damage

Mounds

- These are used to retard flowing snow at the end of the runout zone
- Slow avalanches and reduce their run-out.



Snow sheds

- These sheds allow the avalanche to pass **over** the structure
- Run over the roads and railway