Skråninger

GEG2110 – Skråninger – slopes

Slopes and geomorphology

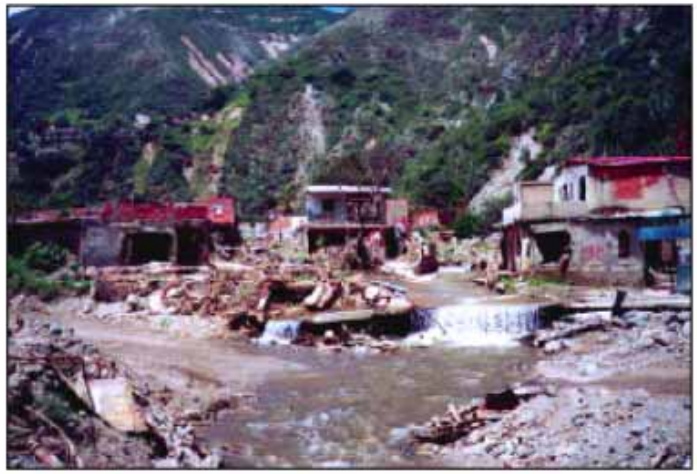
- Slope processes - ... ?
  - Geomorphological aspect
  - Geotechnical aspect
- General about slopes ...
  - Landscape development
  - Processes
  - Landforms
- Basal geotechnical fundamentals
  - Slope stability
  - Applications

GEG2110 – Skråninger – slopes

Slope processes - ...?

- Geomorphological aspect
  - Slopes as landforms
  - Slopes "process frontier" (-> Landscape)
- Geotechnical aspect
  - Slopes as underground for construction
  - Slopes as a potential risk moment
  - Stability ....

Example: Global Hotspot Project



(a) Venezuela, December 1999, mudslides and debris floods causing over 20 000 fatalities.

(b) Haiti, May 2004, slides and debris floods causing over 2 500 fatalities.

(c) El Salvador, January 2001, earthquake-induced landslide at Las Colinas causing over 600 fatalities.

ICG/NGI (F. Nadime et al.): Report to "Global landslide and avalanche risk hotspots"

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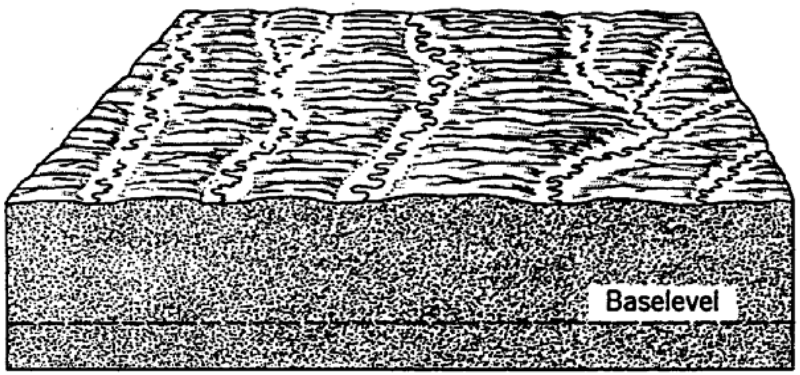
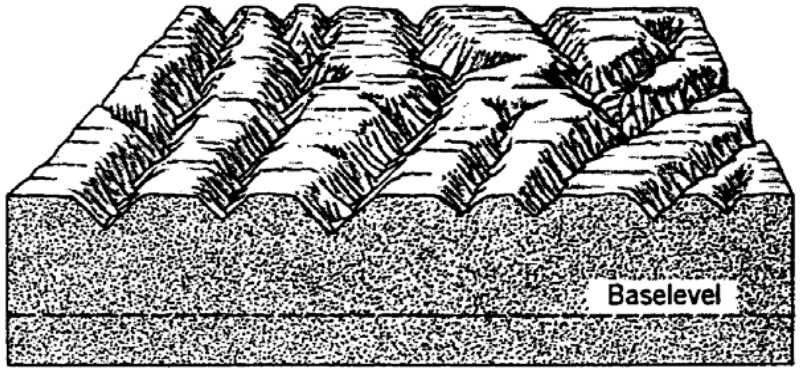
Landscape development

- Denudation cycle (continental scale)
  - Penck/Davis/Reusch
- Process pattern in modern environment (regional-local scale)
  - alpine/arctic area
- Characteristics of these areas
  - high climatic variability during Quaternary, glaciated
  - low temperatures today
  - high precepetation variability today
  - snow cover
  - no/low vegetation

Geomorphometrical description of the earth's surface

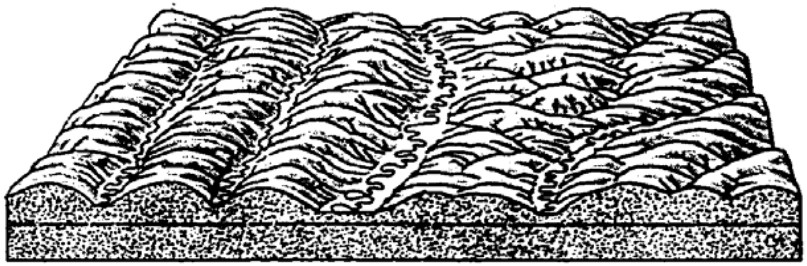


A

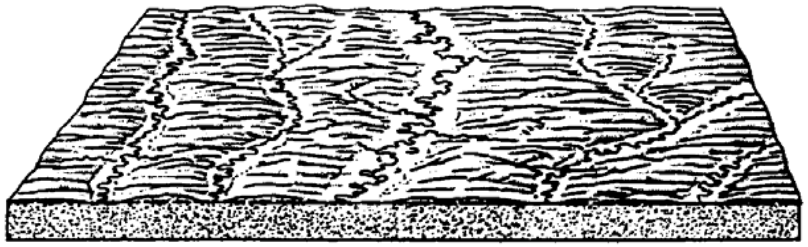


B

C



D



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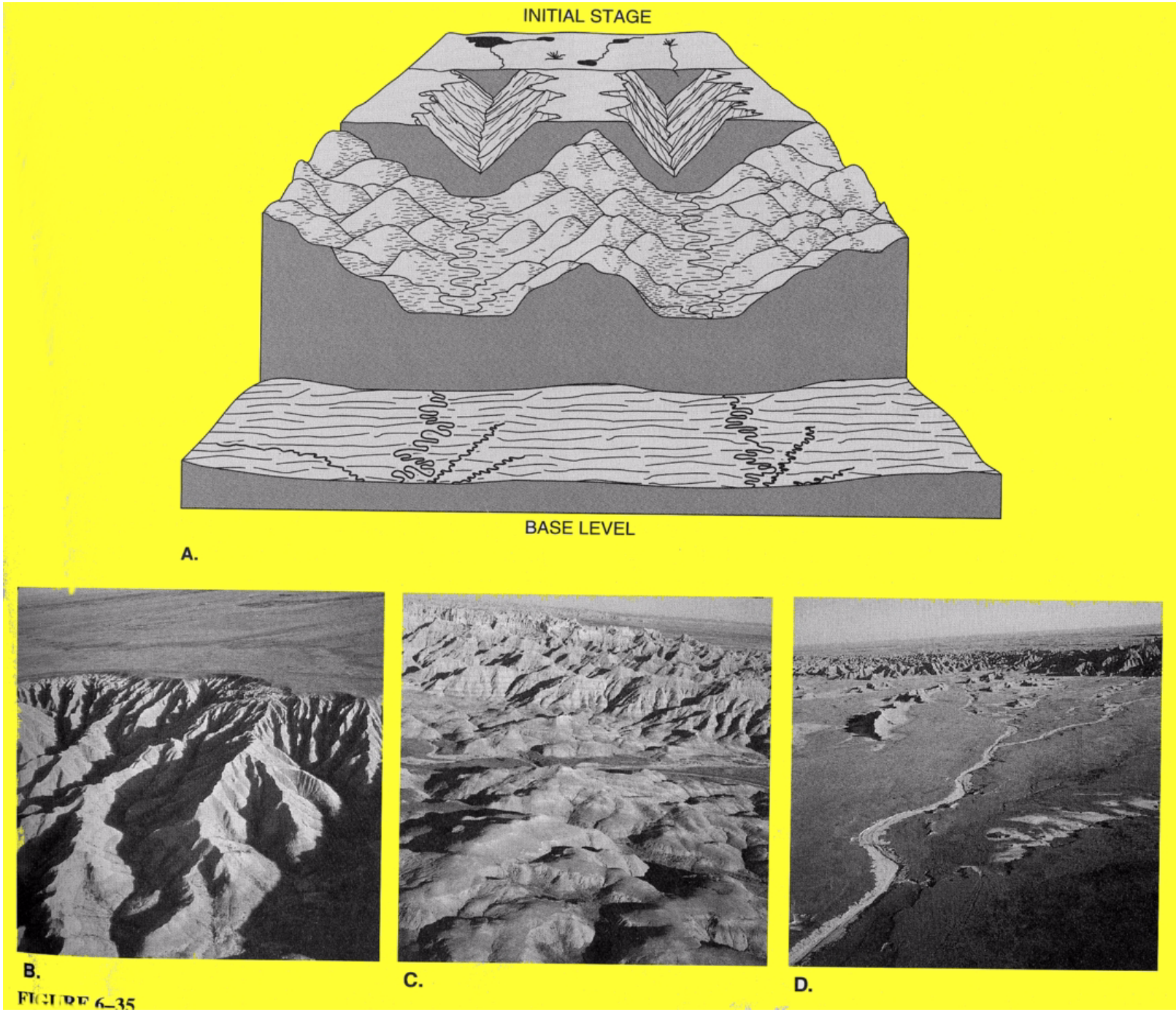
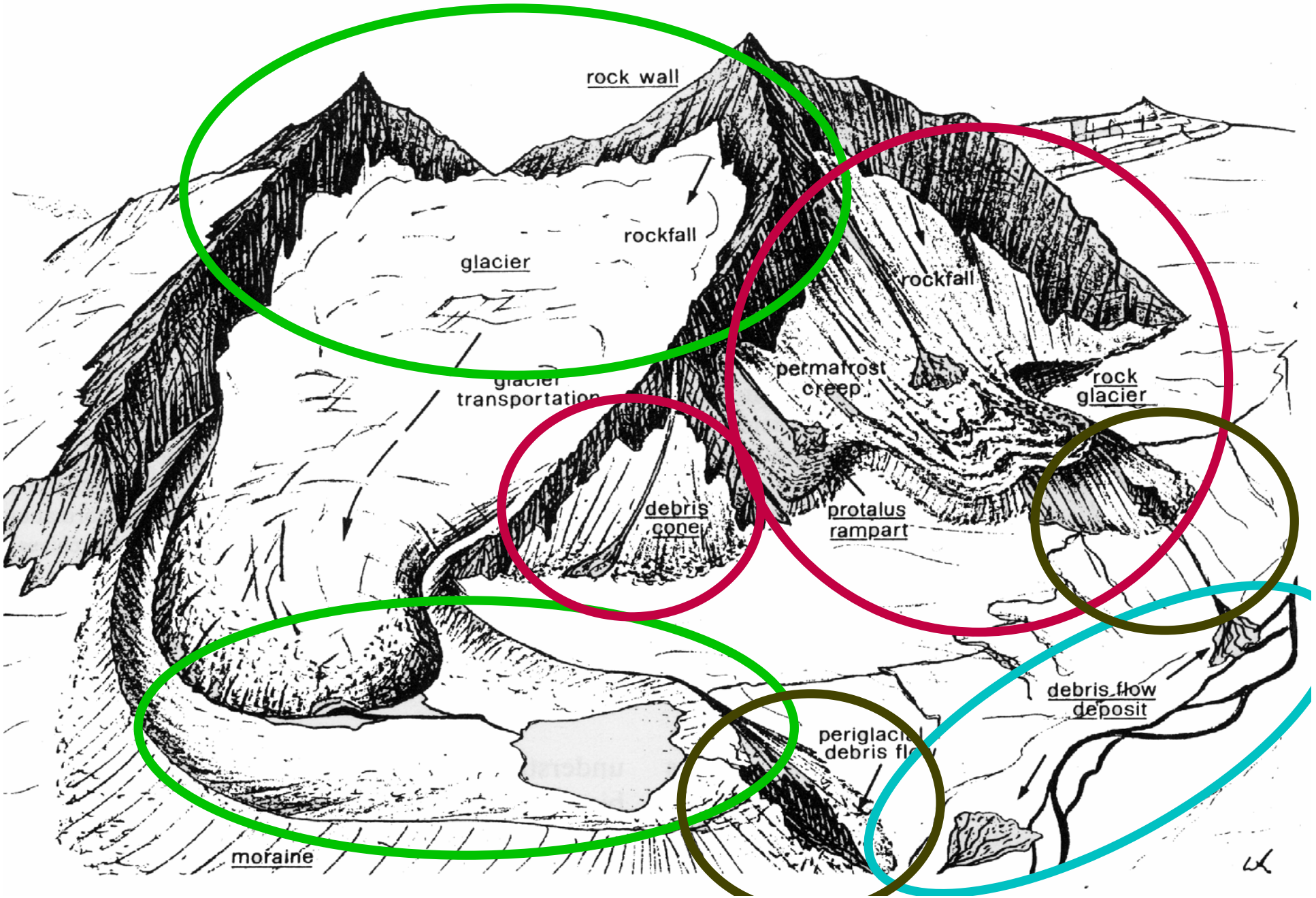


FIGURE 6–35

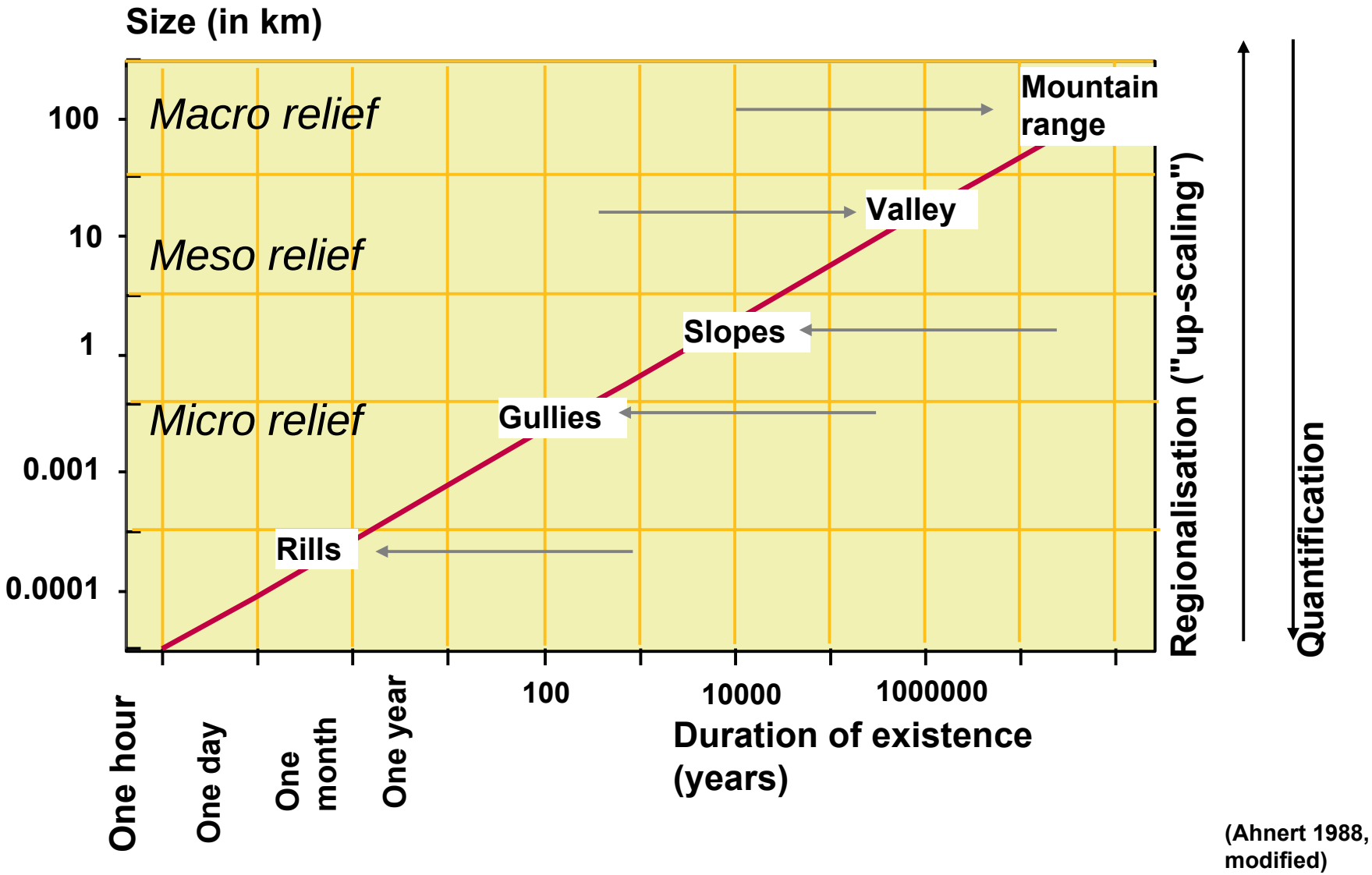
GEG2110 – Skråninger – slopes

Landscape development

- Denudation cycle (continental scale)
  - Penck/Davis/Reusch
- Process pattern in modern environment (regional-local scale)
  - alpine/arctic area
- Characteristics of these areas
  - high climatic variability during Quaternary, glaciated
  - low temperatures today
  - high precepetation variability today
  - snow cover
  - no/low vegetation


rock wall
rockfall
glacier
rockfall
permafrost creep
rock glacier
debris cone
protalus rampart
debris flow deposit
moraine

Landform hierarchy



(Ahnert 1988, modified)

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Processes

- Material production
  - Weathering
  - Inherited material
- Material relocation
  - Slope wash
  - Creep/solifluction
  - Solution
  - Land slide
  - Cliff / slope retreat
- Gravitaional processes
  - Fall
  - Slide
  - Flow
  - Creep

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Corresponding land forms

- Talus
- Lobes
- Levees
- Tracks
- Scars

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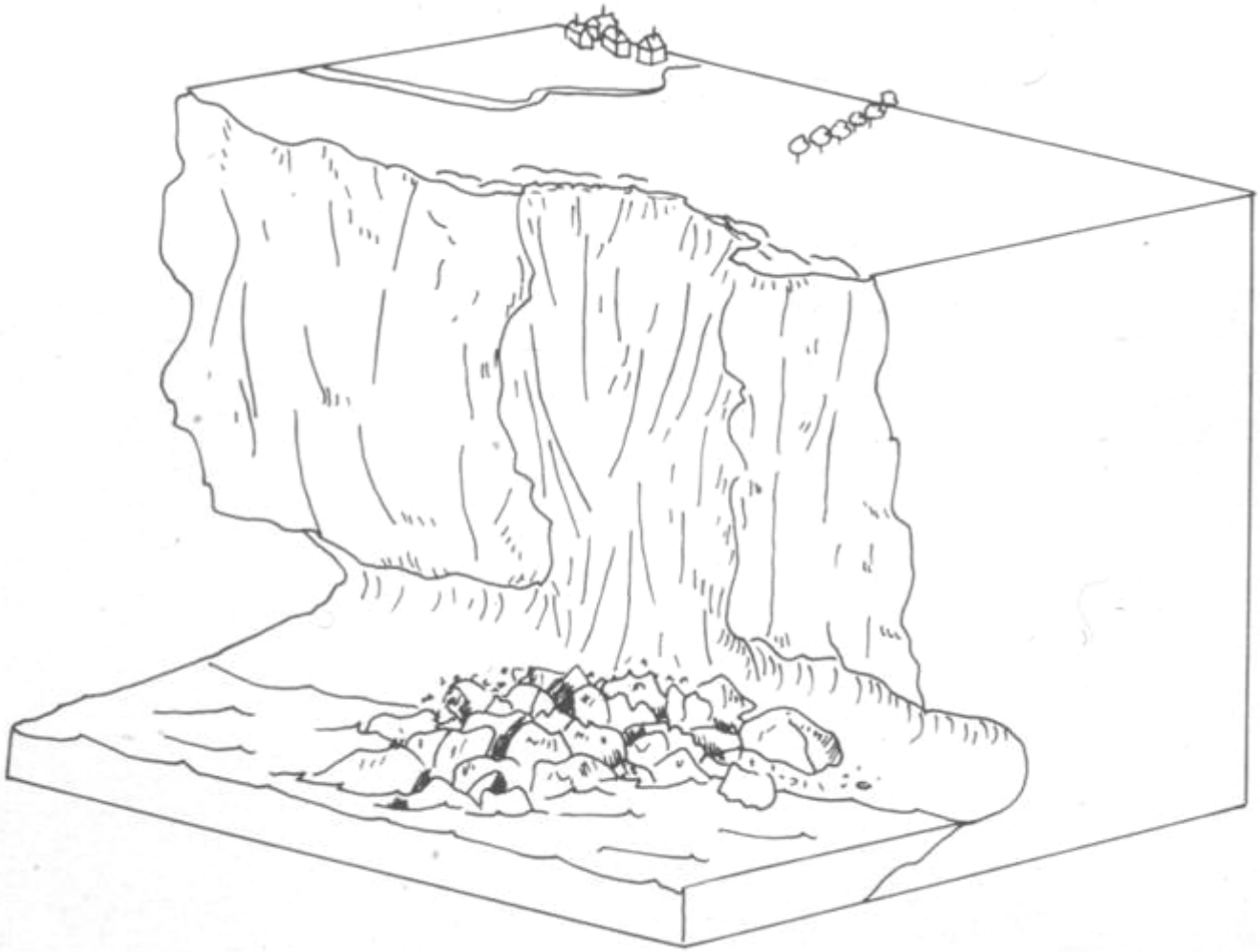

FIGURE 2.2 Block diagram of a typical coastal rock fall (drawn by B. Martin)

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Rock/ice slide modelling

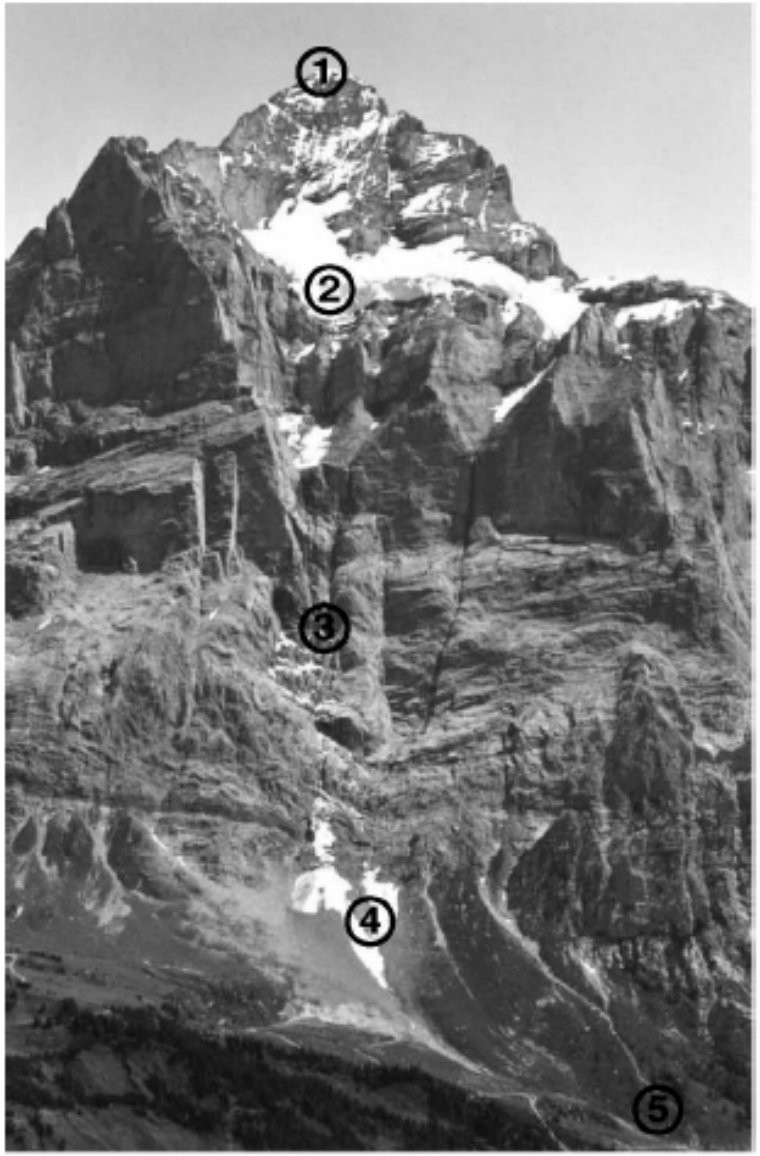

Fig. 1. Gutz Glacier (Bernese Alps, Switzerland), a typical situation of a cliff-type glacier. Wetterhorn (1), frontal cliff of Gutz Glacier (2), avalanche trajectory (3) with small deposits at the bottom of the rock wall (4), and the Grindelwald – Grosse Scheidegg road (5).

Salzmann et al. 2004

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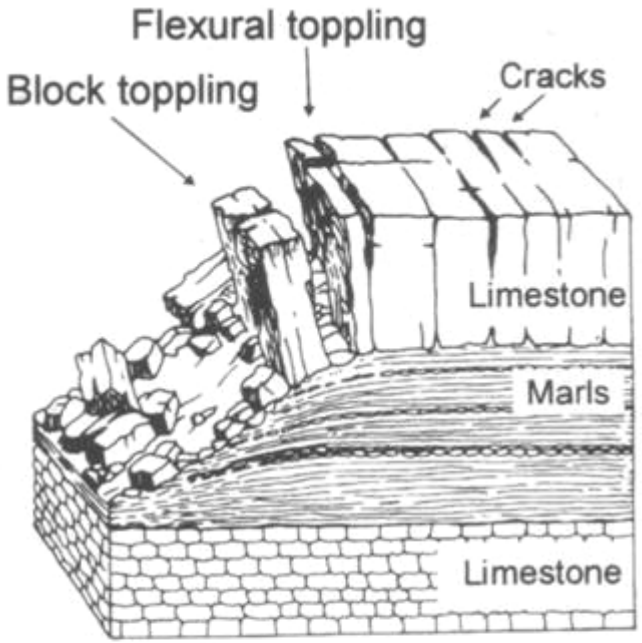

FIGURE 3.2 Typical block diagram of a topple on a Jurassic cuesta scarp slope. The geological situation is generally characterised by hard rocks (e.g. limestone) covering softer rocks (e.g. marls). The figure also illustrates that a topple is very often associated with other types of mass movement, like rockfalls (Chapter 2), rock spreading (Chapter 6.2), translational sliding along the base (chapter 5) and clay extrusion. Because movement takes place in the clays before large-scale slope failure, the required shear strength is reduced from the peak to the residual value

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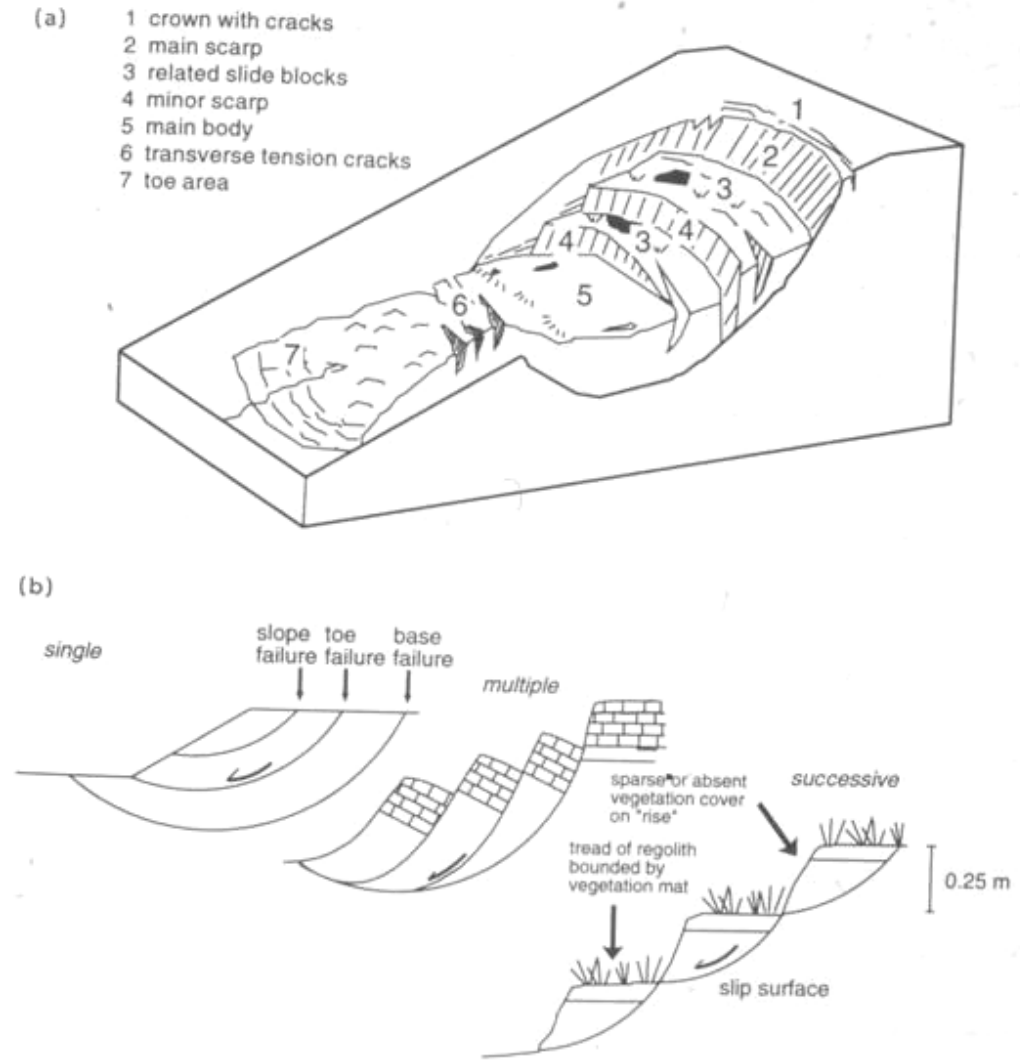

FIGURE 4.2 (a) Typical block diagram of a rotational slide. The important morphological features are marked (after Varnes, 1978). (b) Single, multiple (from Hutchinson, 1988, reproduced by permission of A.A. Balkema) and successive landslides (from Clawes and Comfort, 1982, reproduced by permission of Addison Wesley Longman Ltd)

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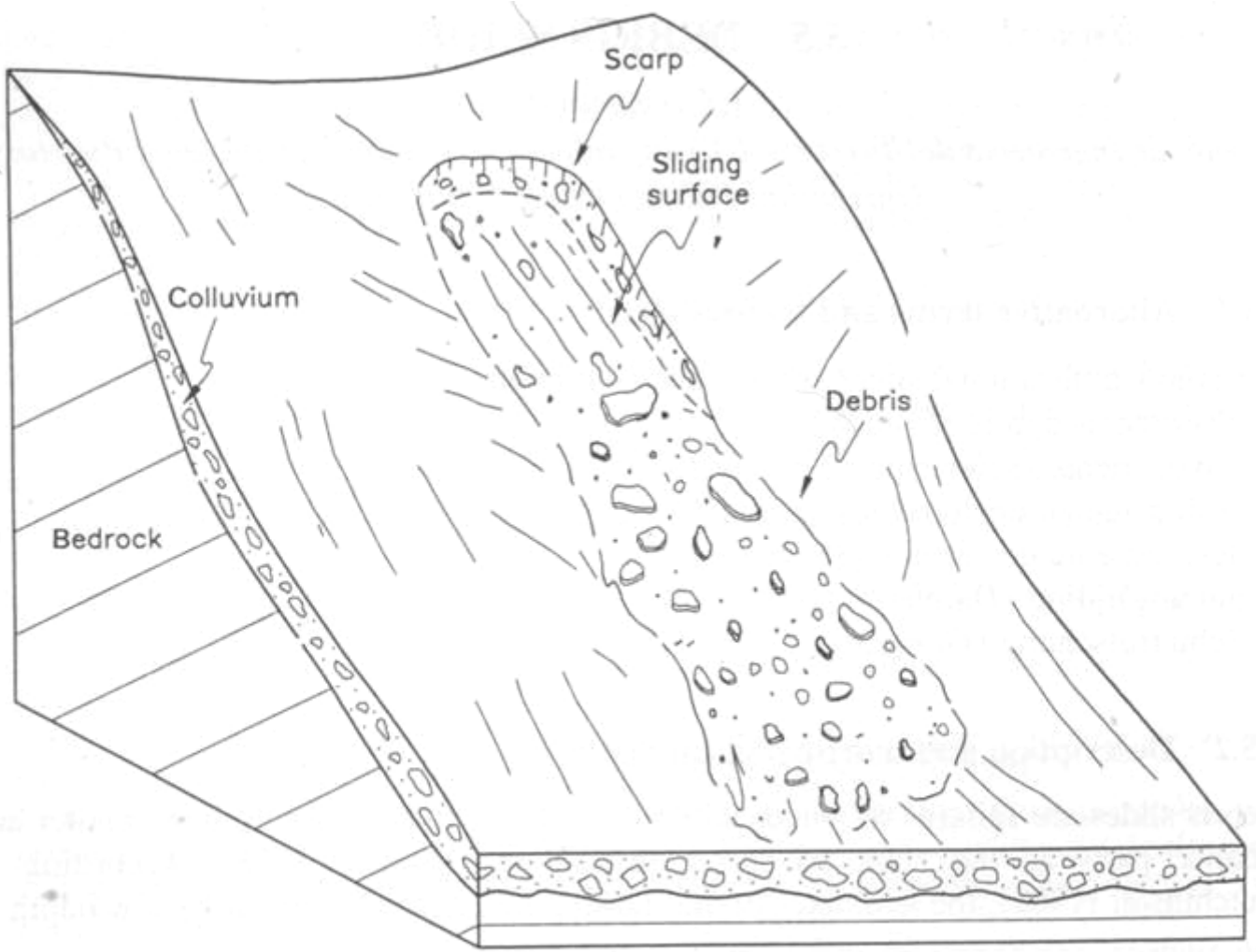

FIGURE 5.5.2 Interpretative block diagram of a debris slide showing the main morphological features

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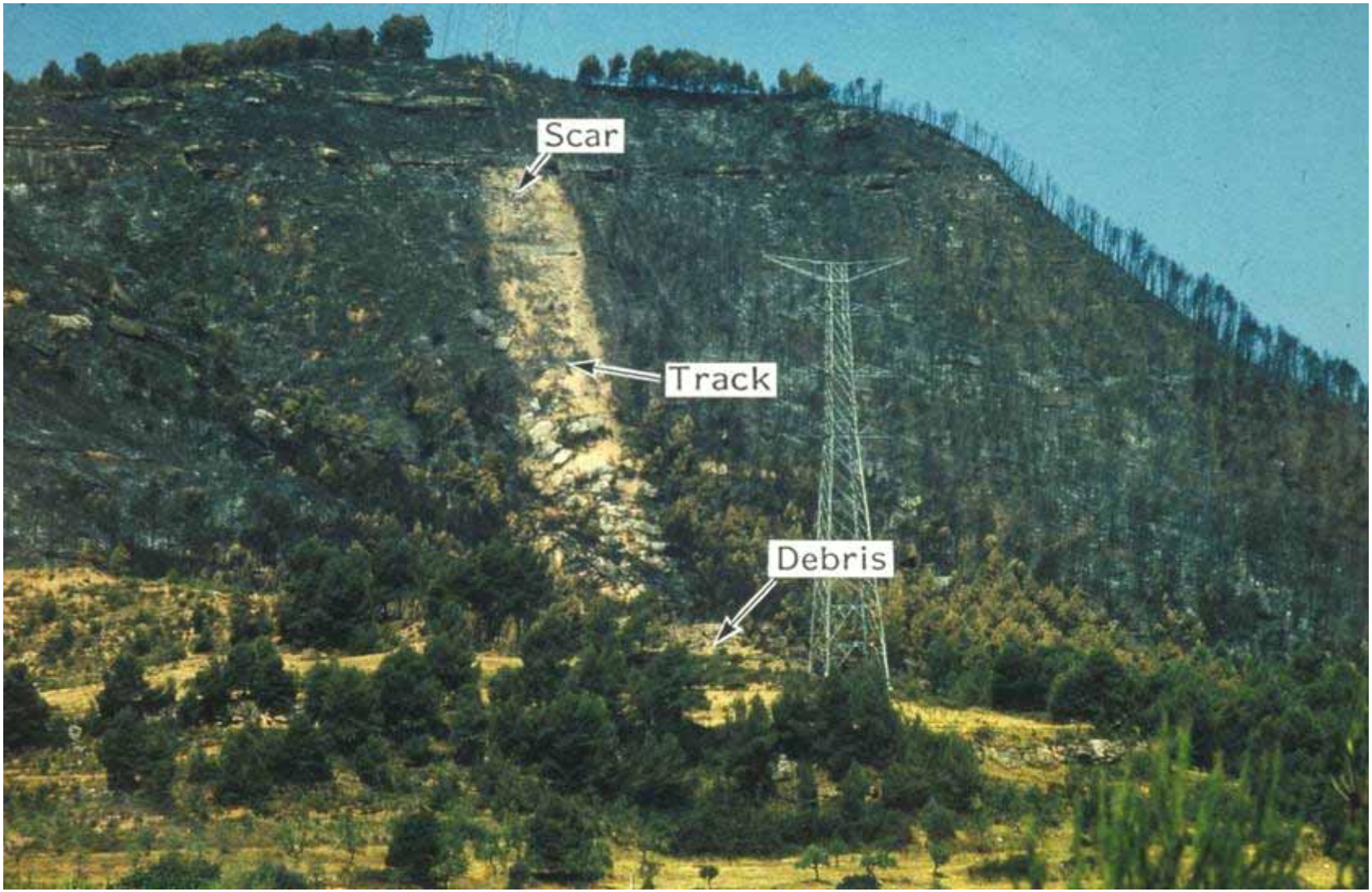

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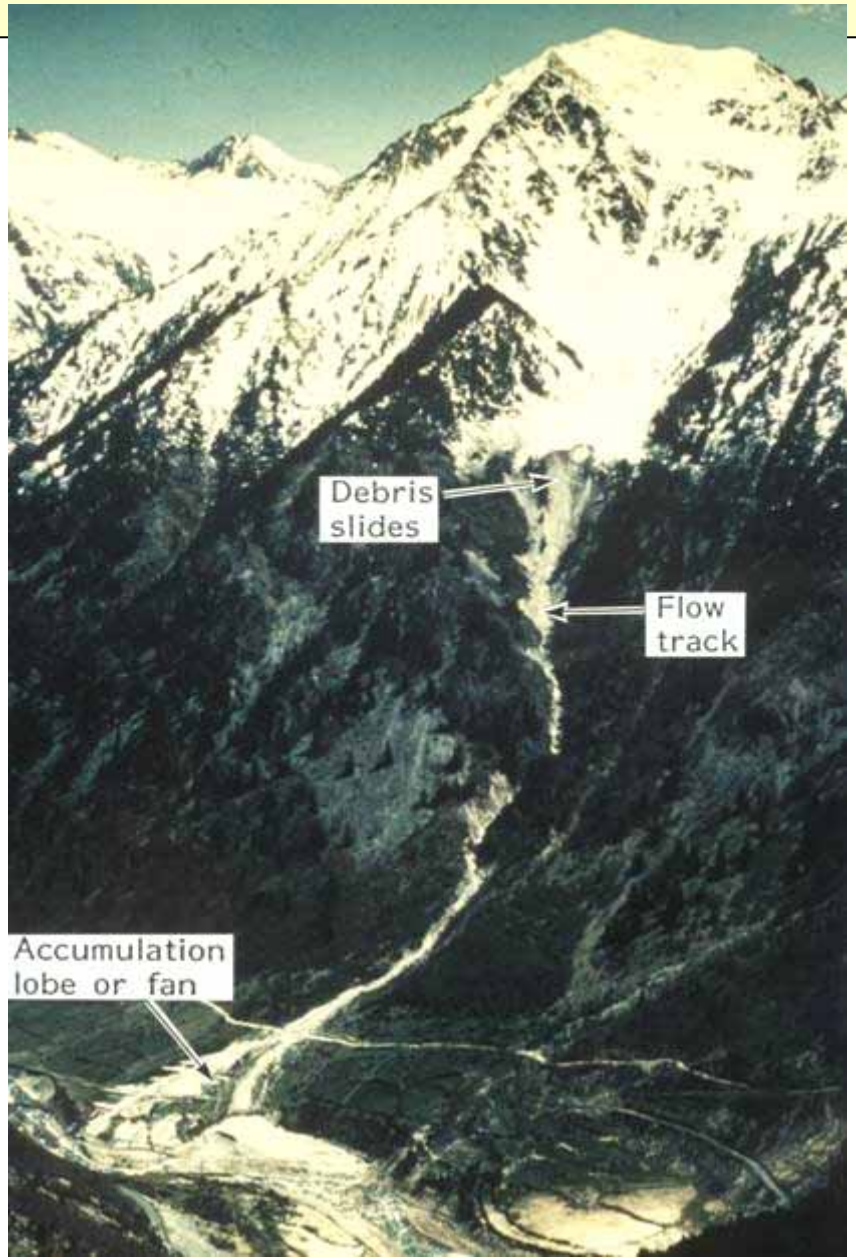

GEG2110 – Skråninger – slopes

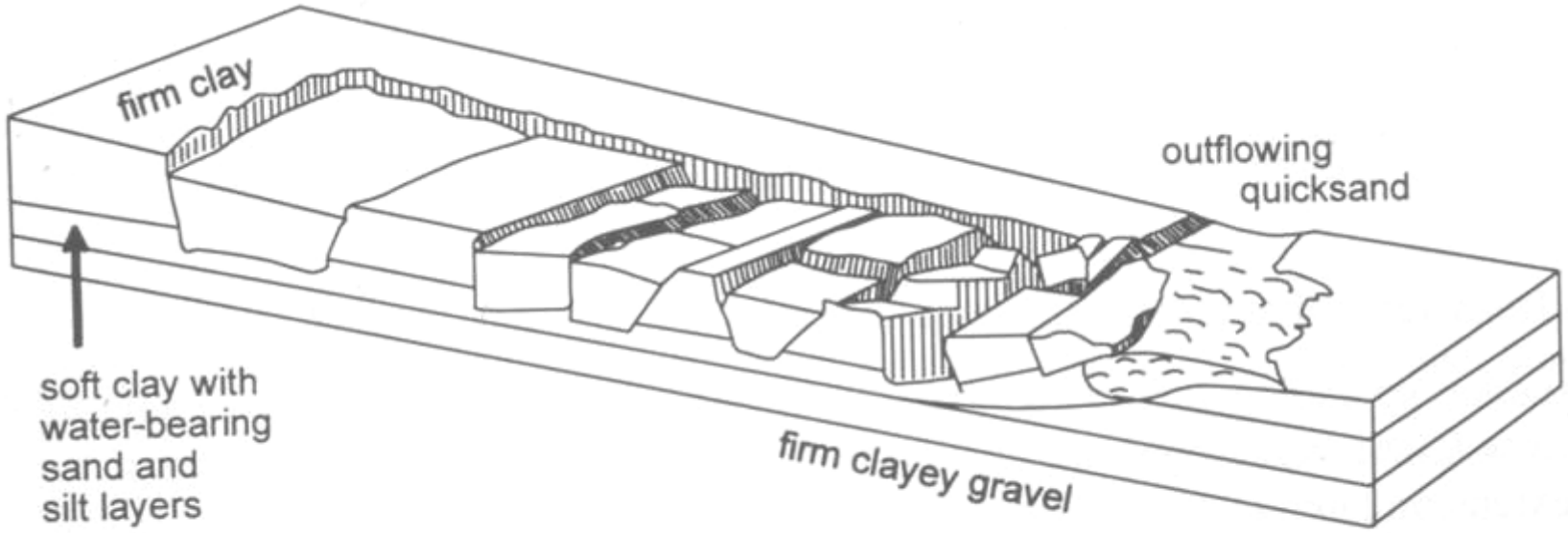

FIGURE 6.3.2 Block diagram of soil spreading failure in fine sand and silt seams (from Varnes, 1978, reproduced by permission of the National Research Council)

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GEG2110 – Skråninger – slopes

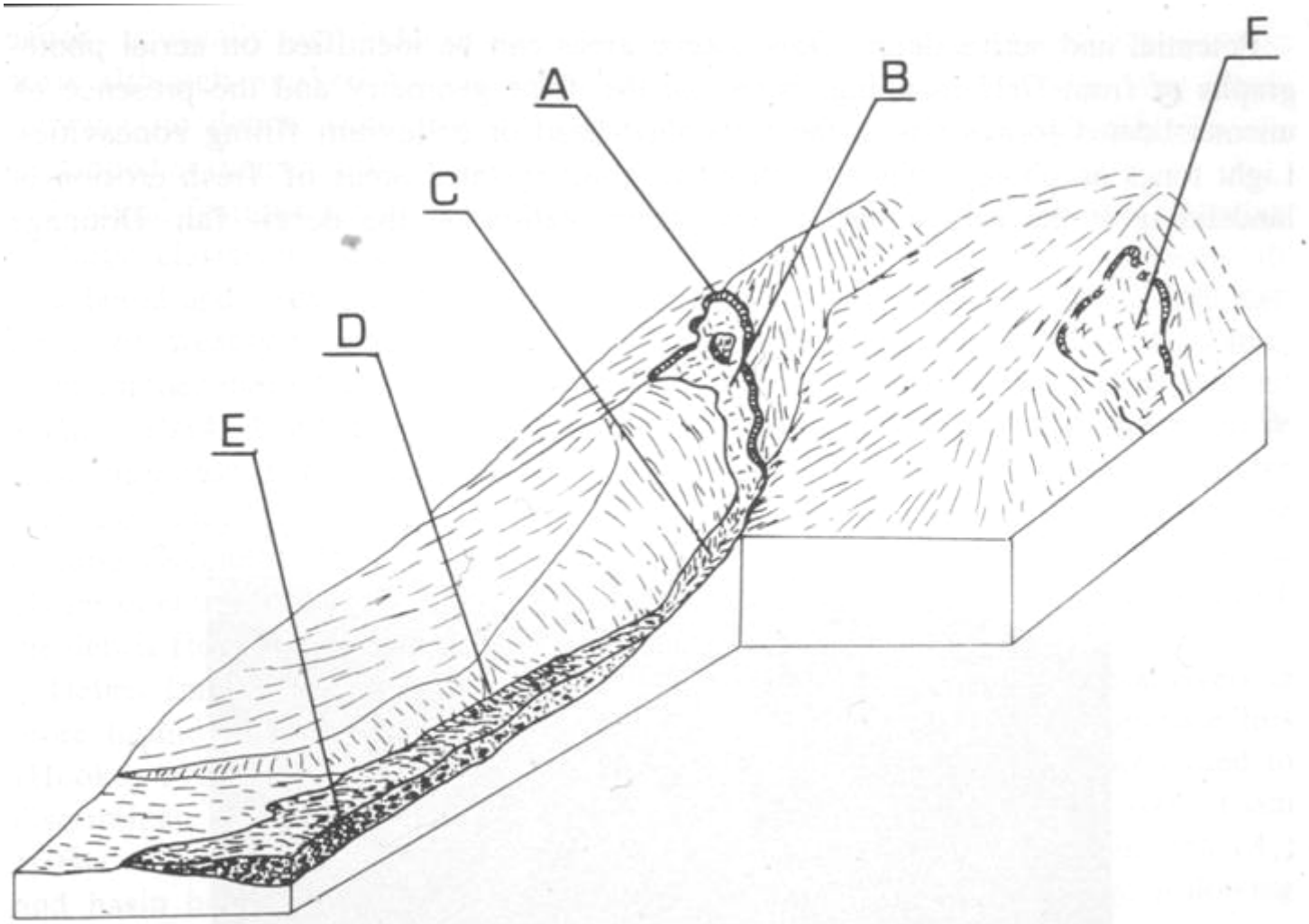

FIGURE 7.3.2 Interpretative block diagram of a debris flow showing morphological features: A, scarp; B and F, surface of rupture; C, channel of erosion; D, levee; E, deposit

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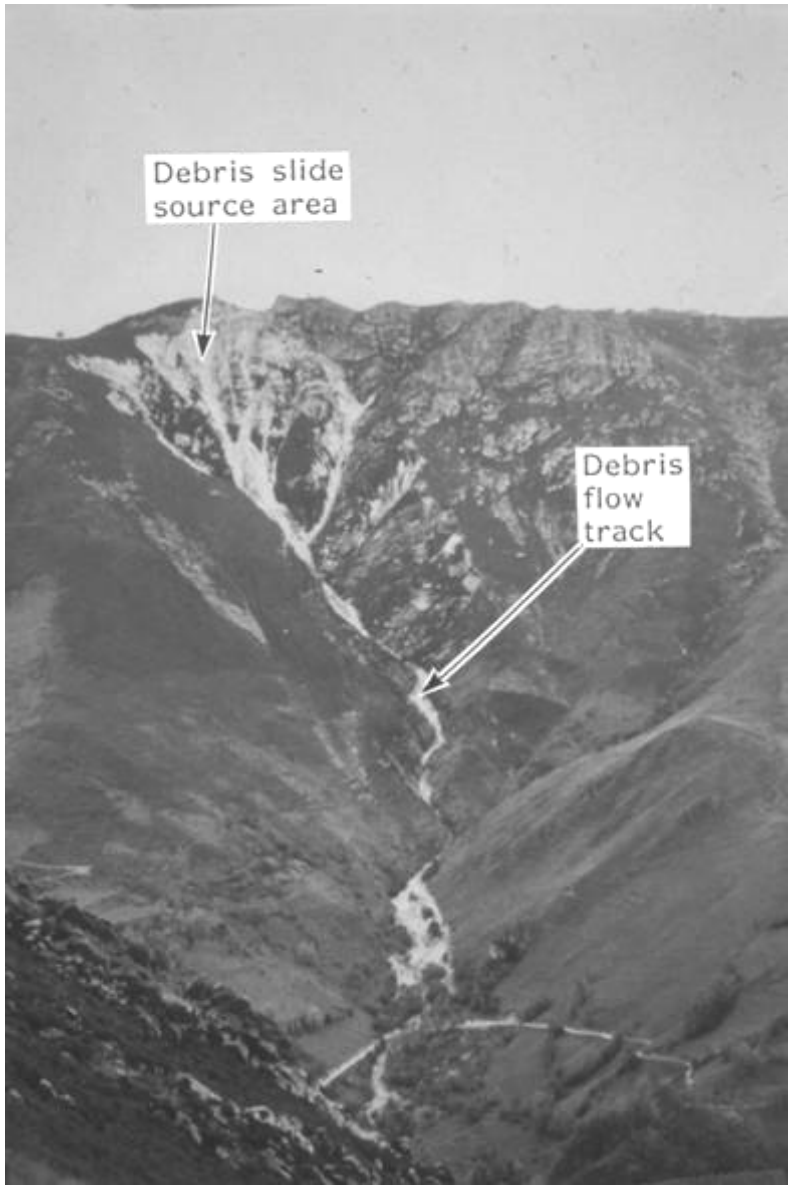
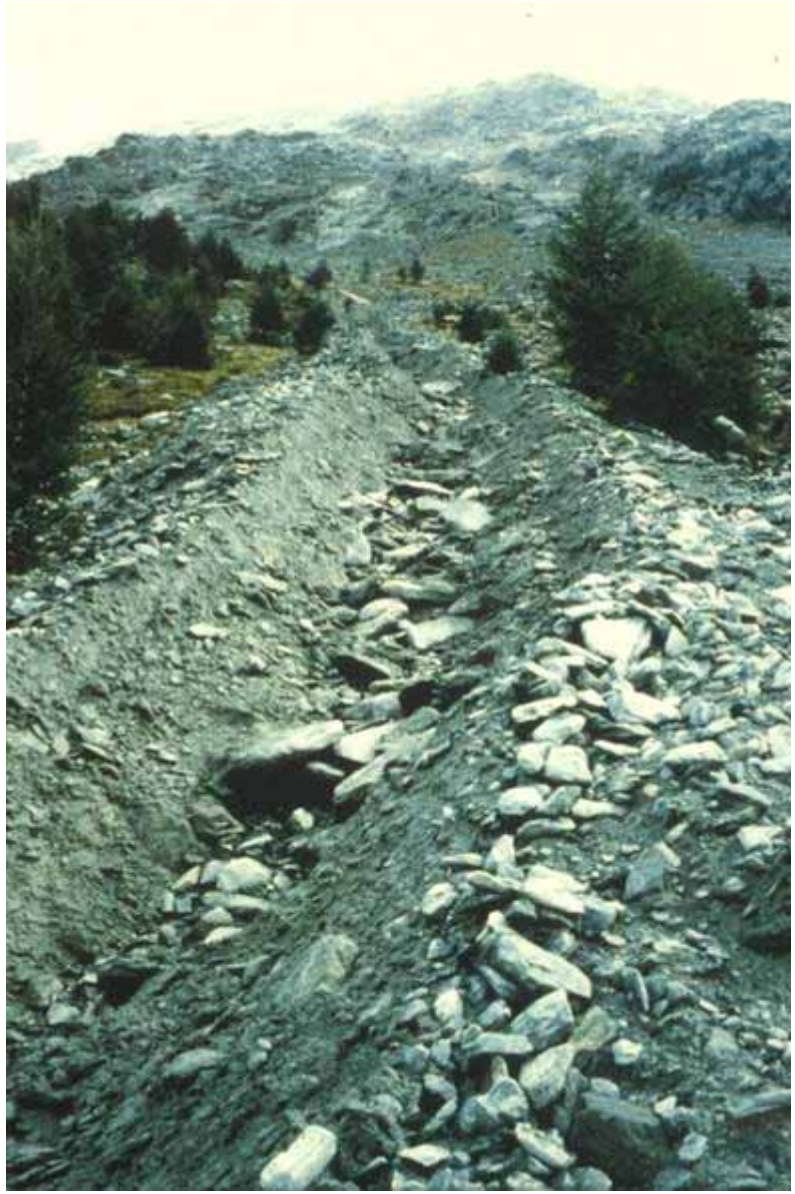
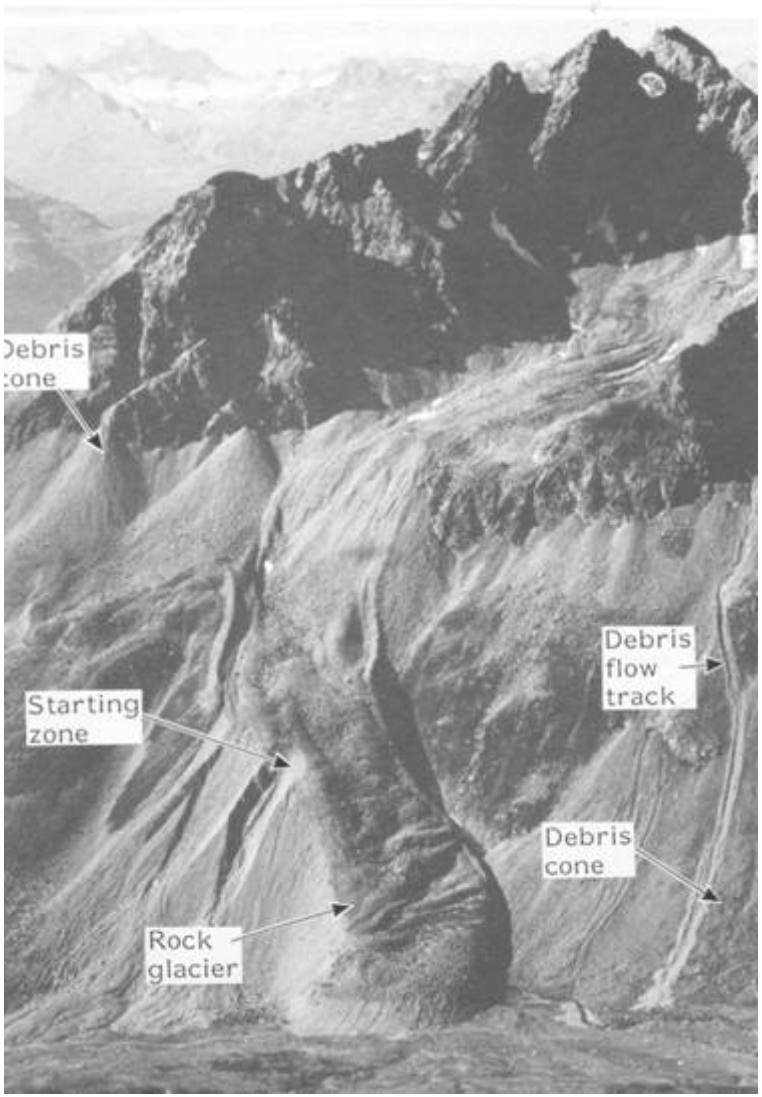




GEG2110 – Skråninger – slopes



GEG2110 – Skråninger – slopes

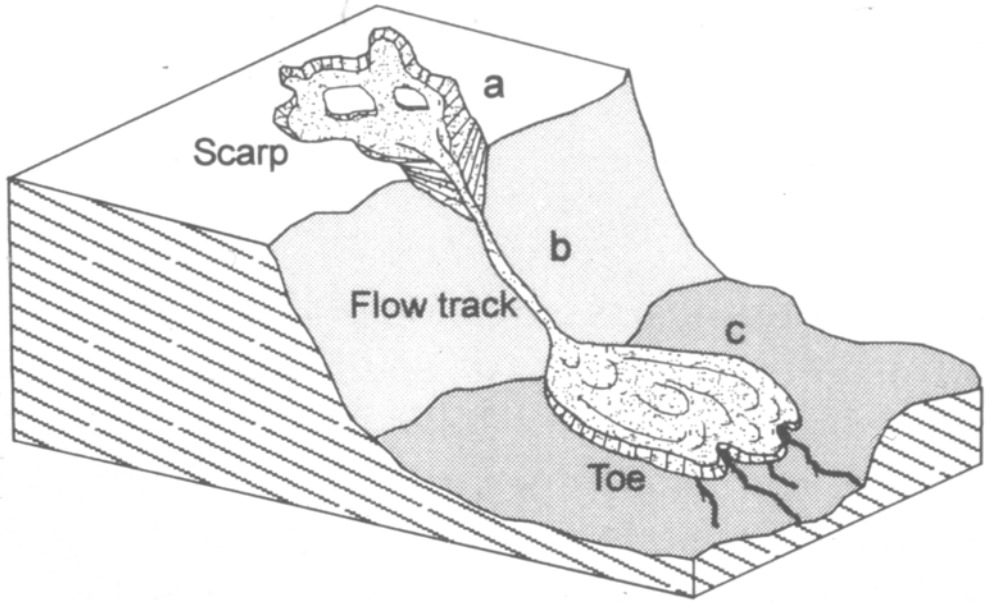


FIGURE 7.4.2 Block diagram showing typical features of a small mudflow: (a) zone of initiation; (b) zone of channel erosion; (c) zone of accumulation

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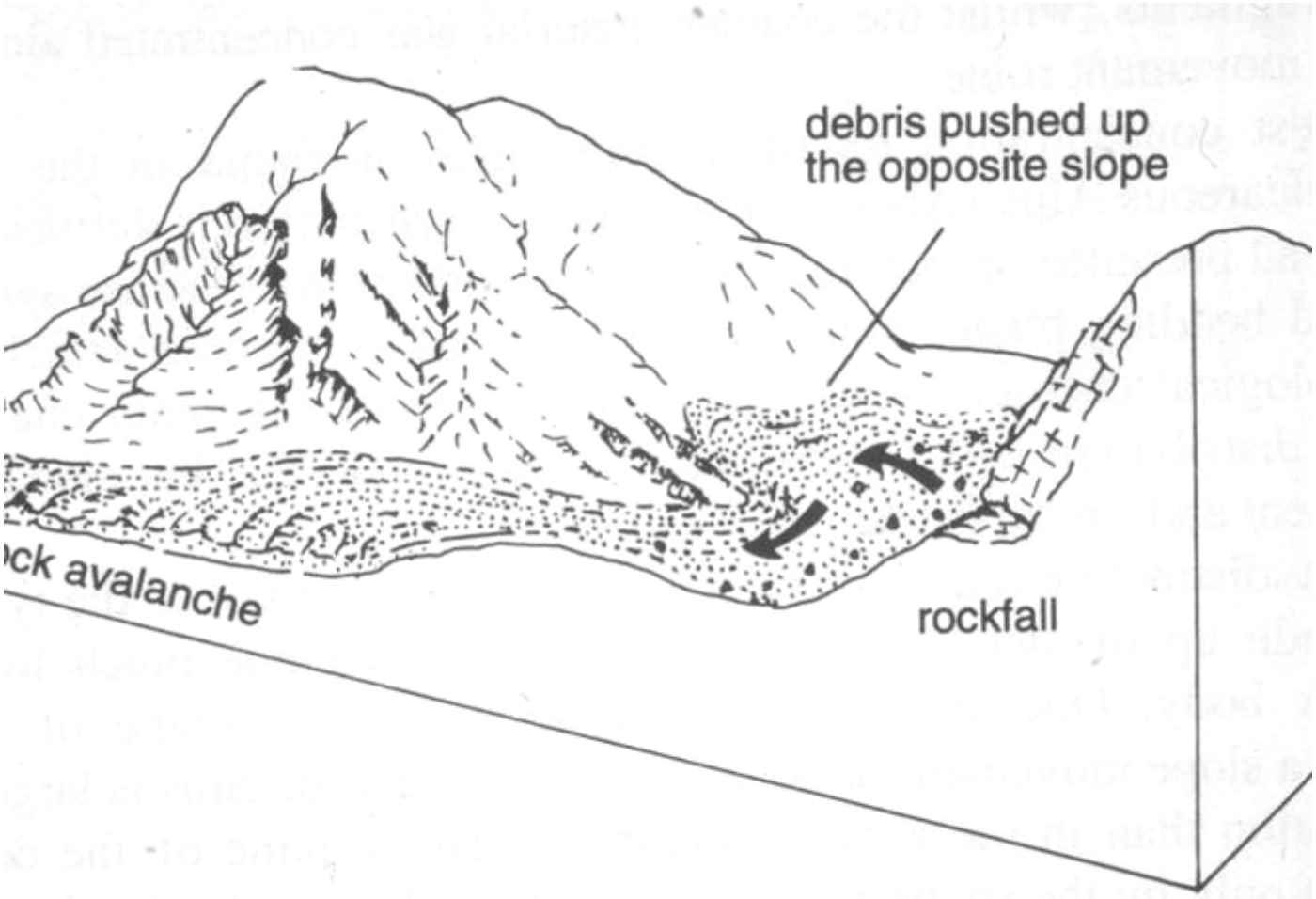

FIGURE 8.2.1 Schematic block diagram of a rockfall avalanche

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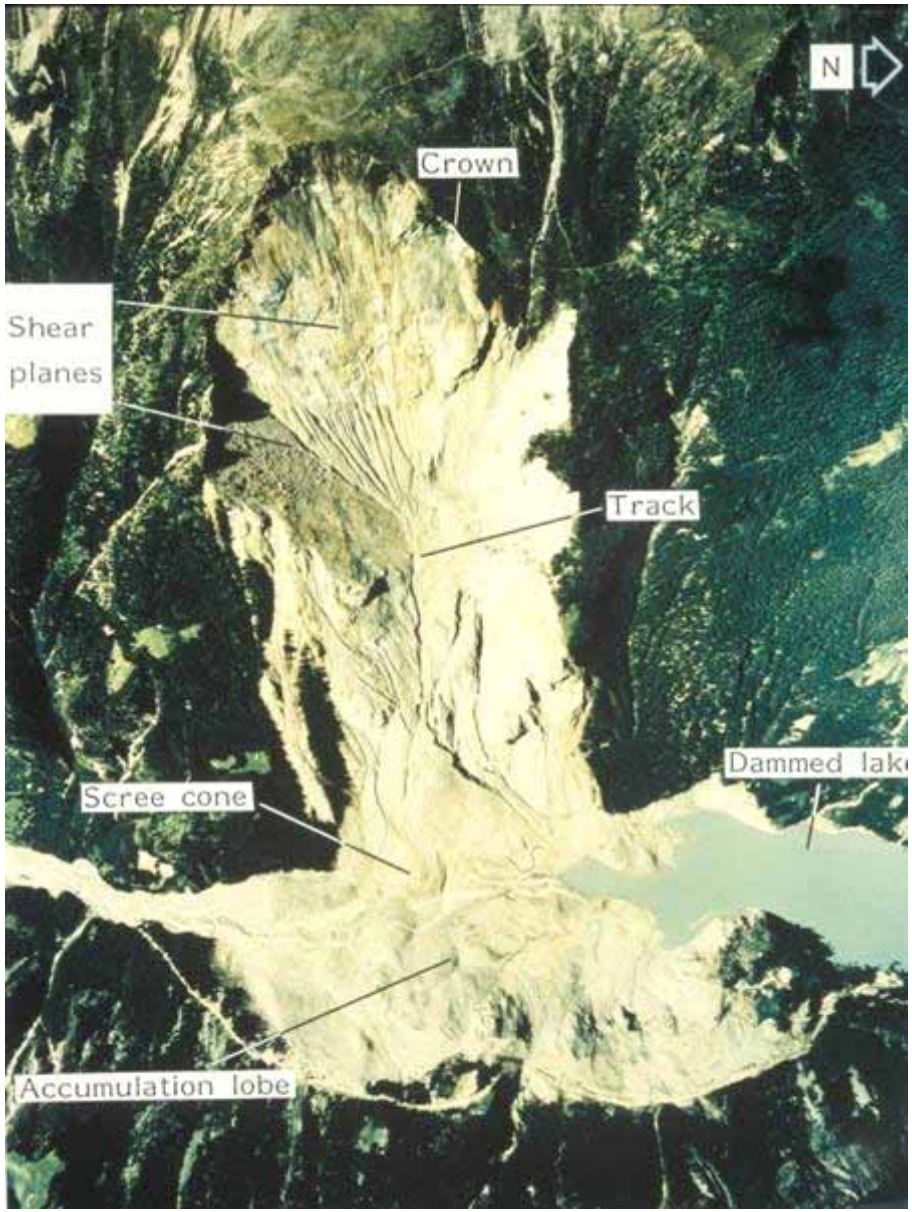

GEG2110 – Skråninger – slopes

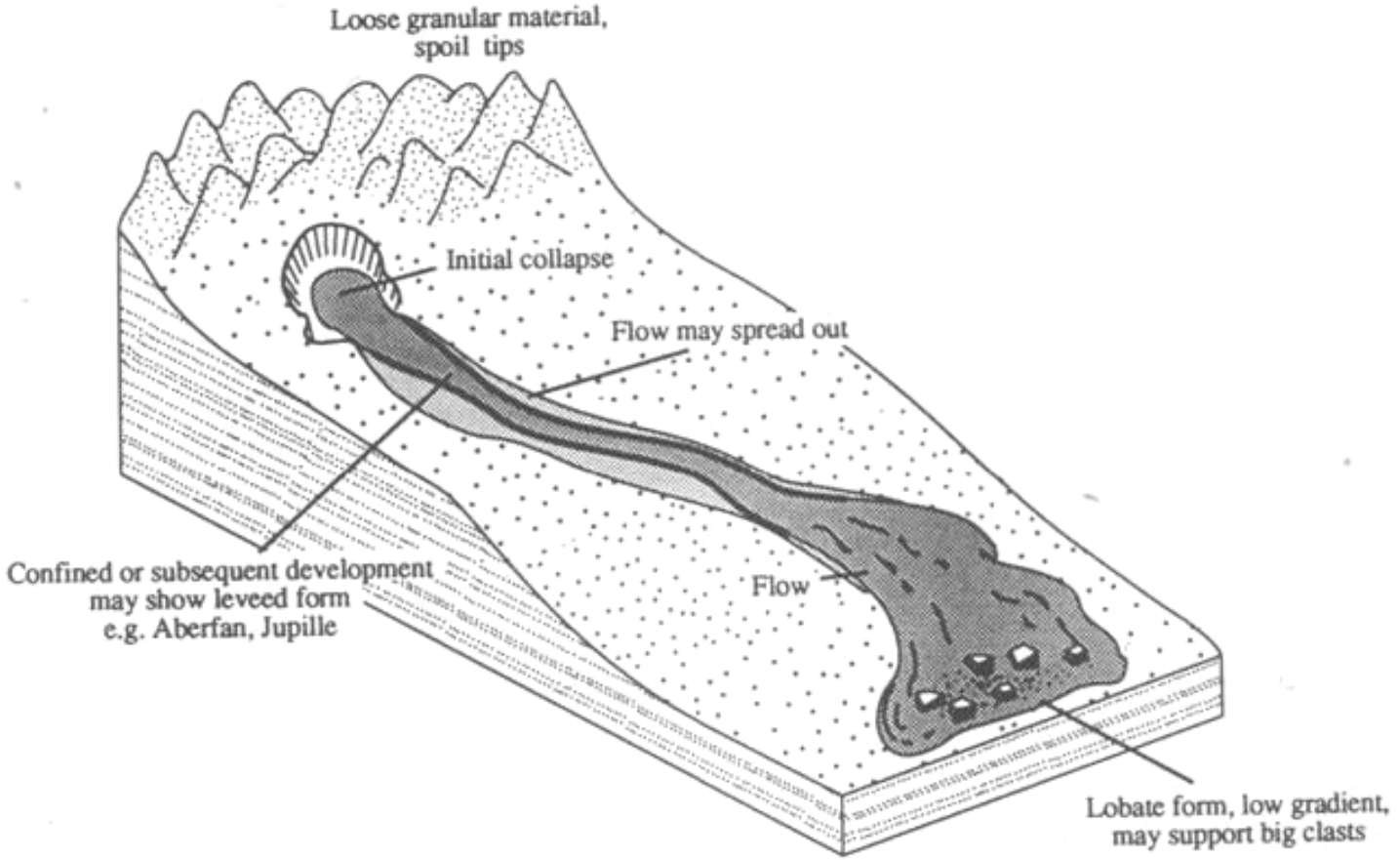

FIGURE 8.3.2 Typical schematic block diagram of a flow slide

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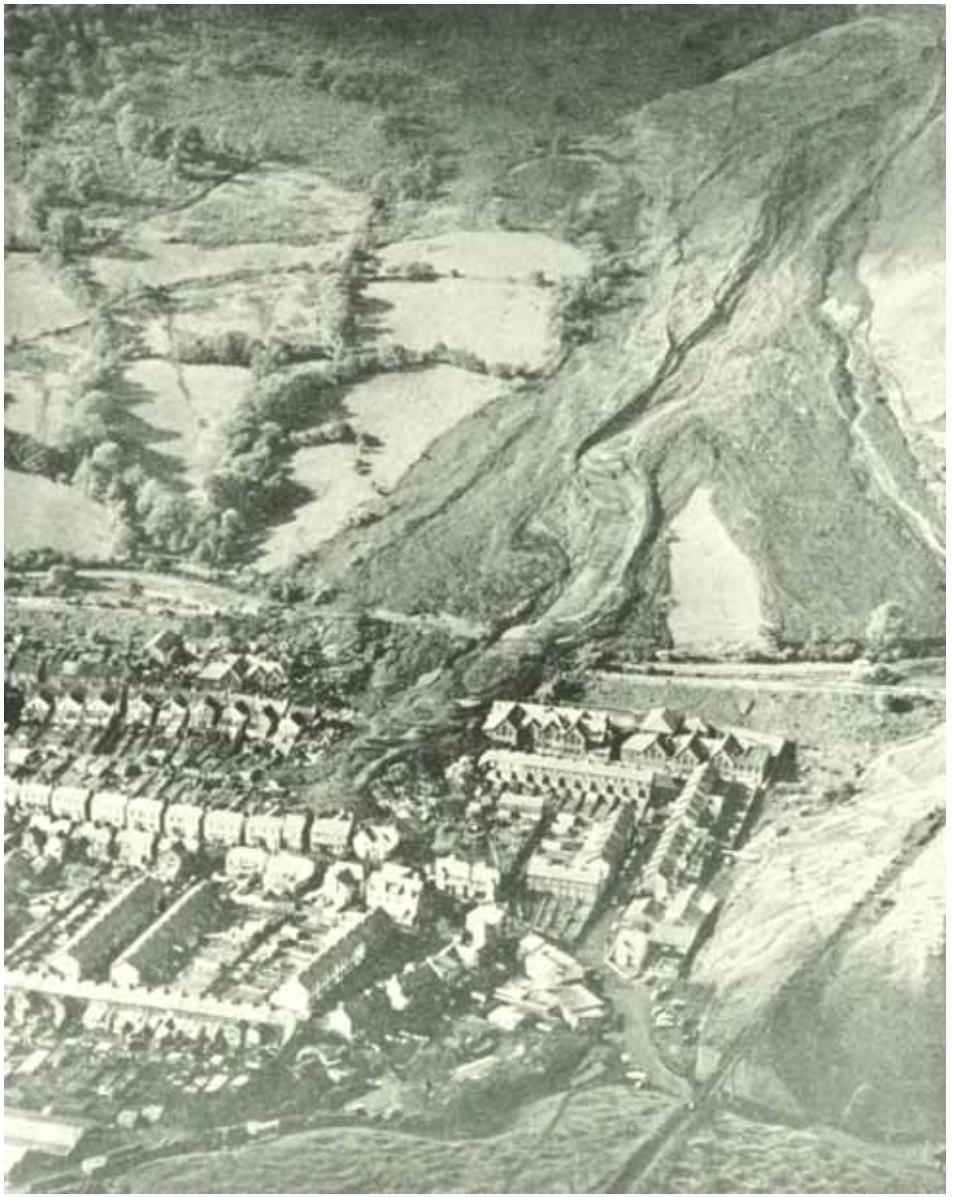

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Hastighet / Kornstørrelse	**Sakte**	**Hurtig**
Fin (rikt på leire)	Jordsig	Jordskred Leirskred Leirstrøm
Middels (blanding, med steiner og blokker)	Sig i grovere masser	Debris flow (materialførende snøskred)
Grov (mest steiner og blokker)	Steinbreer	Steinsprang Fjellskred (materialførende snøskred)

GEG2110 – Skråninger – slopes

Process rates

- Material relocation
- Denudation
- Frequency/Magnitude concept
- Slope evolution models

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Slope stability - fundamentals

- Type of material
  - friction
  - cohesivt
- Topography
- Ground water table

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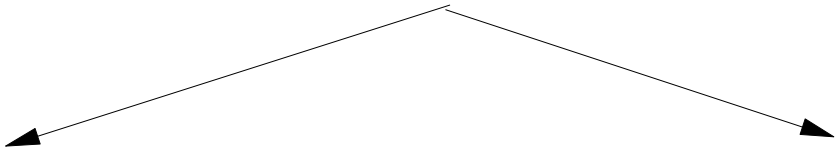
Massebevegelse - prosesser

Spørsmål : hvor bratt kan en skråning bli uten at den raser ut.



fjellskråninger **løsmaterialskråninge**

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Generell ligning som beskriver stabiliteten i løsmateriale:

$$s = c + (\sigma - N) \tan \theta$$

Hvis høyre siden av ligningen blir større enn venstre siden blir skråningen ustabil.

En skiller:

- ✓ friksjonsmateriale
- ✓ kohesjonsmateriale

Friksjonsmateriale : kohesjonen og porevannstrykk alltid = 0

Kohesjonsmateriale : kohesjonen alltid > 0, porevannstrykk > 0 ved mye nedbør

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Dette betyr

- ✓ Stabiliteteten av grovt materiale styres av friksjonsvinkelen og materialtilgangen (rasvinkel ca. 35°)
- ✓ Stabiliteten av skråninger i finmaterial reduseres av porevannstrykket. Skråningsvinkelen pleier vanligvis være mindre (ofte ca. halvparten av friksjonsvinkelen)

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Massebevegelse - prosesser

Faktorer som bestemmer stabiliteten i fjellskråninger :

- ➡ skråningsvinkelen
- ➡ forvitringsgrad
- ➡ sprekketetthet

Faktorer som bestemmer stabiliteten i løsmaterialskråninger :

- ➡ skråningsvinkelen
- ➡ kornfordelingen av løsmateriale
- ➡ vann (is) innholdet i løsmateriale

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External factors influencing stability

- Climate
  - Freezing-thawing cycles
  - Slope aspect / local climate
  - Permafrost
  - Intensity of precipitation
- Geology
  - Foot erosion
  - Head wall geology
  - Earth quake
  - Weathering
- Biology
  - Vegetation cover - forest
  - Roots

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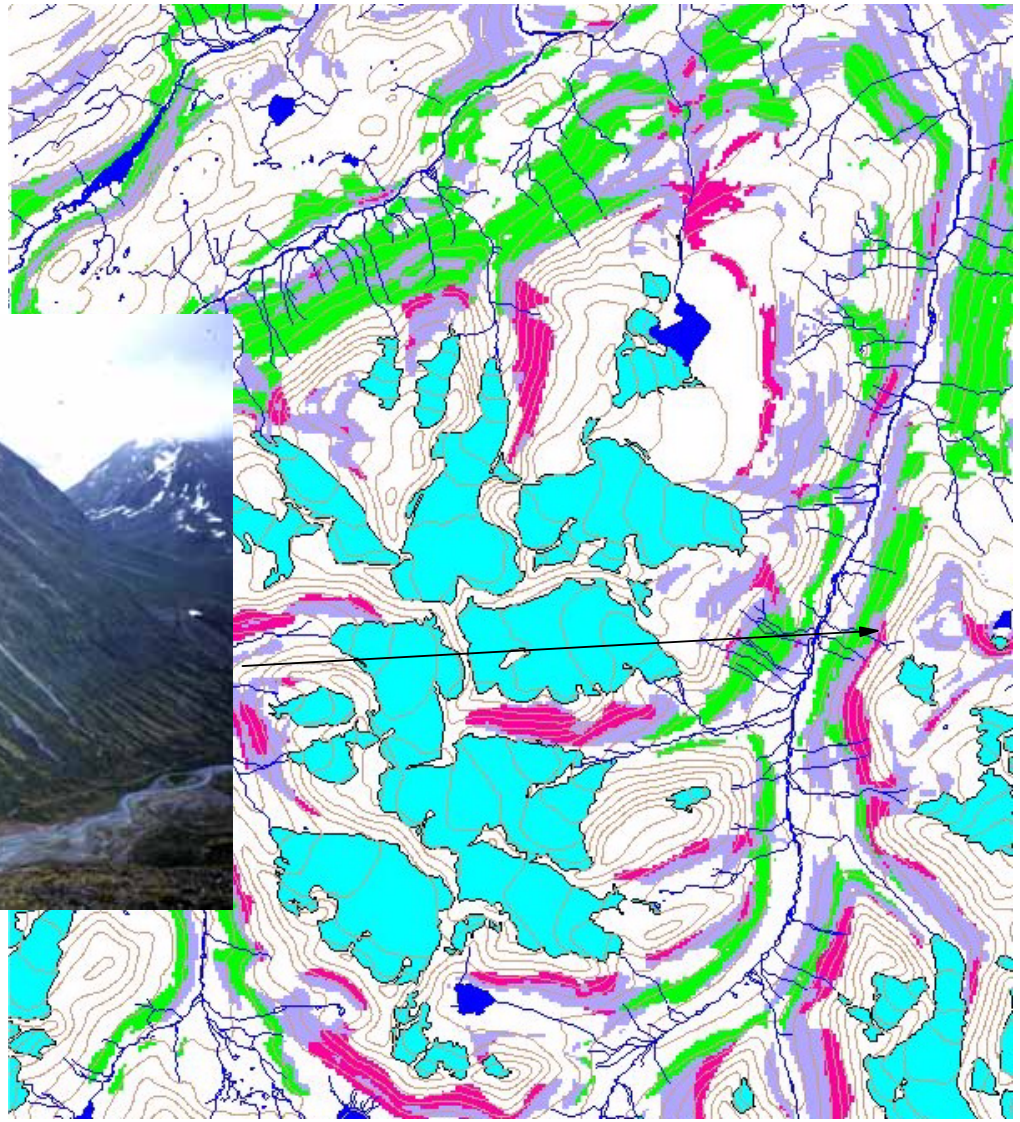
Massebevegelse - Påvirkning av mennesker

- Forandring av skråningsvinkel (graving)
- Fjerning av vegetasjon
- Forandring av grunnvannsnivå
- Belastning av løsmateriale (økning av normalspenningen) pga. anlegg

Potential risk for permafrost-induced debris flow hazard



Harris et al. in prep.