Addis Ababa University, Ethiopia
October / November 2013

CZECH REPUBLIC
DEVELOPMENT COOPERATION

CLASSIFICATON OF LANDSLIDES AND OTHER MASS MOVEMENTS BY A.NEMCOK, J.PASEK, AND J.RYBAR

Rock Mechanics 4, 71-78 (1972) by Springer-Verlag 1972

Jan Novotný

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Nemčok, Pašek & Rybář (1972): Classification of Landslides and Other Mass Movements

MASS MOVEMENT

- Movement of rock/soil masses on a slope by gravitation

Photo: Washington Dept. of Washington

Afternoon Creek, Skagit River, Washington, November 2003

NEMČOK, PAŠEK, RYBÁŘ 1972

4 TYPES OF PROCESSES

Based on geomechanical character and velocity of the movement

- CREEP
- SLIDING
- FLOW
- FALL

In each group elementary phenomena can be further subdivided according to different types determined by regional, morphological, geological or climatic conditions. For this reason it is not possible to consider all possible variations.

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

CREEP

- Geologically **long-term movements** of **non-increasing velocity without well-defined sliding surfaces**. (In most cases we can speak of deep-seated (or viscous) flow.)
- Displacements are nearly negligible in contrast to space of rock massif affected by creep
- Velocity **0.1 mm/year– mm/day**

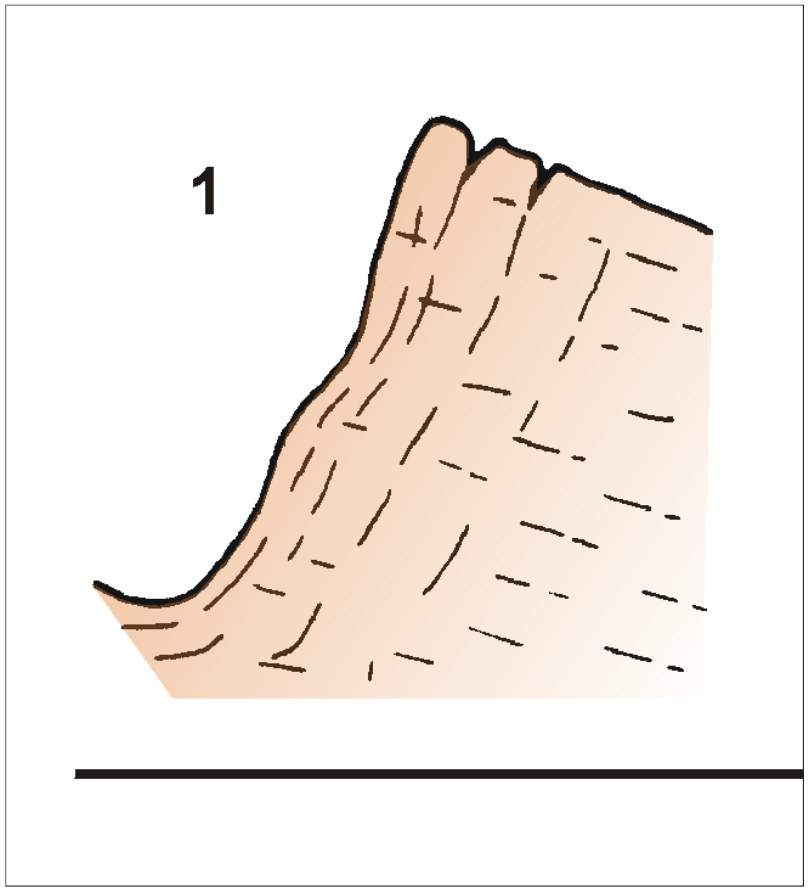
- The movements are designated as creeping movement, the resulting phenomenon is rock creep, talus creep, soil creep…
- If it achieves a critical acceleration, the creep becomes sliding, flow or fall.

Nemčok, Pašek & Rybář (1972)

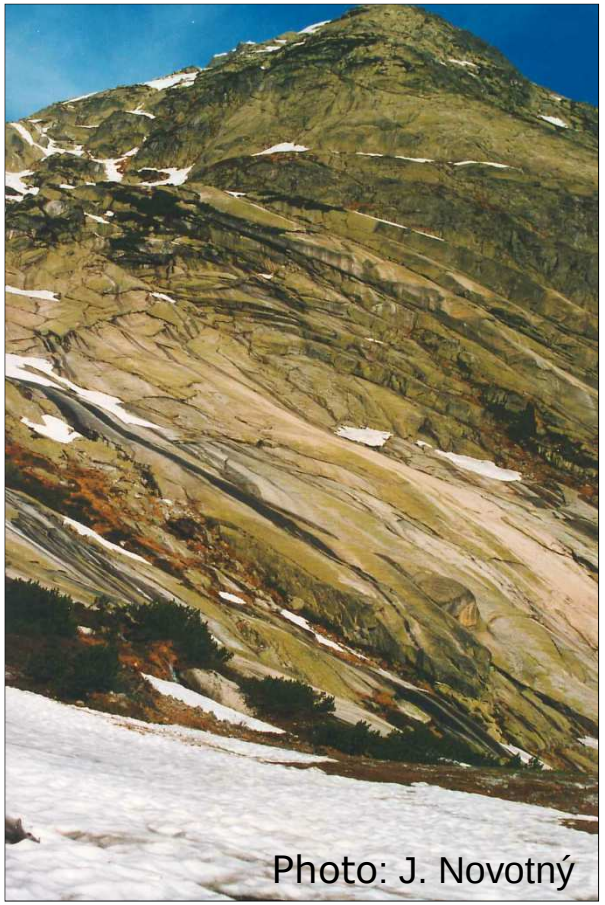
creep : *sliding* : *flow* : *fall*

1) LOOSENING OF THE ROCKS IN THE VALLEY SLOPE BY CRACKS PARALLEL TO THE SURFACE

EXFOLIATION



Alps, Grimsel pass



Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

1) LOOSENING OF THE ROCKS IN THE VALLEY SLOPE BY CRACKS PARALLEL TO THE SURFACE

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

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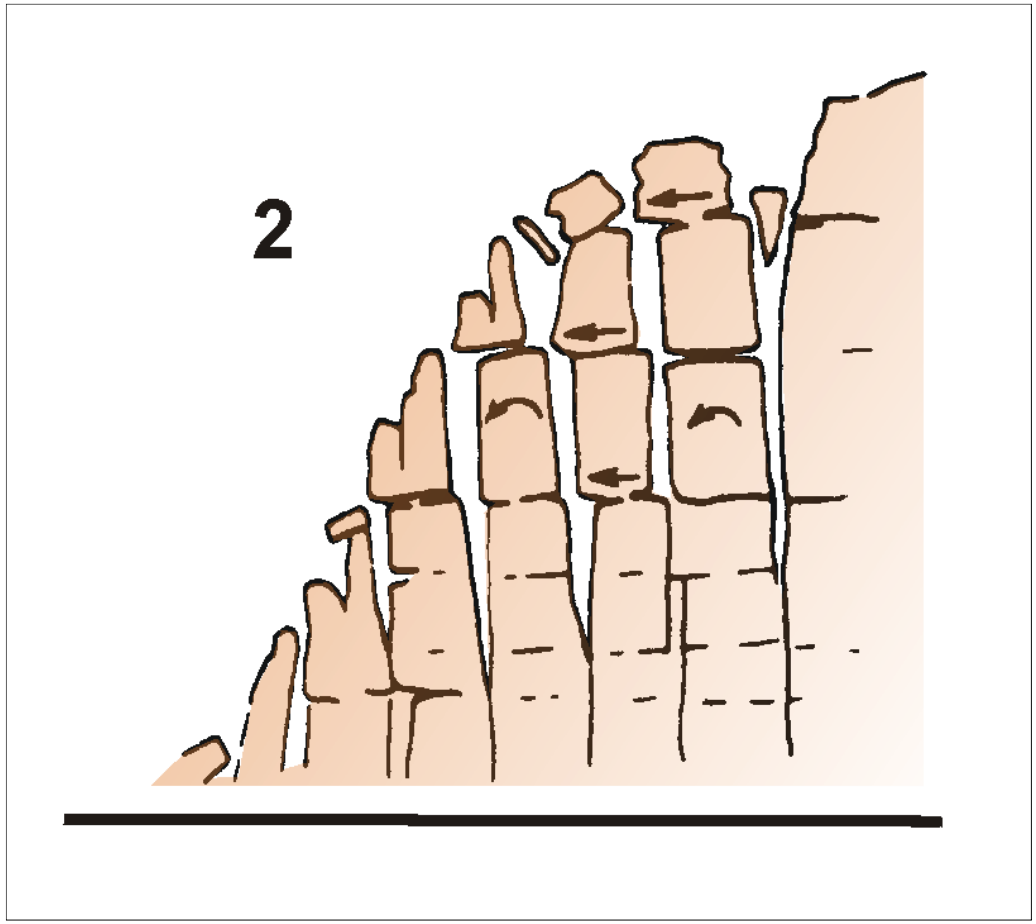
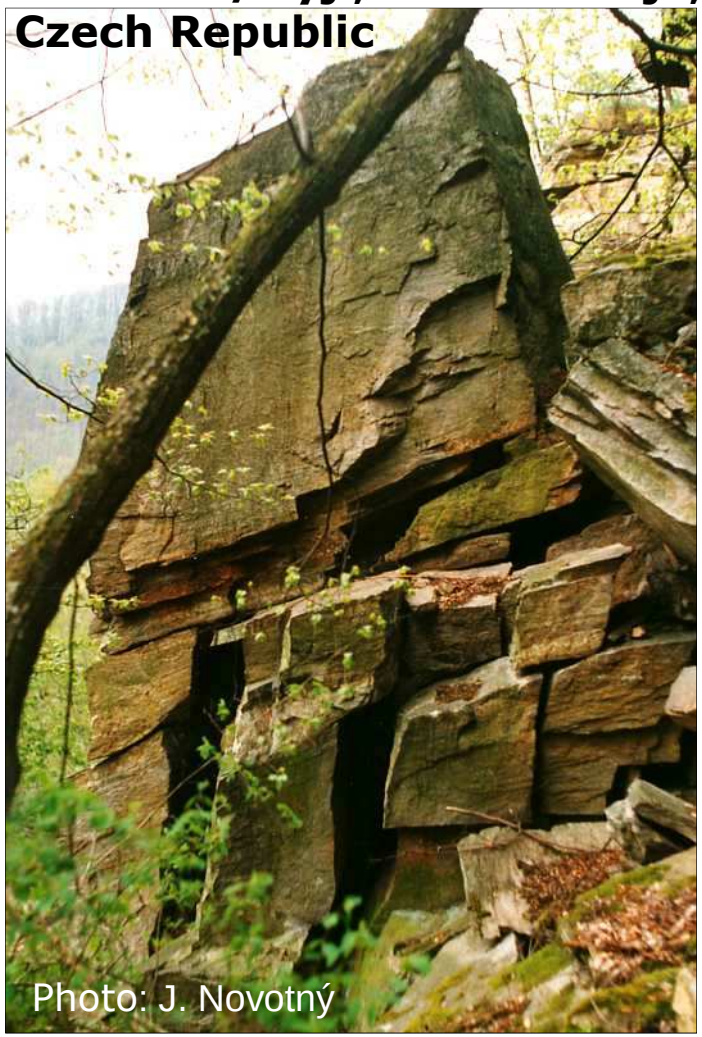
Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

2) LOOSENING BY OPENING OF TENSION CRACKS IN UPPER PART OF THE SLOPE



Vranov n/Dyjí, Ledové Sluje, Czech Republic



Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

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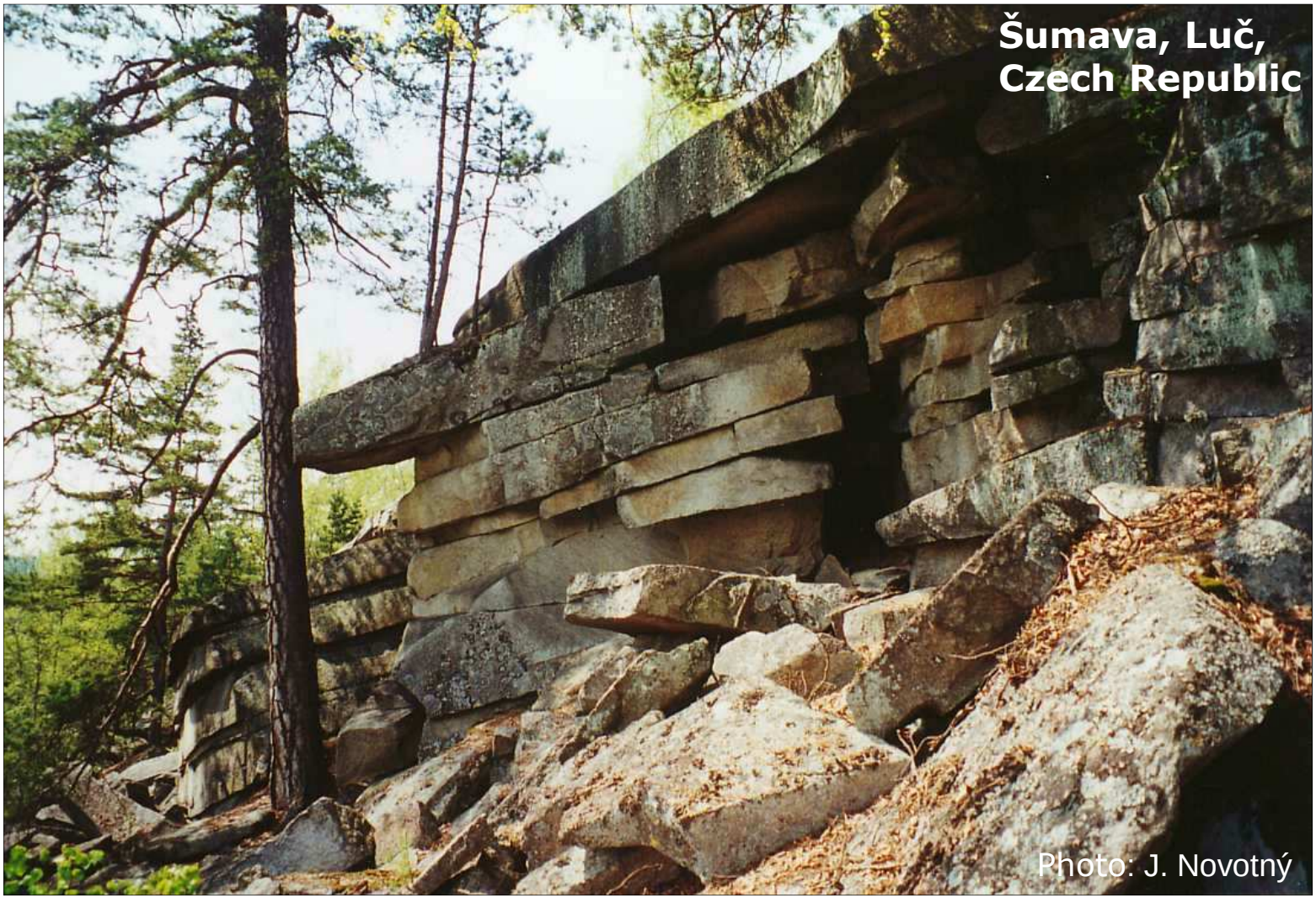

Nemčok, Pašek & Rybář (1972)

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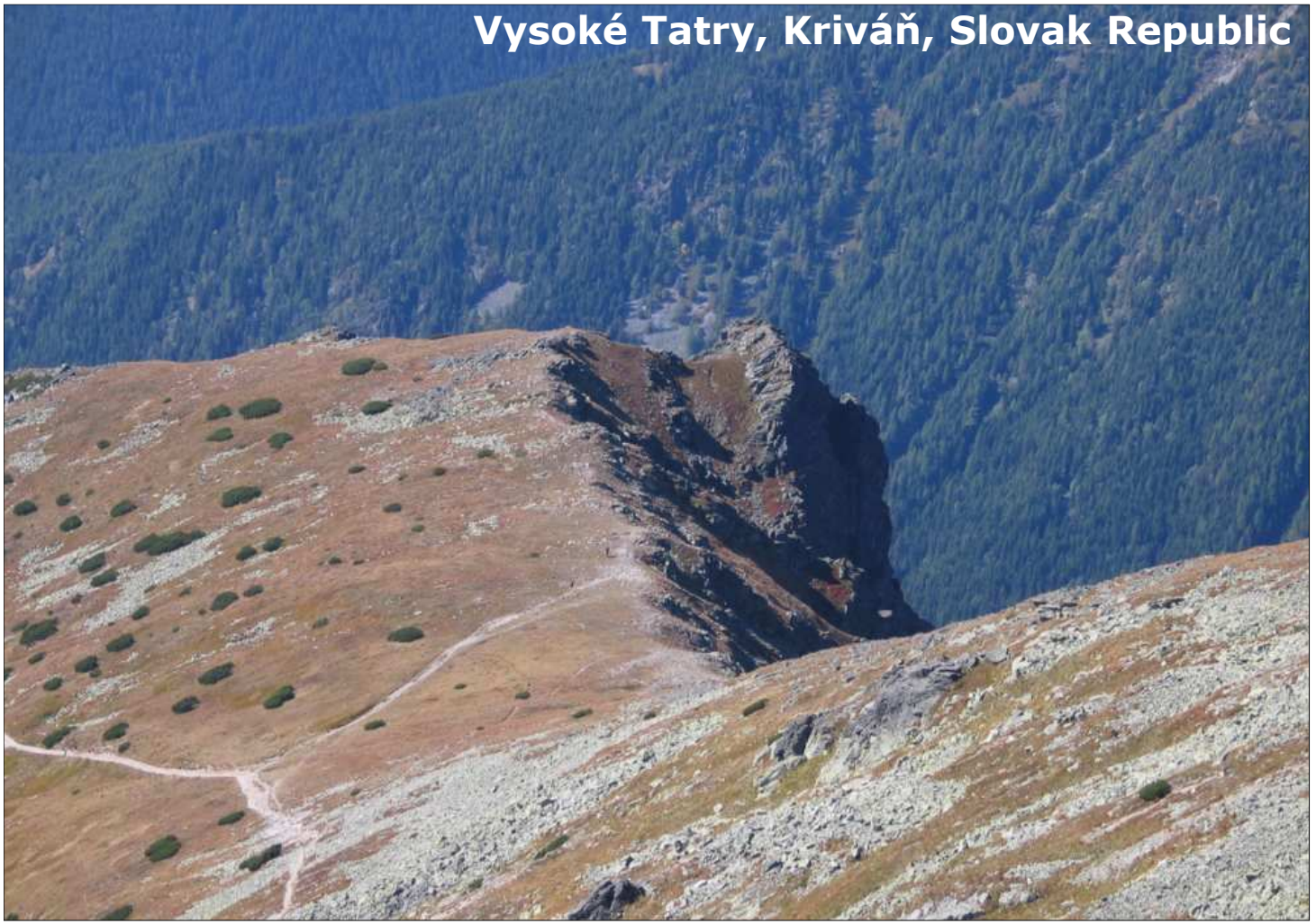

Photo: J. Novotný

Nemčok, Pašek & Rybář (1972)

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Photo: J. Novotný

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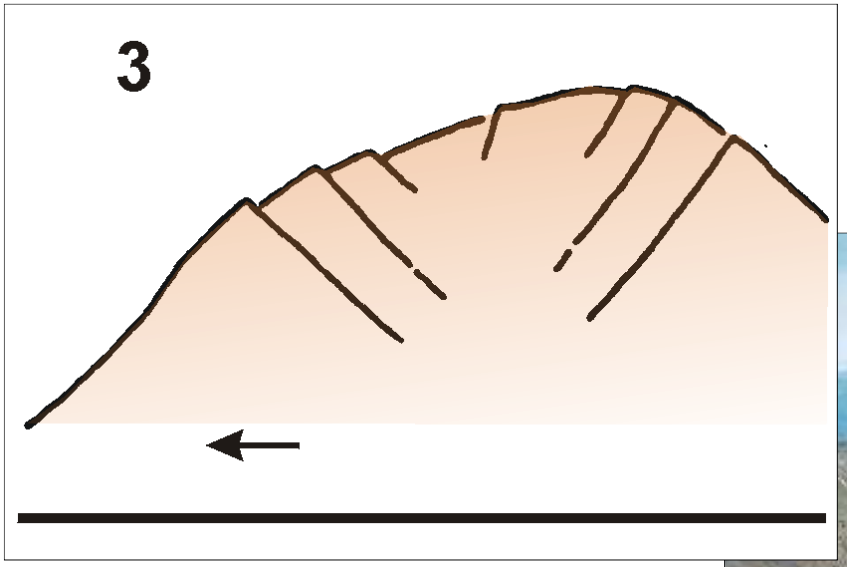
Photo: J. Novotný

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

2) LOOSENING BY OPENING OF TENSION CRACKS IN UPPER PART OF THE SLOPE

3) LOOSENING OF SLOPE BY DEEP SEATED CREEP OF HIGH MOUNTAIN RIDGES



BREAKING OF MOUNTAIN RIDGE, DOUBLE RIDGES

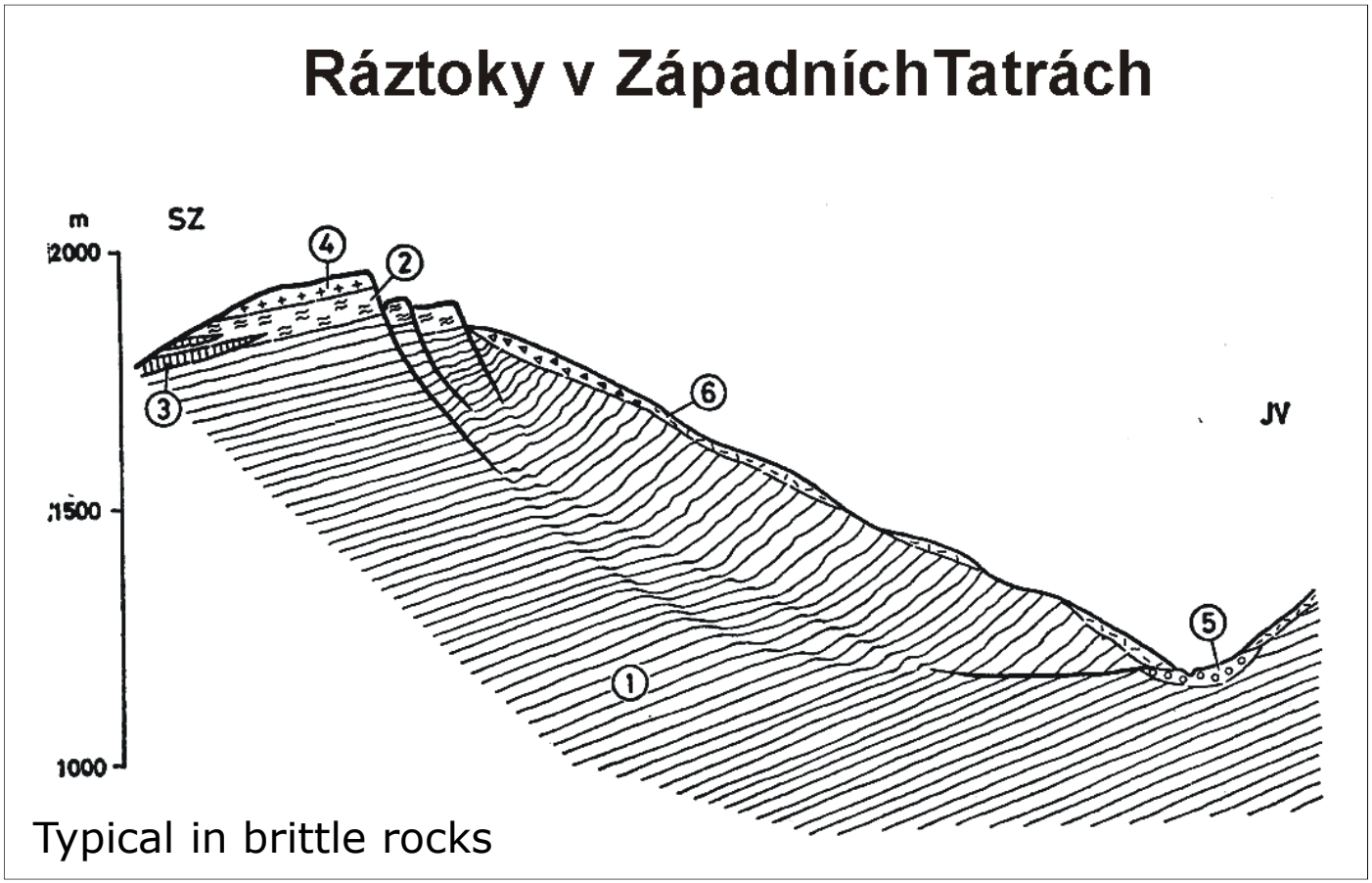
Typical in brittle rocks

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

3) LOOSENING OF SLOPE BY DEEP SEATED CREEP OF HIGH MOUNTAIN RIDGES

BREAKING OF MOUNTAIN RIDGE, DOUBLE RIDGES



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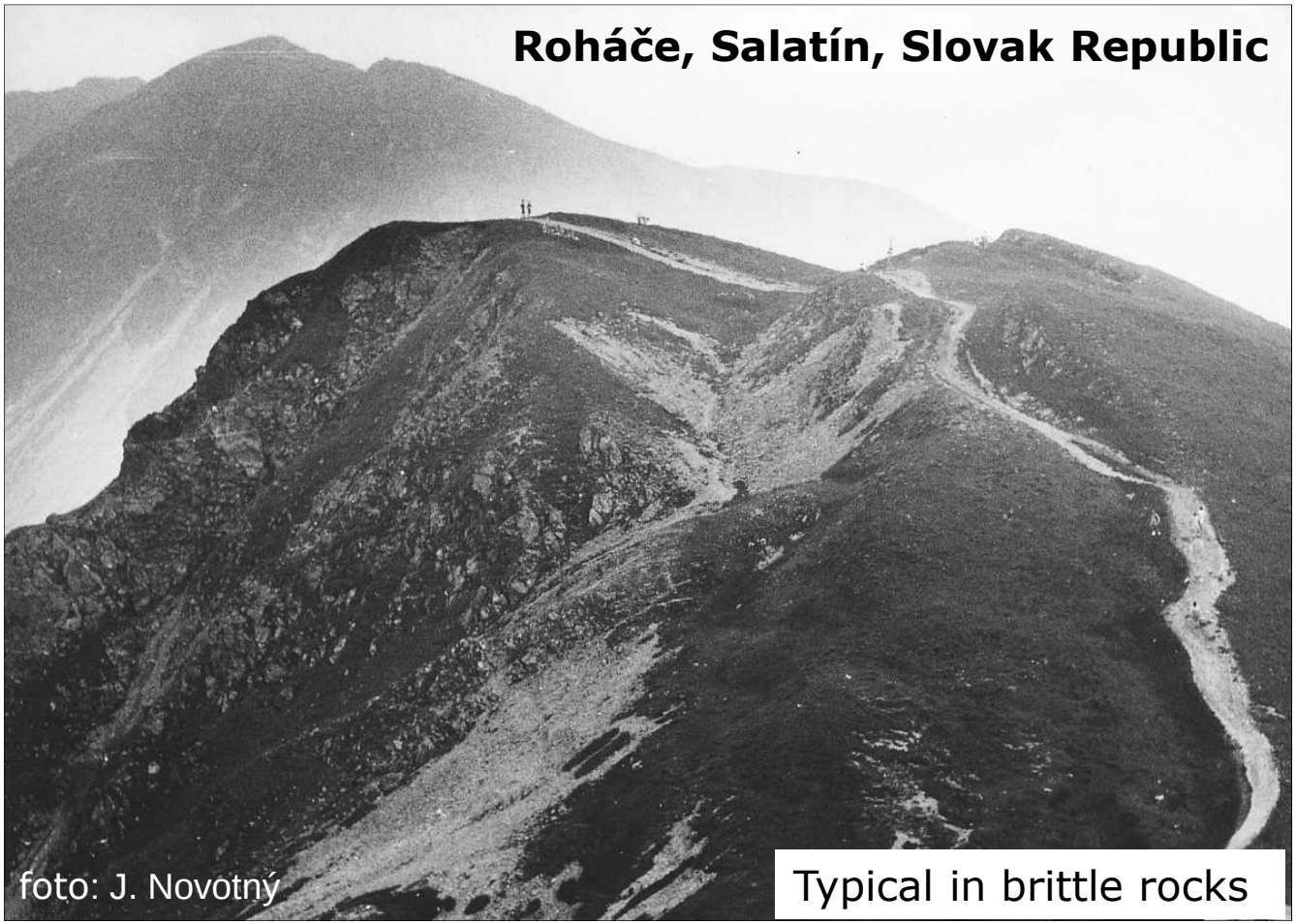
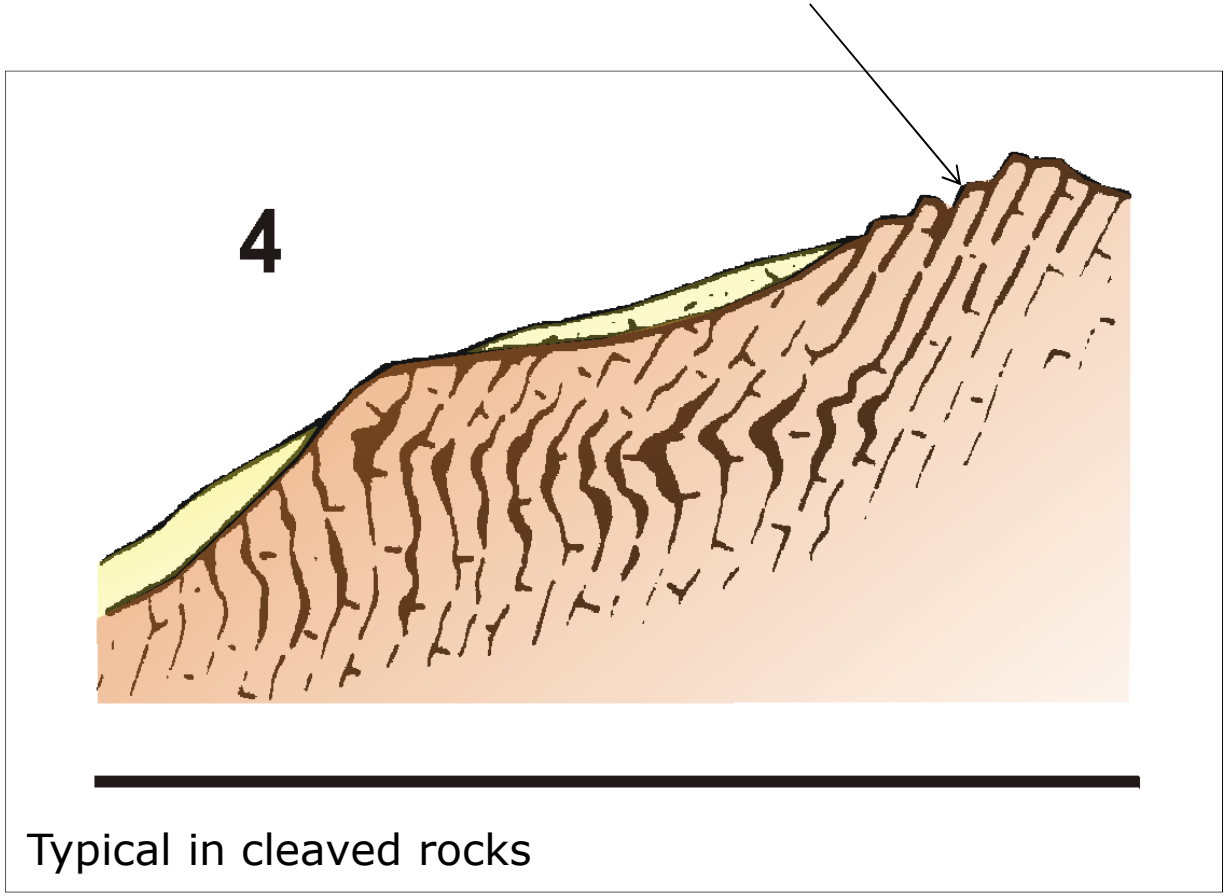
BREAKING OF MOUNTAIN RIDGE, DOUBLE RIDGES



4) GRAVITATONAL FOLDING BY DEEP SEATED CREEP – DEFORMATION OF HIGH MOUNTAIN SLOPES

BREAKING OF MOUNTAIN RIDGE, DOUBLE RIDGES

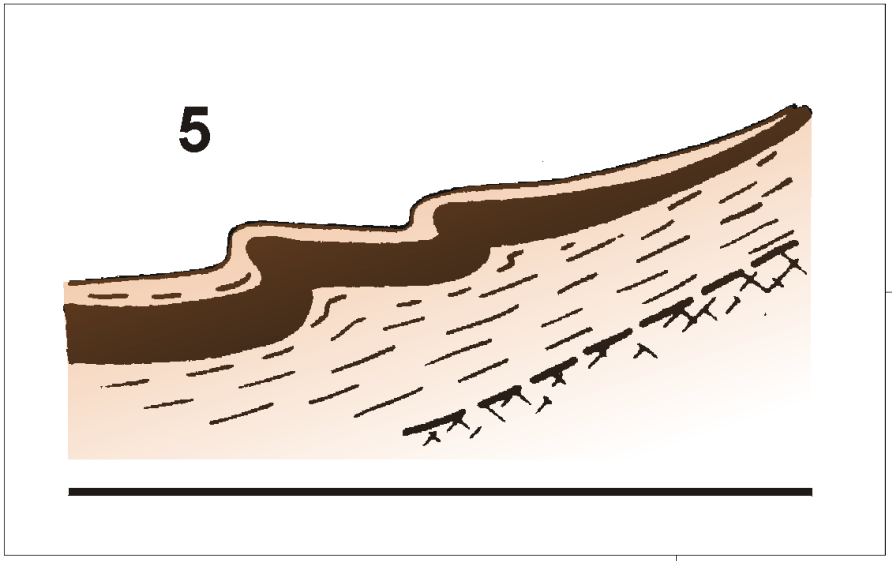


Typical in cleaved rocks

Nemčok, Pašek & Rybář (1972)

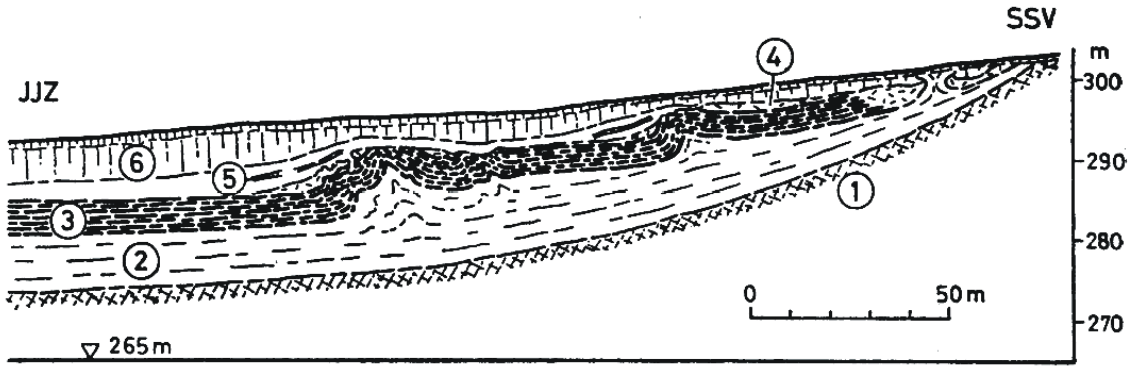
creep : *sliding* : *flow* : *fall*

5) GRAVITATONAL FOLDING ALONG BASINS MARGINS



GRAVITATIONAL FOLDS

Gravitational folds near Kadaň (according to Rybář 1960)

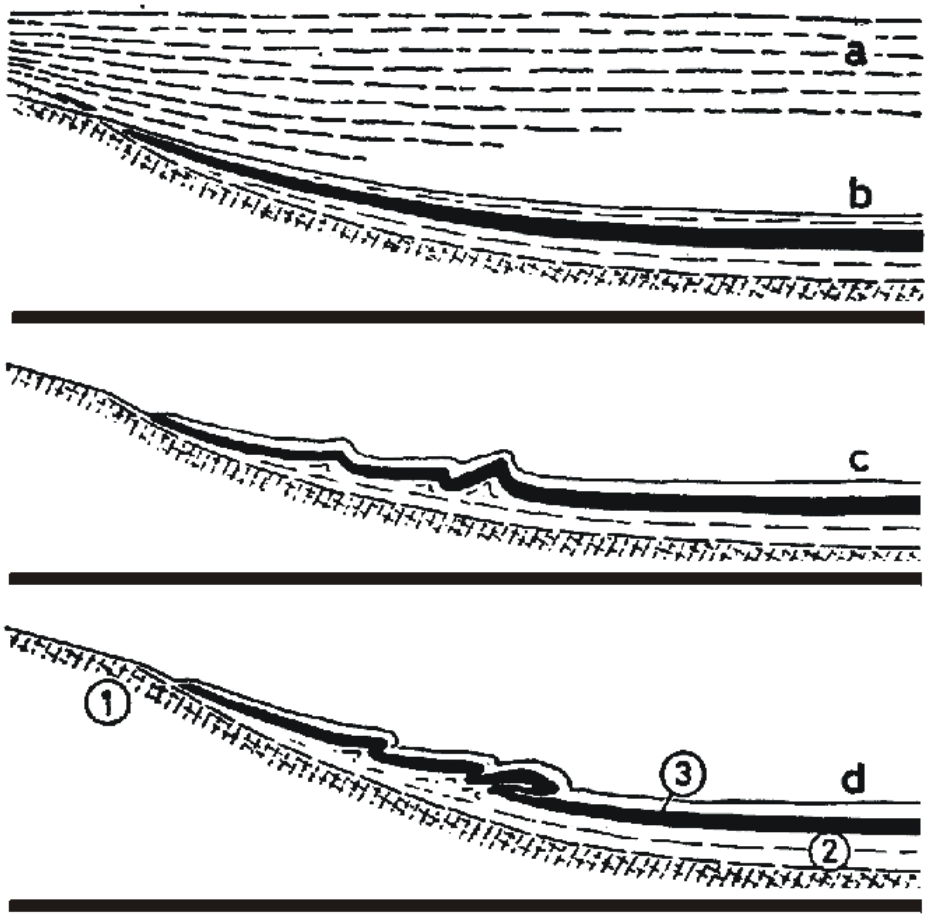


Typical in coaly and clayey complexes along margins of Tertiary basins in Czech Republic and Germany, occurring also in limestones with marly interlayers in geosynclinal mountains

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

5) GRAVITATONAL FOLDING ALONG BASINS MARGINS



Evolution of gravitational folding

Rybář, Dobr1966

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

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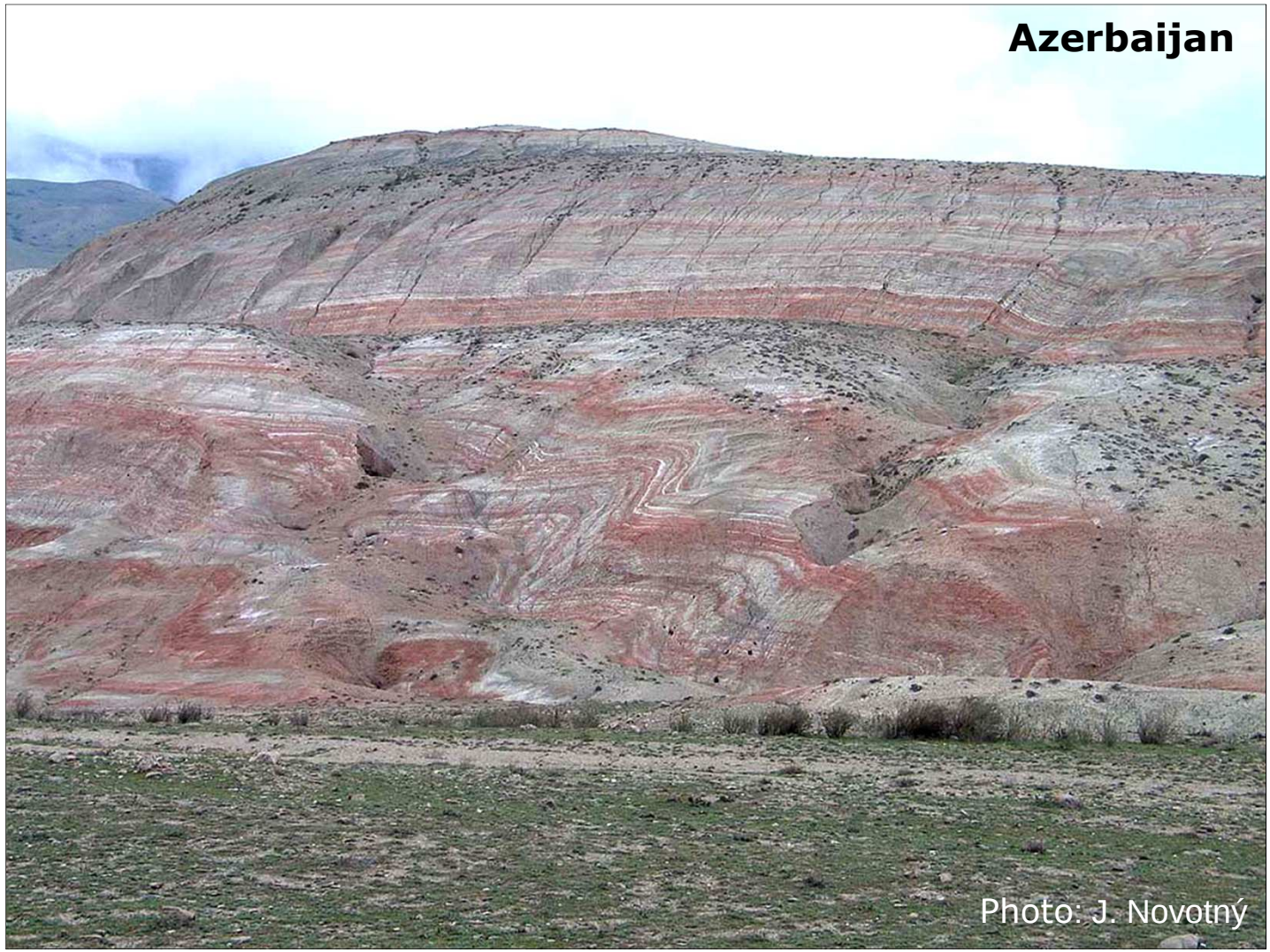
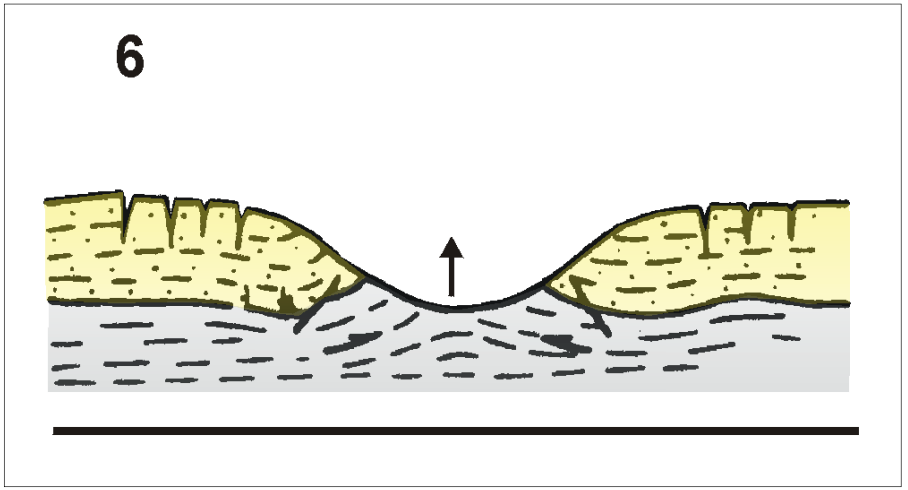
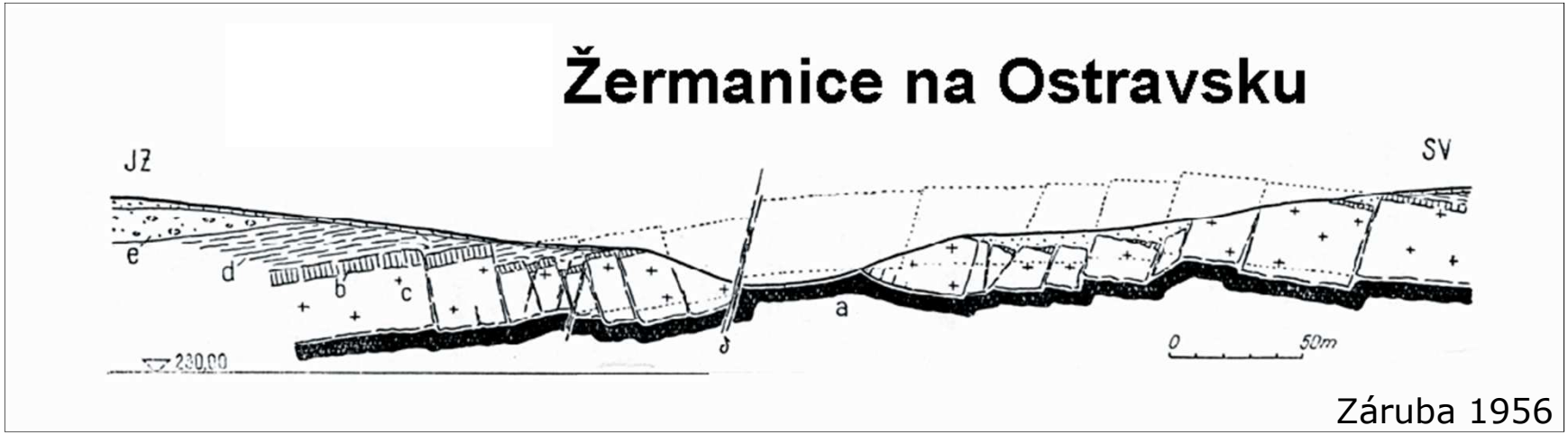


6) GRAVITATIONAL FOLDING OF SOFT ROCK IN VALLEY BOTTOM

VALLEY ANTICLINAL, BULGING

More plastic rock are squeezed out in the bottom of erosional valley and form an anticlinal in valley



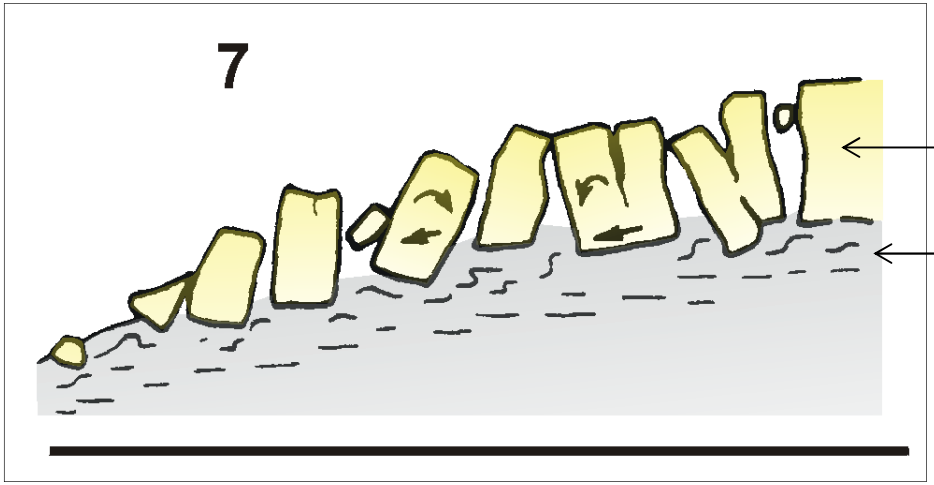


Záruba 1956

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

7) BLOCK-TYPE MOVEMENTS ON PLASTIC UNDERLYING ROCKS



CAMBERING

Competent (rigid) rock

Incompetent (plastic) rock

Czech Republic, Raná near Louny

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

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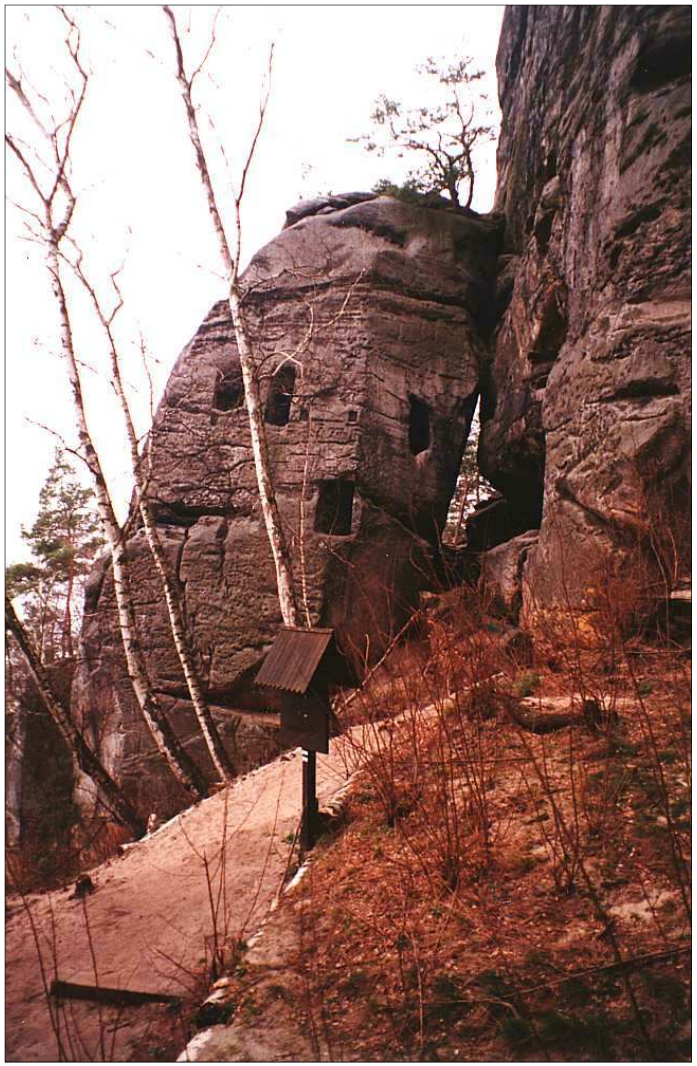


Photo J.Novotný

Drábské světničky, Czech Republic

Czech Republic, Praha, Strahov

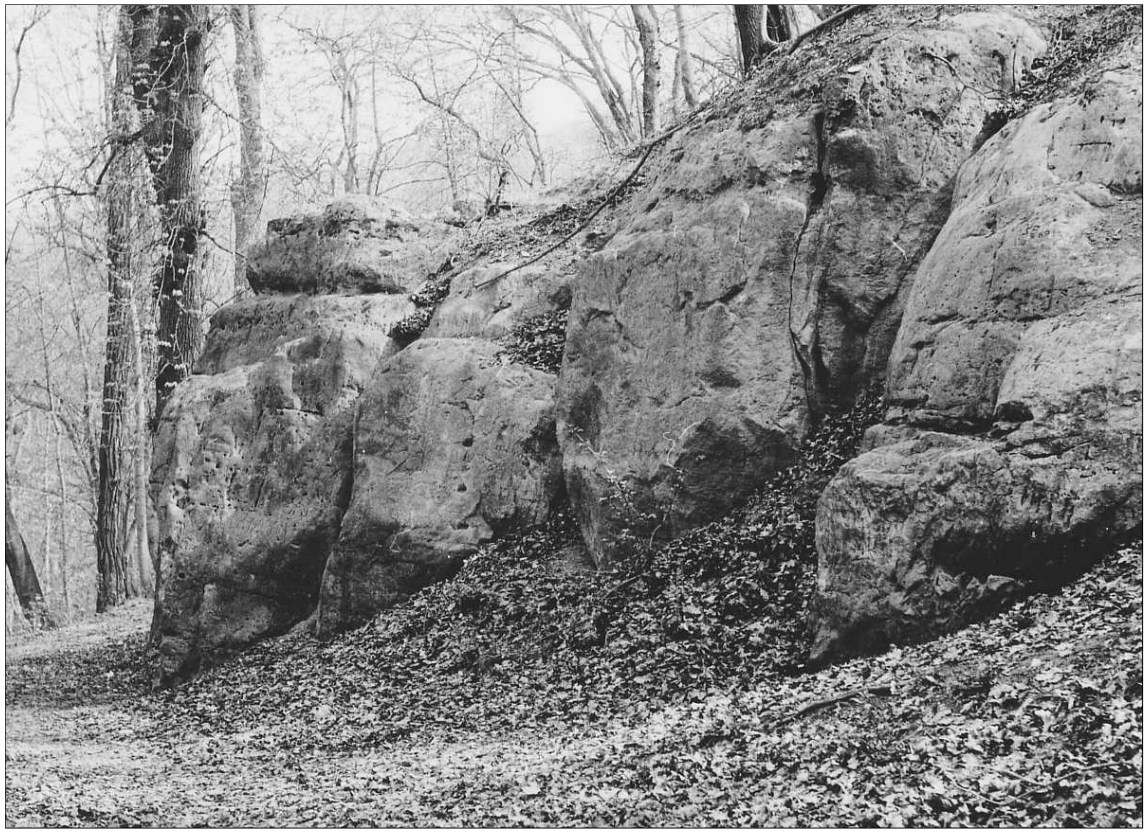


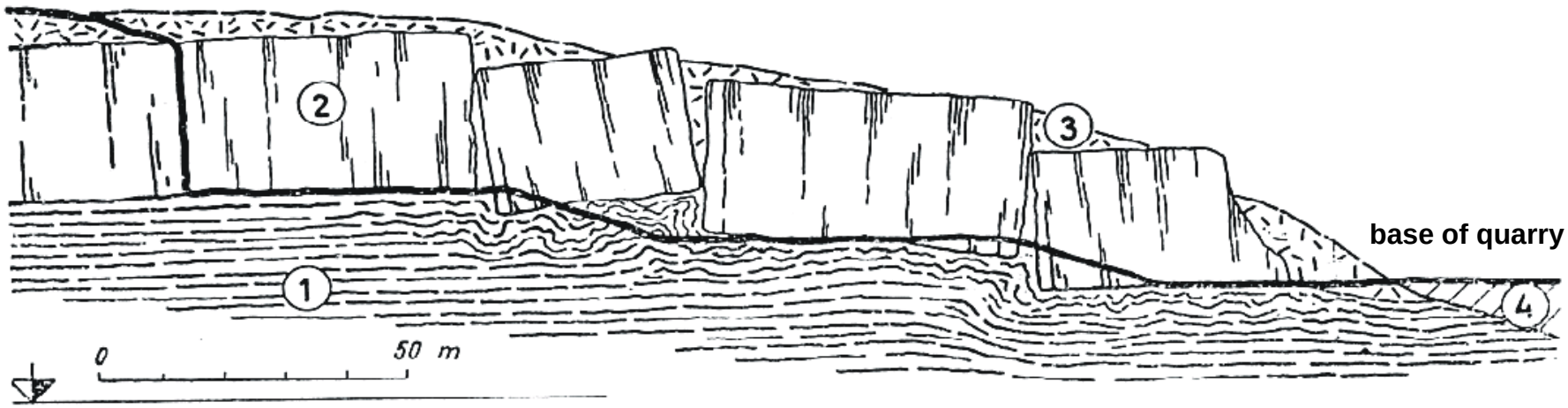
Photo J.Novotný

7) BLOCK-TYPE MOVEMENTS ON PLASTIC UNDERLYING ROCKS

Obrnice u Mostu

Blocks of basalt moved on marls

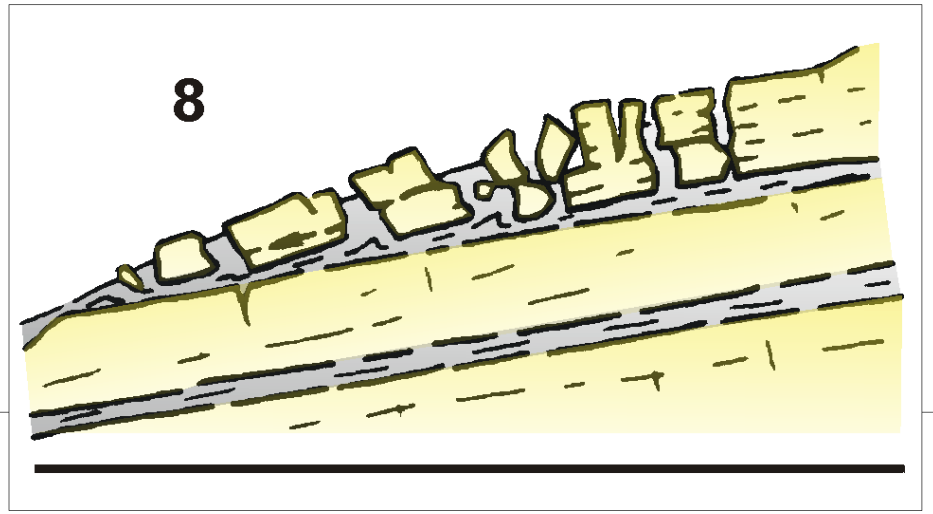
(Záruba 1956)



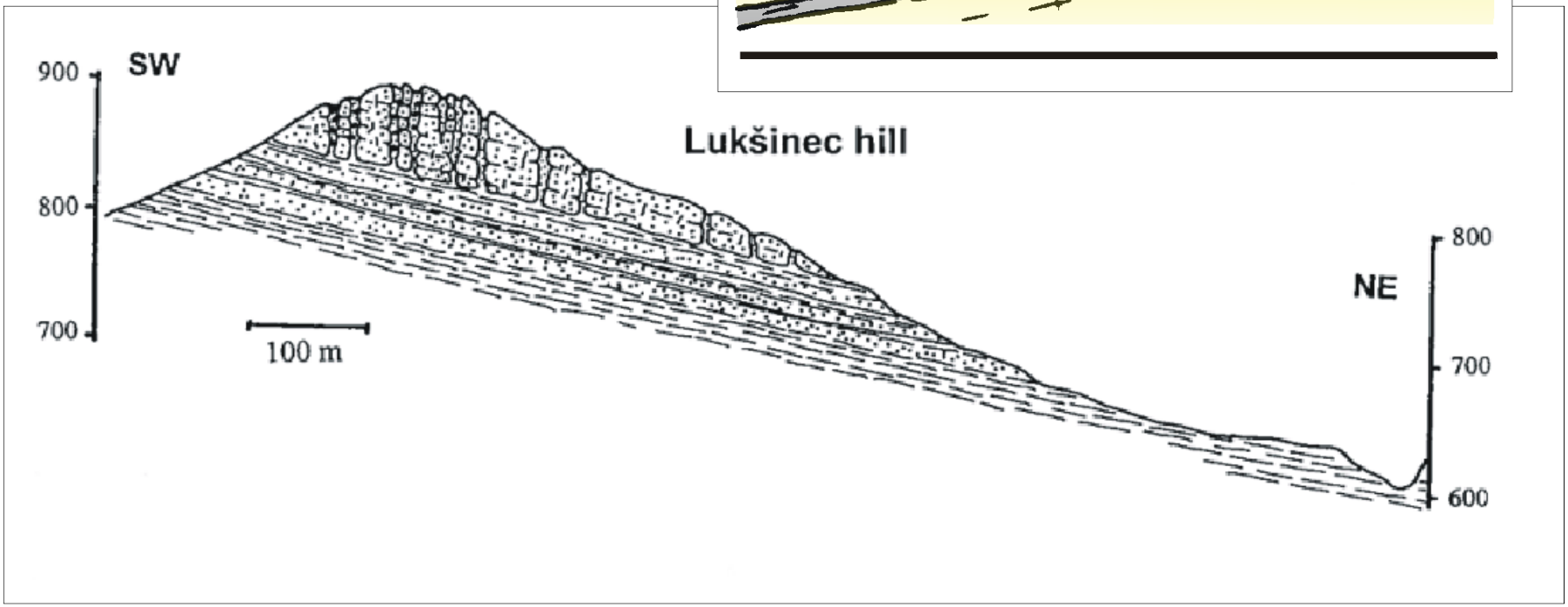
Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

8) BLOCK-TYPE MOVEMENTS ON PRE-EXISTING SURFACE



Heiland 1996



Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

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Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

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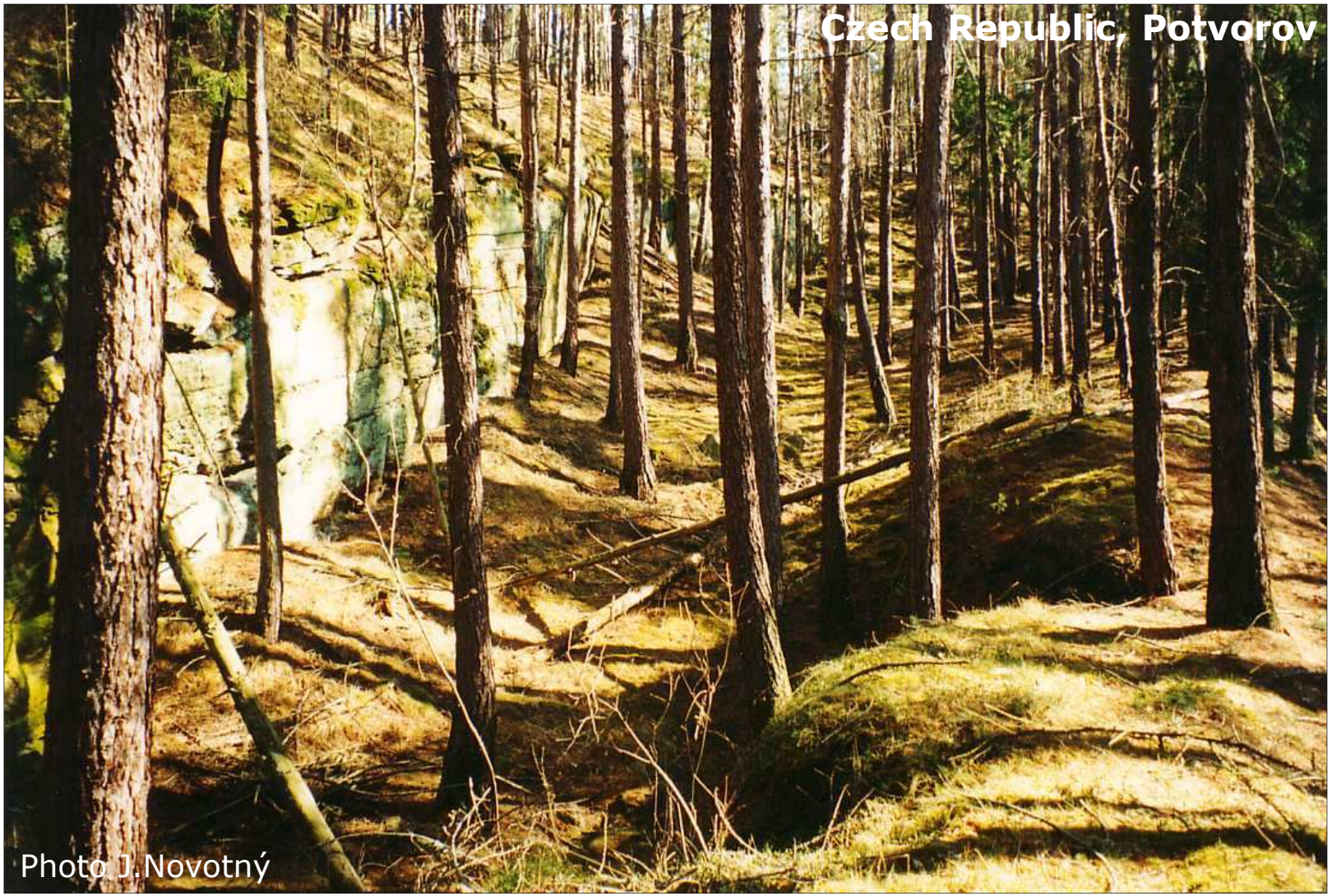
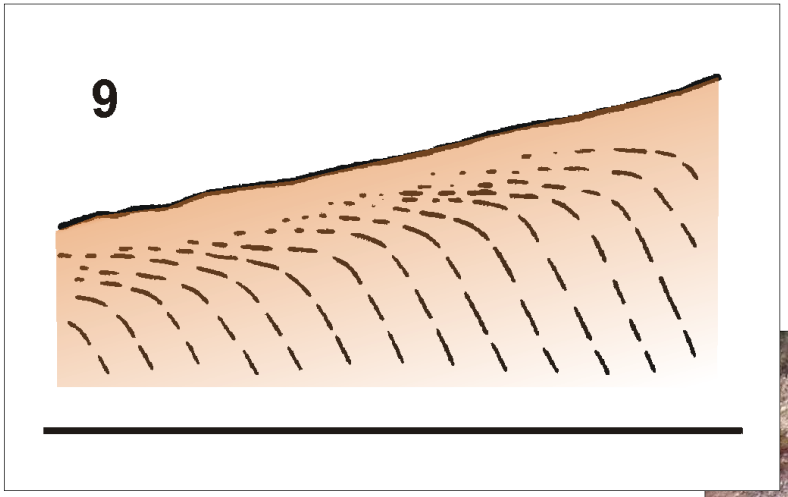


Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : *fall*

9) SUPERFICIAL CREEP



BENDING OF BEDS

Czech Republic, Praha, Hlubočepy

Liberec

Nemčok, Pašek & Rybář (1972)

creep : ***sliding*** : ***flow*** : ***fall***

9) SUPERFICIAL CREEP

SLIDING

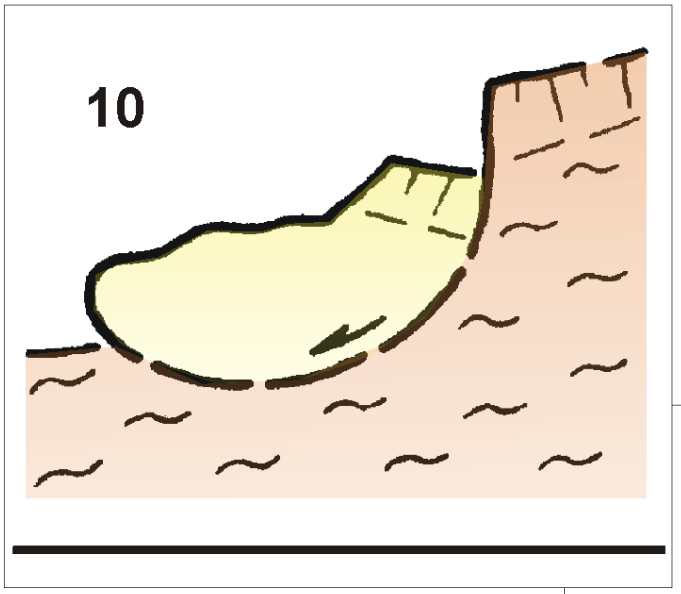
- Slope movements of coherent masses along one or more well-defined rupture surfaces (shear surfaces, slip planes)

- Part of masses is shifted onto original terrain

- Result of movement is landslide
- Velocity **m/hour (soils) to km/hour (rocks)**

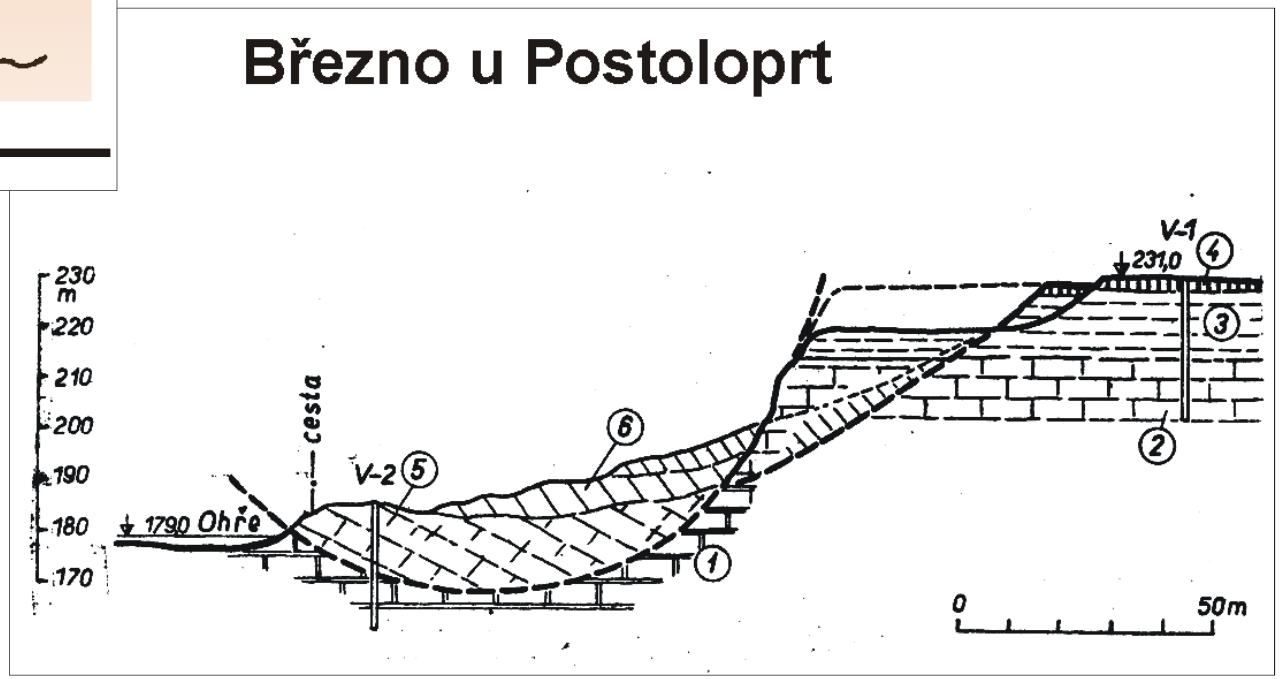
SLIDING

10) SLIDING ON SIMPLE ROTATIONAL SHEAR SURFACE

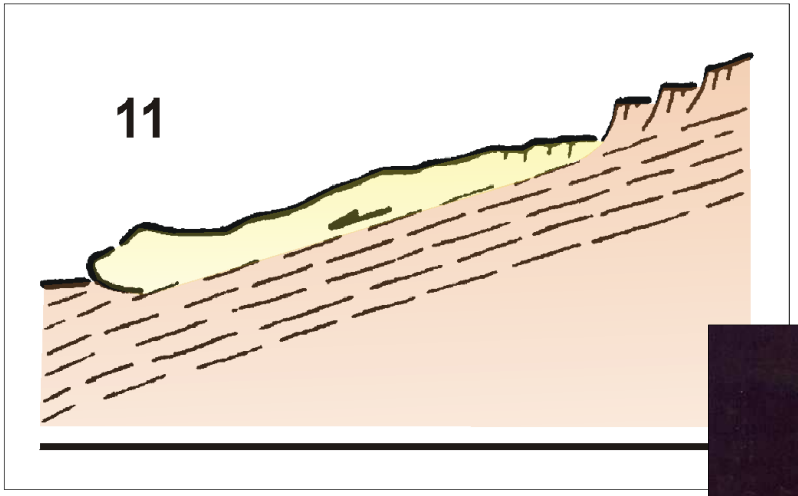


ROTATIONAL LANDSLIDE

Pašek 1974

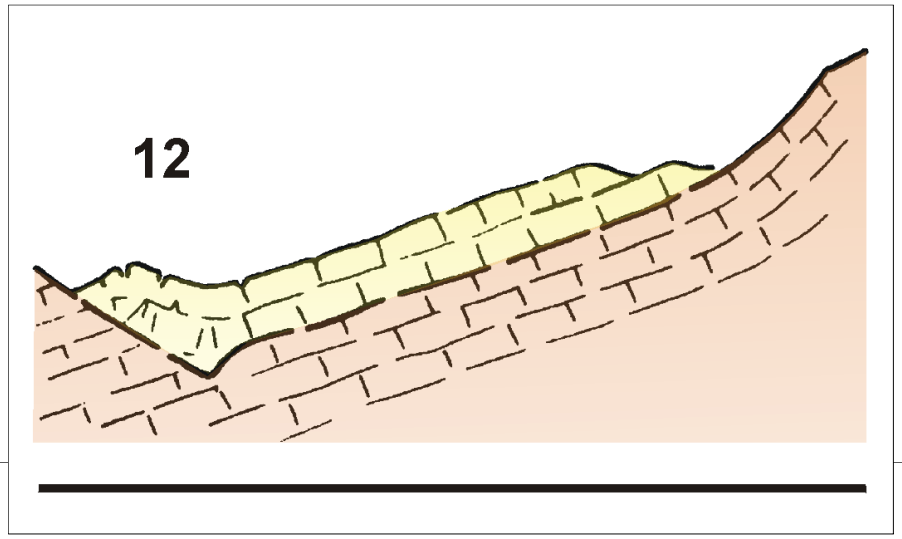


11) **SLIDING** ALONG A PLANAR SLIDING SURFACE IN SOILS



PLANAR LANDSLIDES IN SOILS,
PLANAR LANDSLIDES ALONG PRE-DISPOSED SHEAR SURFACE

12) **SLIDING** ALONG A PLANAR SLIDING SURFACE IN ROCKS

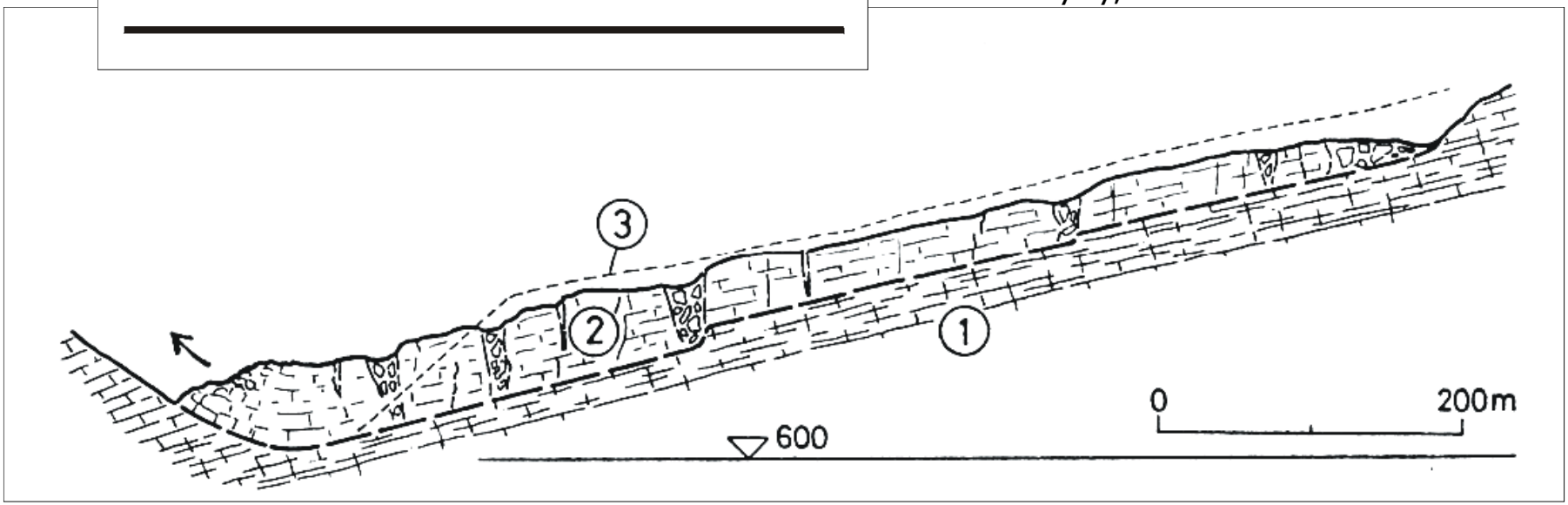


PLANAR LANDSLIDES IN ROCKS,

PLANAR LANDSLIDES ALONG PRE-DISPOSED

SHEAR SURFACE (BEDDING, SCHISTOSITY, JOINTING, FAULTS…)

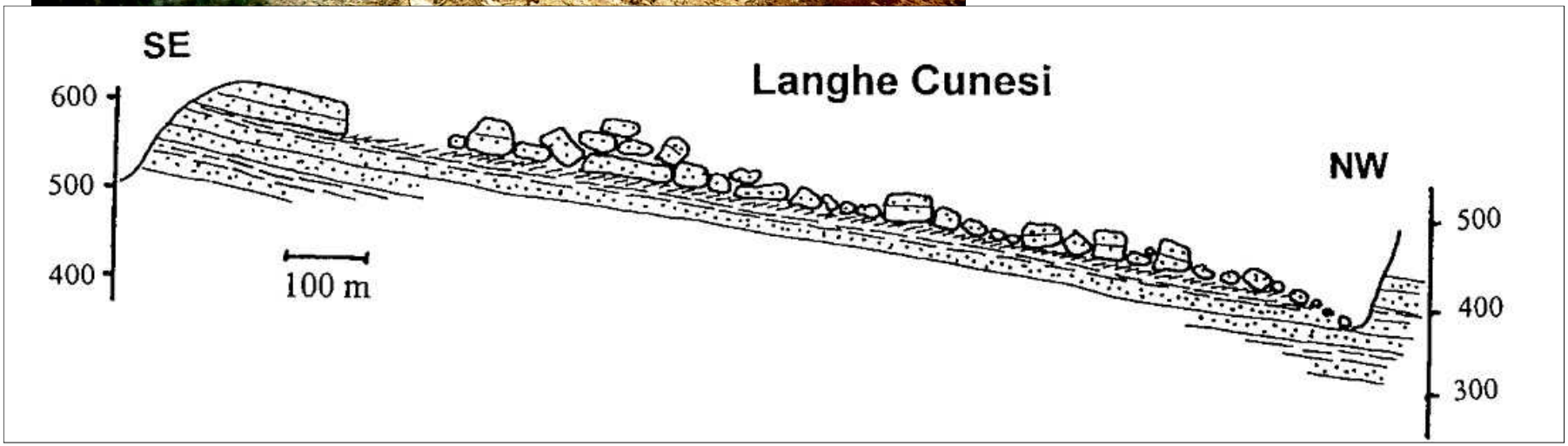
Beskydy, Šance Novosad 1993



12) **SLIDING** ALONG A PLANAR SLIDING SURFACE IN ROCKS

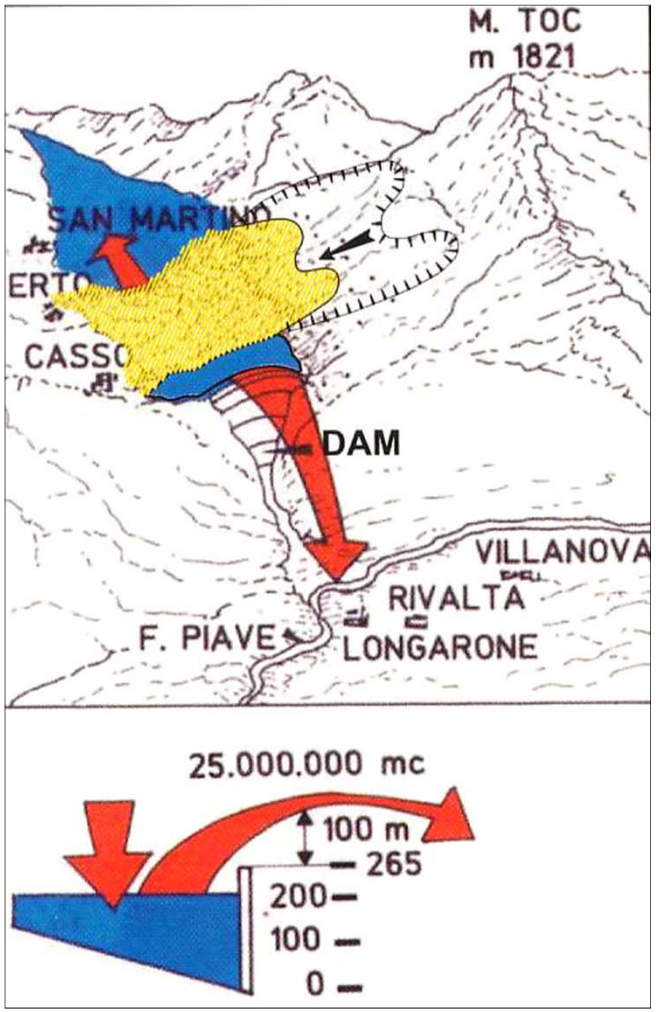
Langhe Cunesi, ITALY 1994

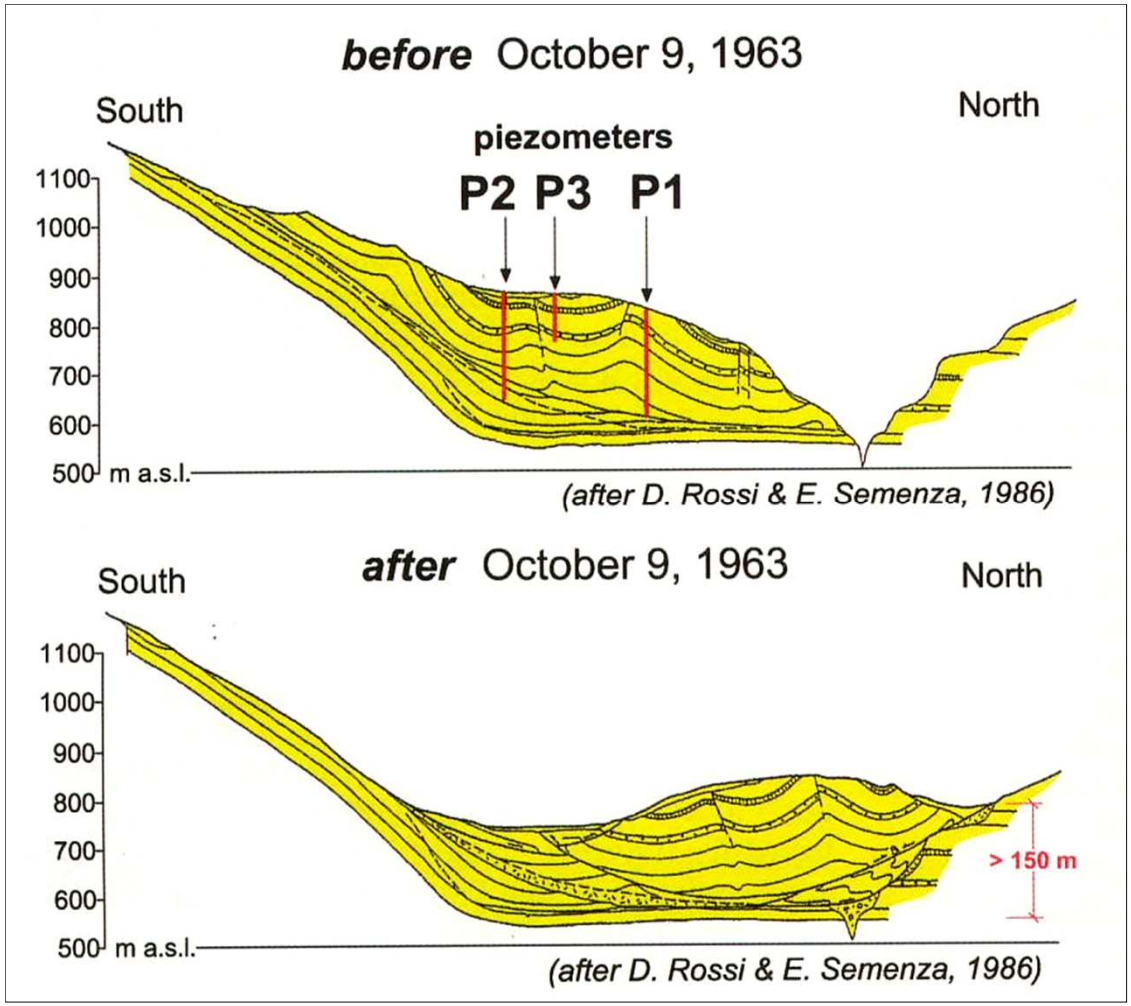
Heiland 1996



12) SLIDING ALONG A PLANAR SLIDING SURFACE IN ROCKS

Vaiont 1963 Cotecchia 2006





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Vaiont 1963

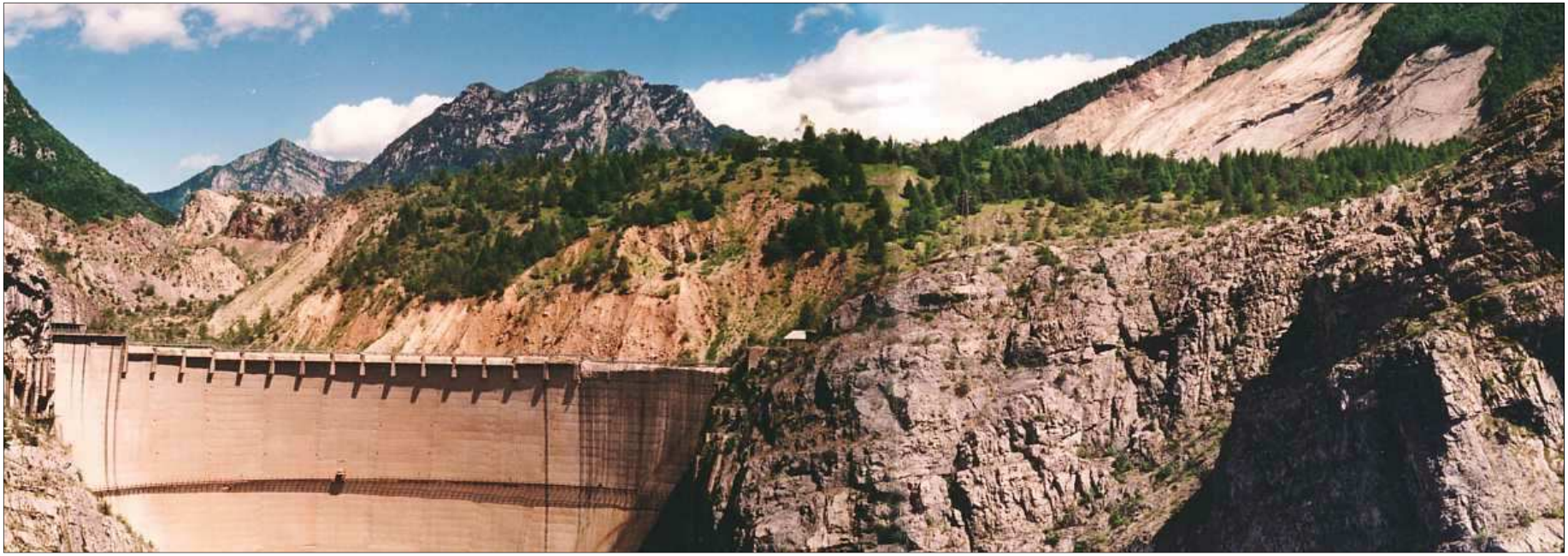

Photo J.Novotný

12) **SLIDING** ALONG A PLANAR SLIDING SURFACE IN ROCKS

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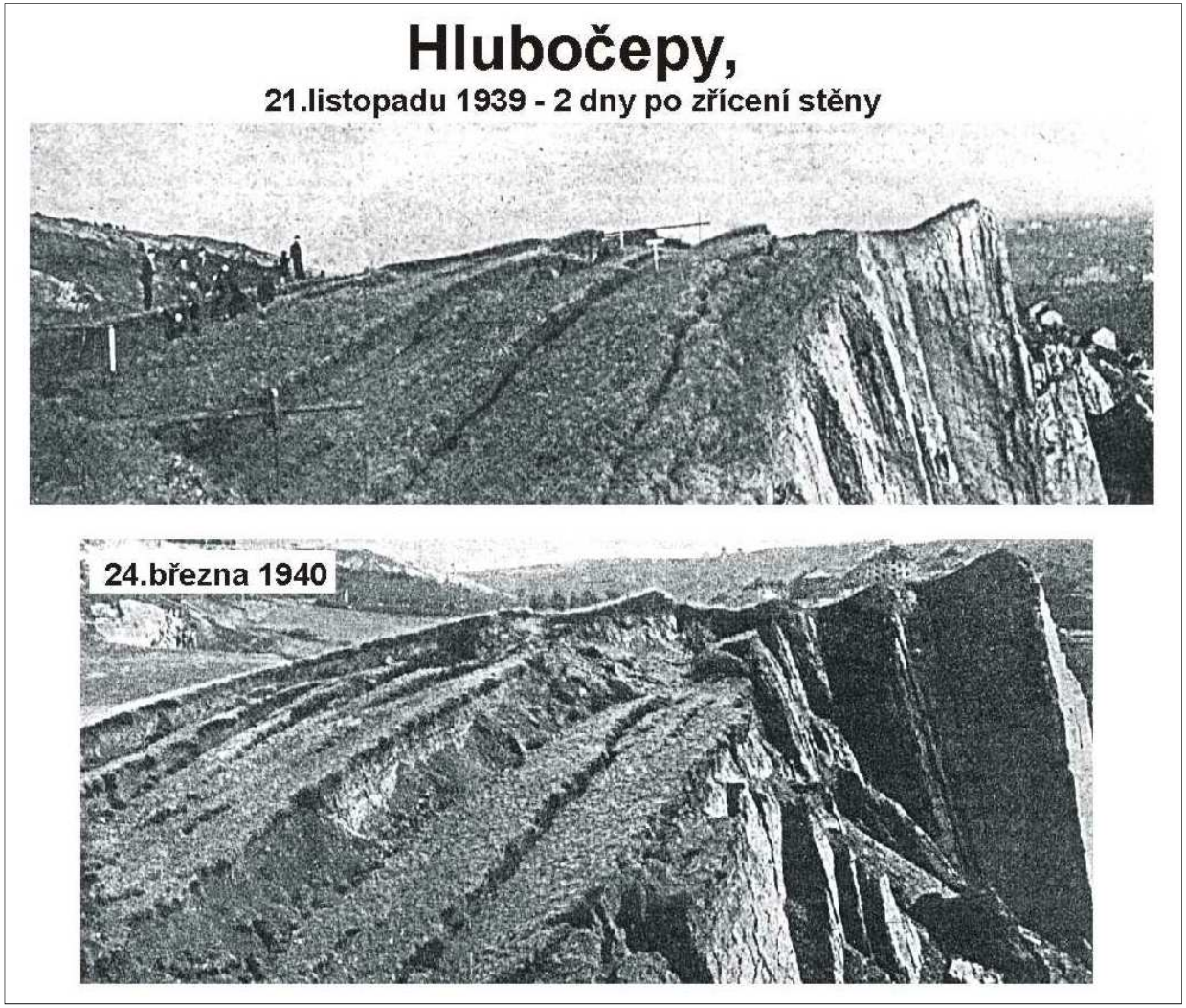
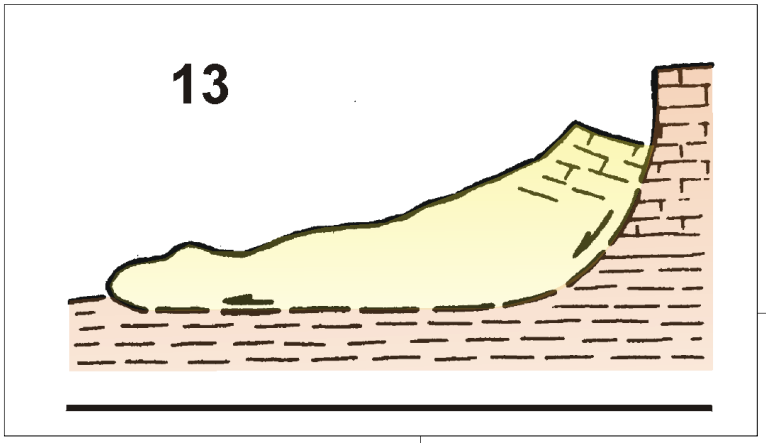
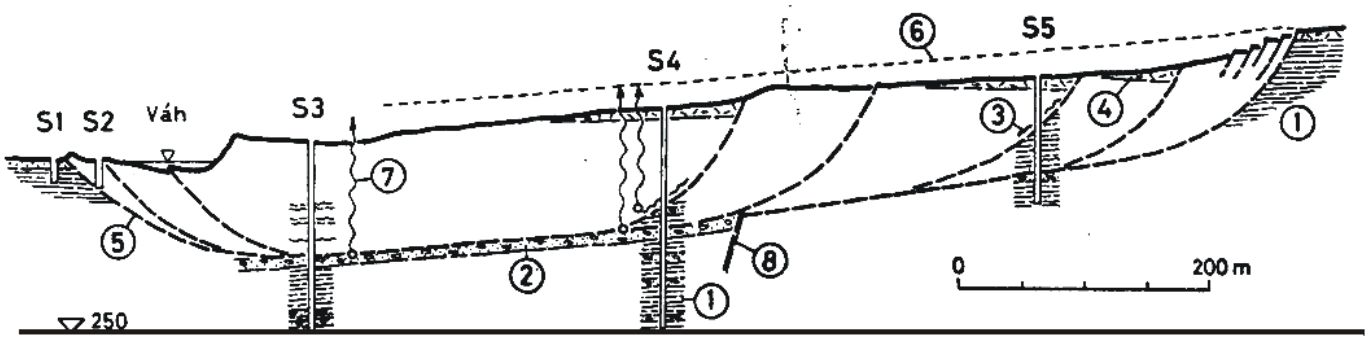


13) SLIDING ALONG COMBINED SLIDING SURFACE



ROTATIONAL PLANAR LANDSLIDE

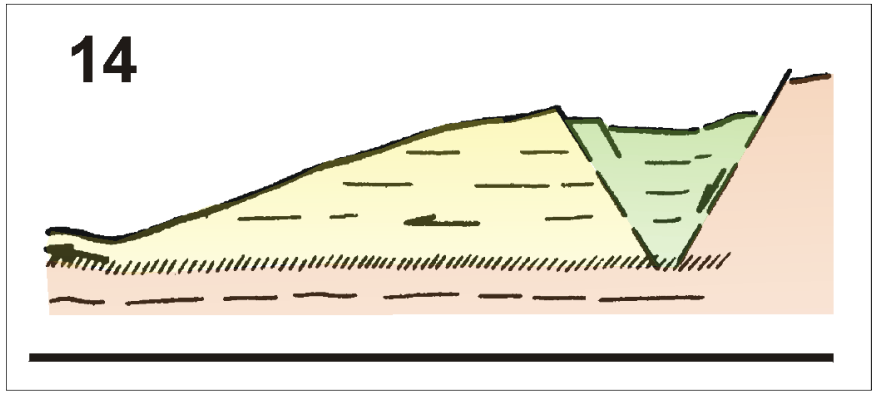
SUČANY ON VÁH RIVER, SLOVAK REPUBLIC



Záruba, Mencl 1958

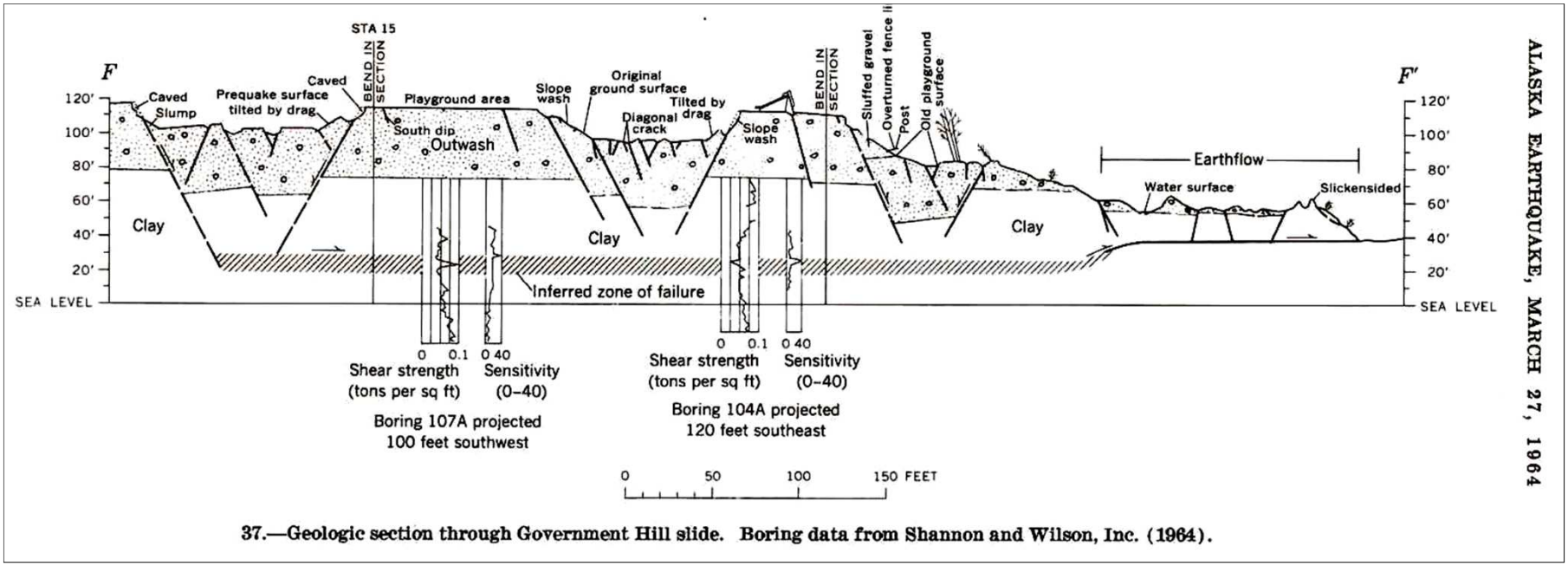
13) **SLIDING** ALONG COMBINED SLIDING SURFACE

14) **HORIZONTAL TRANSLATION** ON A PRE-EXISTING SLIDING SURFACE



LATERAL LANDSLIDES, TRANSLATIONAL LANDSLIDES

Anchorage 1964 Hansen 1965



37.—Geologic section through Government Hill slide. Boring data from Shannon and Wilson, Inc. (1964).

Klasifikace svahových pohybů

ploužení : sesouvání : stékání : řícení

14) **HORIZONTAL TRANSLATION** ON A PRE-EXISTING SLIDING SURFACE

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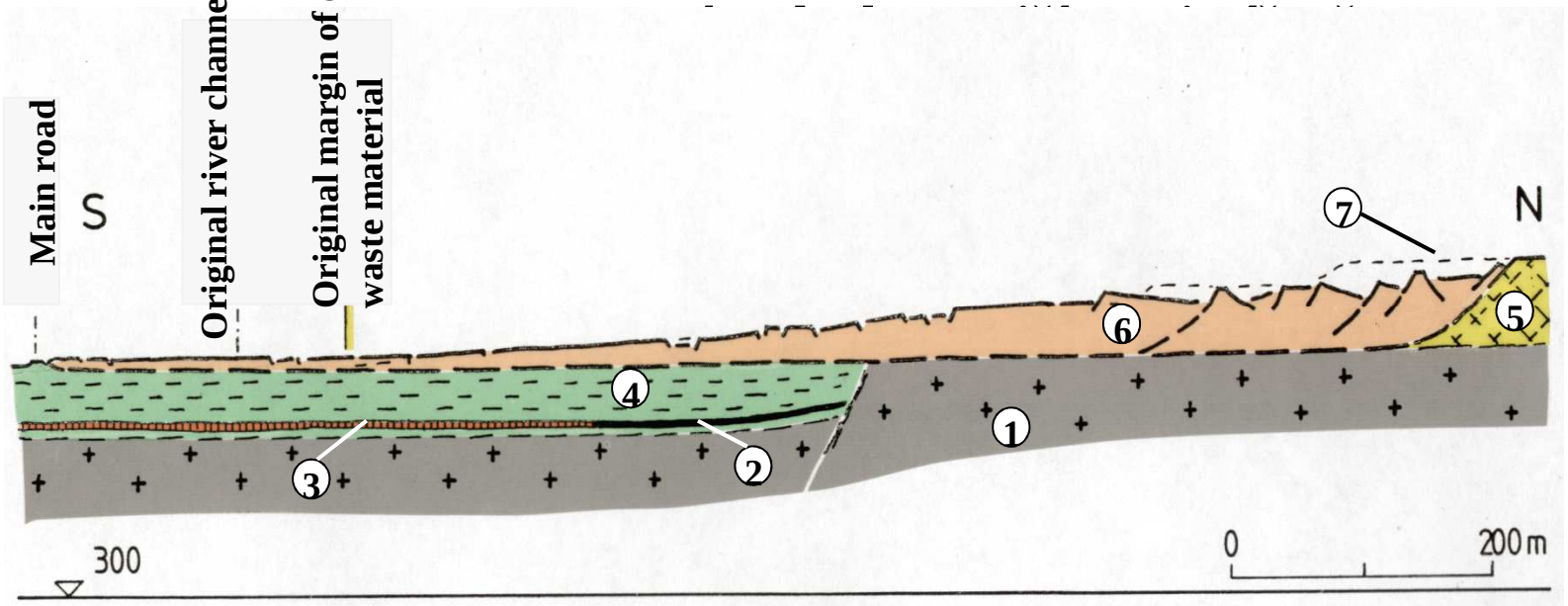


1 - Bedrock – crystalinic rocks
2 - Coal seam Josef
3 - Partly exploited coal seam
4 - Tufitic clays
5 - Original dump waste material
6 - Sliding of waste material
7 - State before landslide

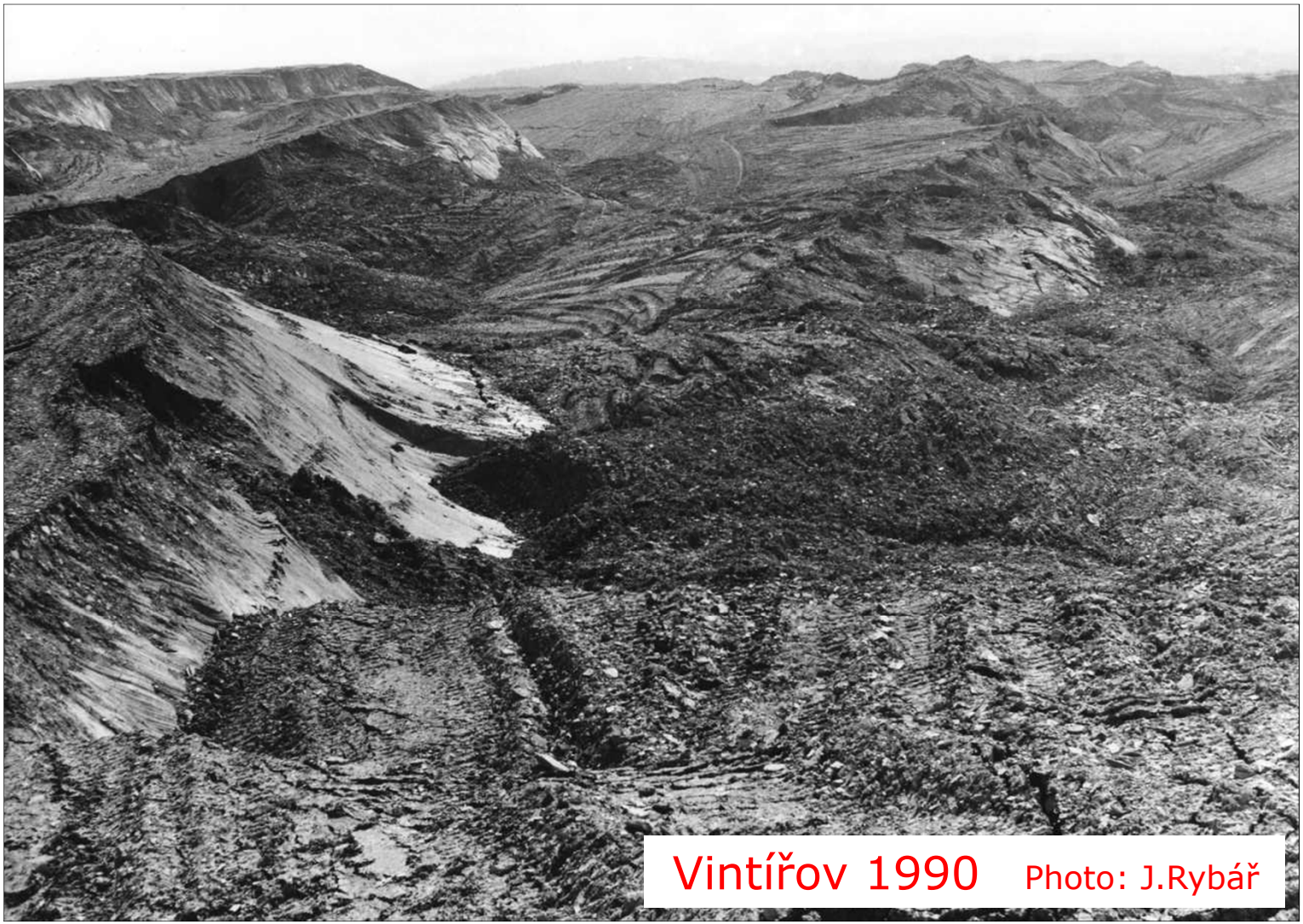
Vintířov 1990

According to J.Rybář

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

14) **HORIZONTAL TRANSLATION** ON A PRE-EXISTING SLIDING SURFACE



Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

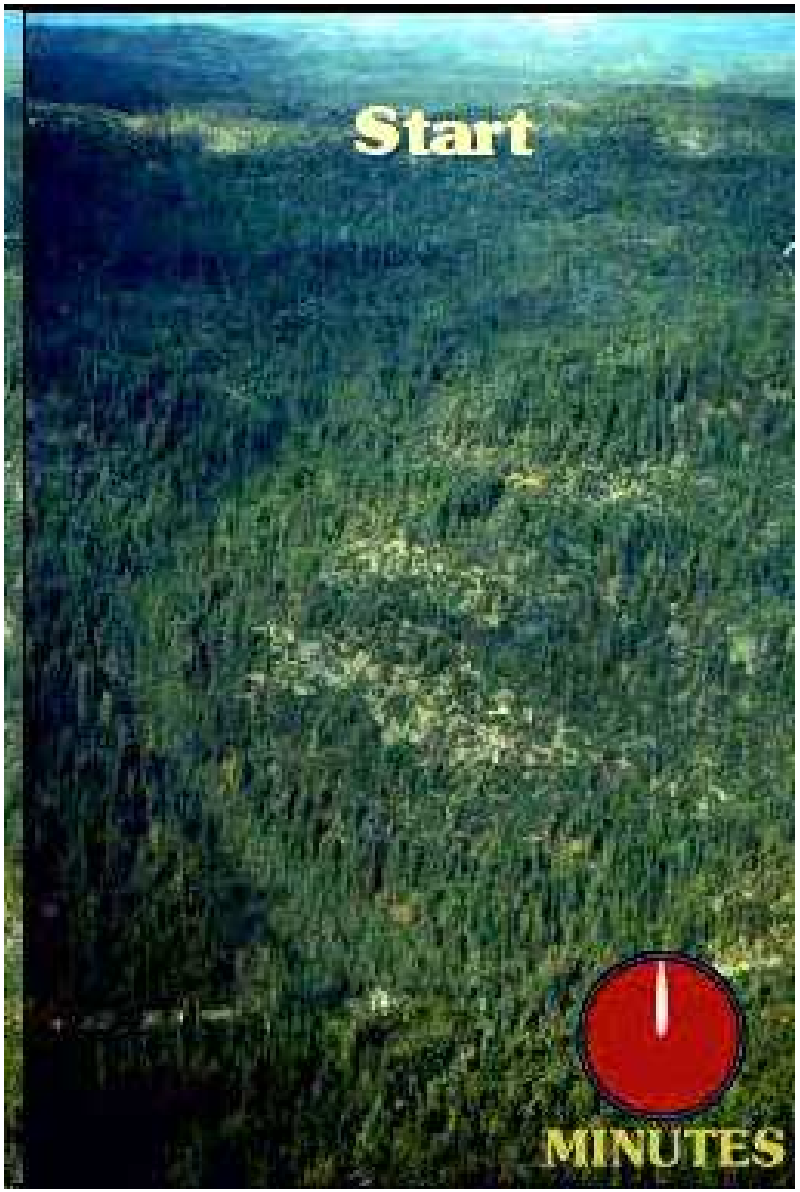
FLOW

- Slope movement in rock and soil analogous to the movements of liquids. Material flow from source area on a terrain surface on a long distance. There is a sharp contact between flowing material and terrain
- Result of movement is flow
- Velocity **km/day (earth flow) to km/hour (debris flow)**

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

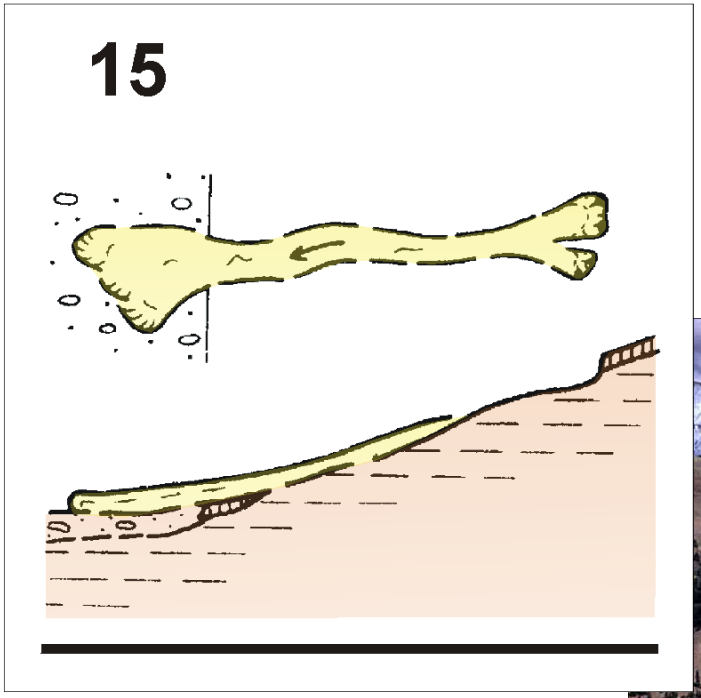
FLOW



Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

15) FLOW OF CLAYEY AND SILTY SANDY SOILS



EARTHFLOW,

FLOW IN SENSITIVE CLAYS

THE SLUMGULLION LANDSLIDE, COLORADO
STÁŘÍ CCA 700 LET

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

15) FLOW OF CLAYEY AND SILTY SANDY SOILS

LA CONCHITA, USA

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

15) FLOW OF CLAYEY AND SILTY SANDY SOILS

LA CONCHITA 2005

Photo J.Novotný

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

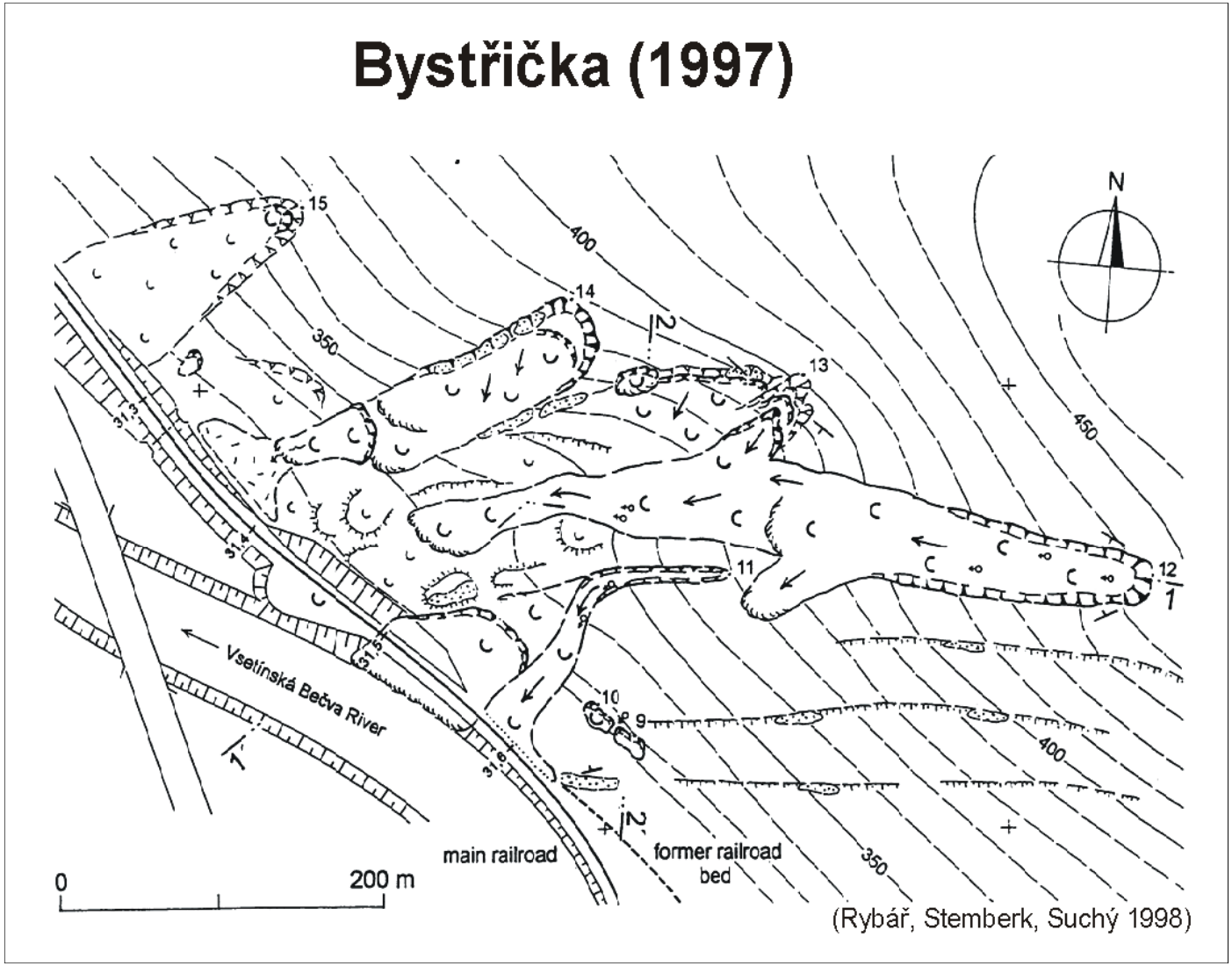
15) FLOW OF CLAYEY AND SILTY SANDY SOILS

LA CONCHITA 2005

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

15) FLOW OF CLAYEY AND SILTY SANDY SOILS



Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

15) FLOW OF CLAYEY AND SILTY SANDY SOILS

Czech Republic, Bystřička 1997

Nemčok, Pašek & Rybář (1972)

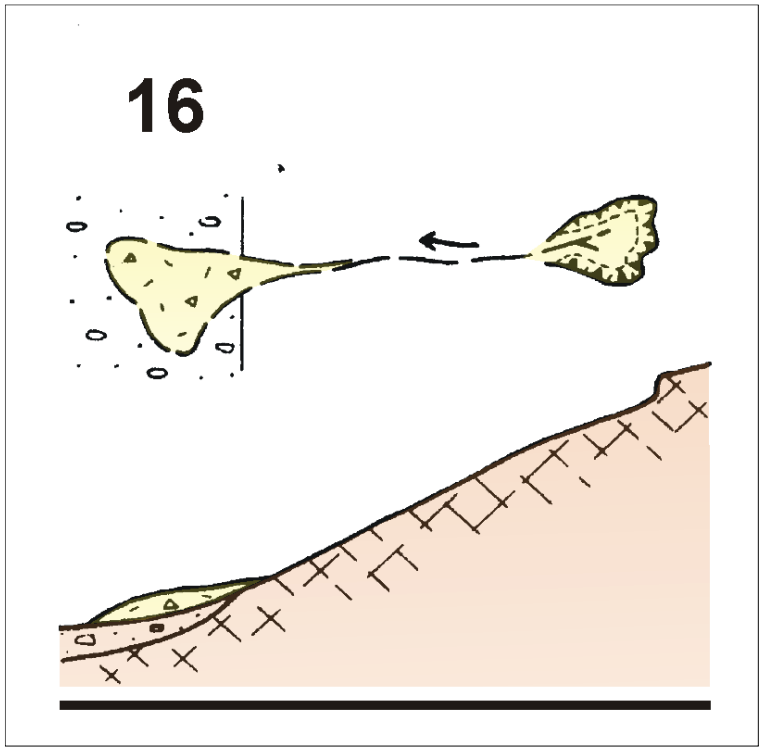
creep : sliding : flow : fall

15) FLOW OF CLAYEY AND SILTY SANDY SOILS

Czech Republic, Fryšták 2002

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

DEBRIS FLOW, MUD FLOW



Alps

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Highway 101 near Ventura, CALIFORNIA 2005

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

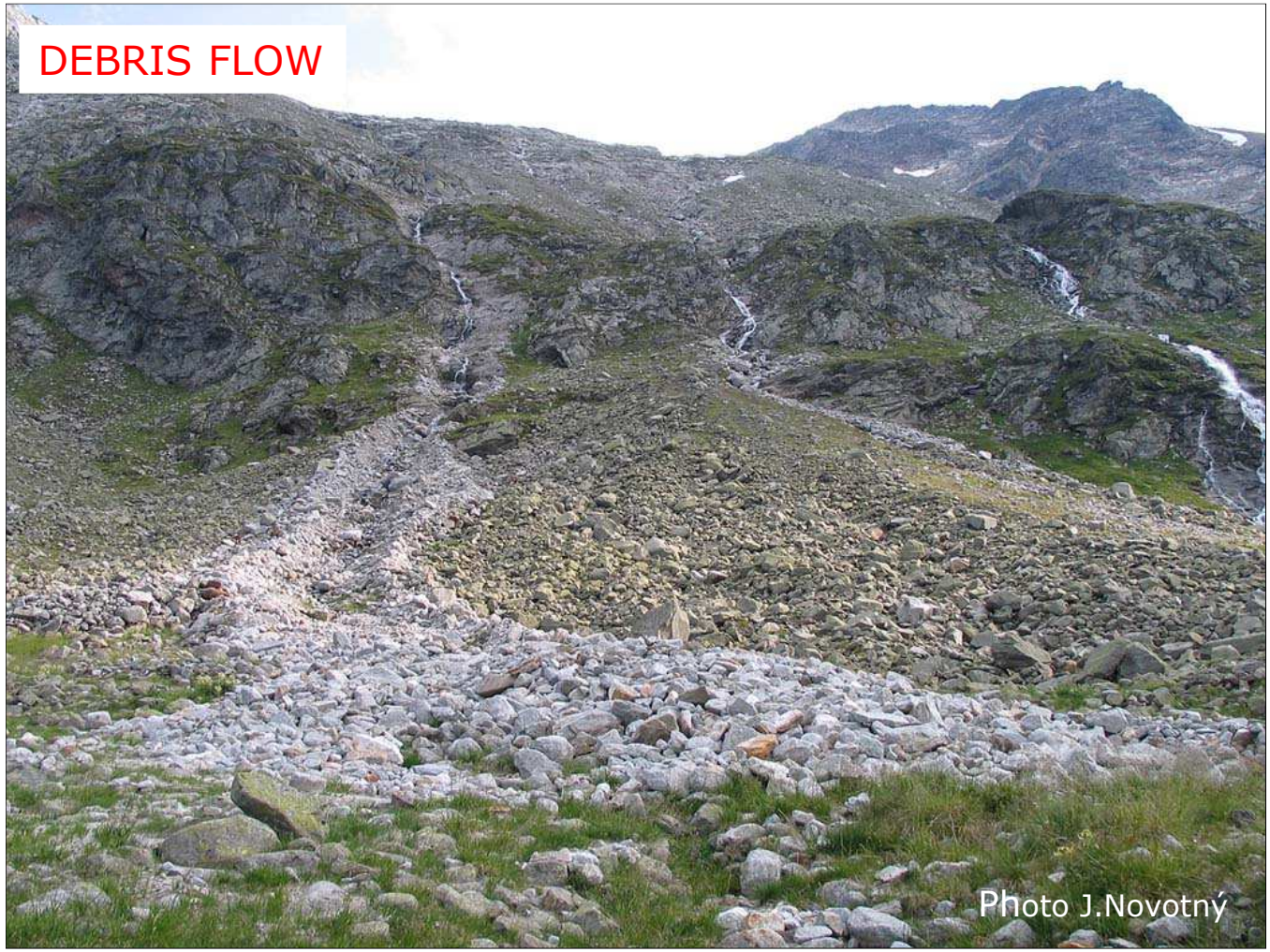
16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Nemčok, Pašek & Rybář (1972)

*creep : sliding : **flow** : fall*

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Alps



Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Debris-flow damage to the city of Caraballeda, located at the base of the Cordillera de la Costan, on the north coast of Venezuela. In December 1999, this area was hit by Venezuela's worst natural disaster of the 20th century; several days of torrential rain triggered flows of mud, boulders, water, and trees that killed as many as 30,000 people. (Photograph by L.M. Smith, Waterways Experiment Station, U.S. Army Corps of Engineers.)

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Photo: J. Novotný

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

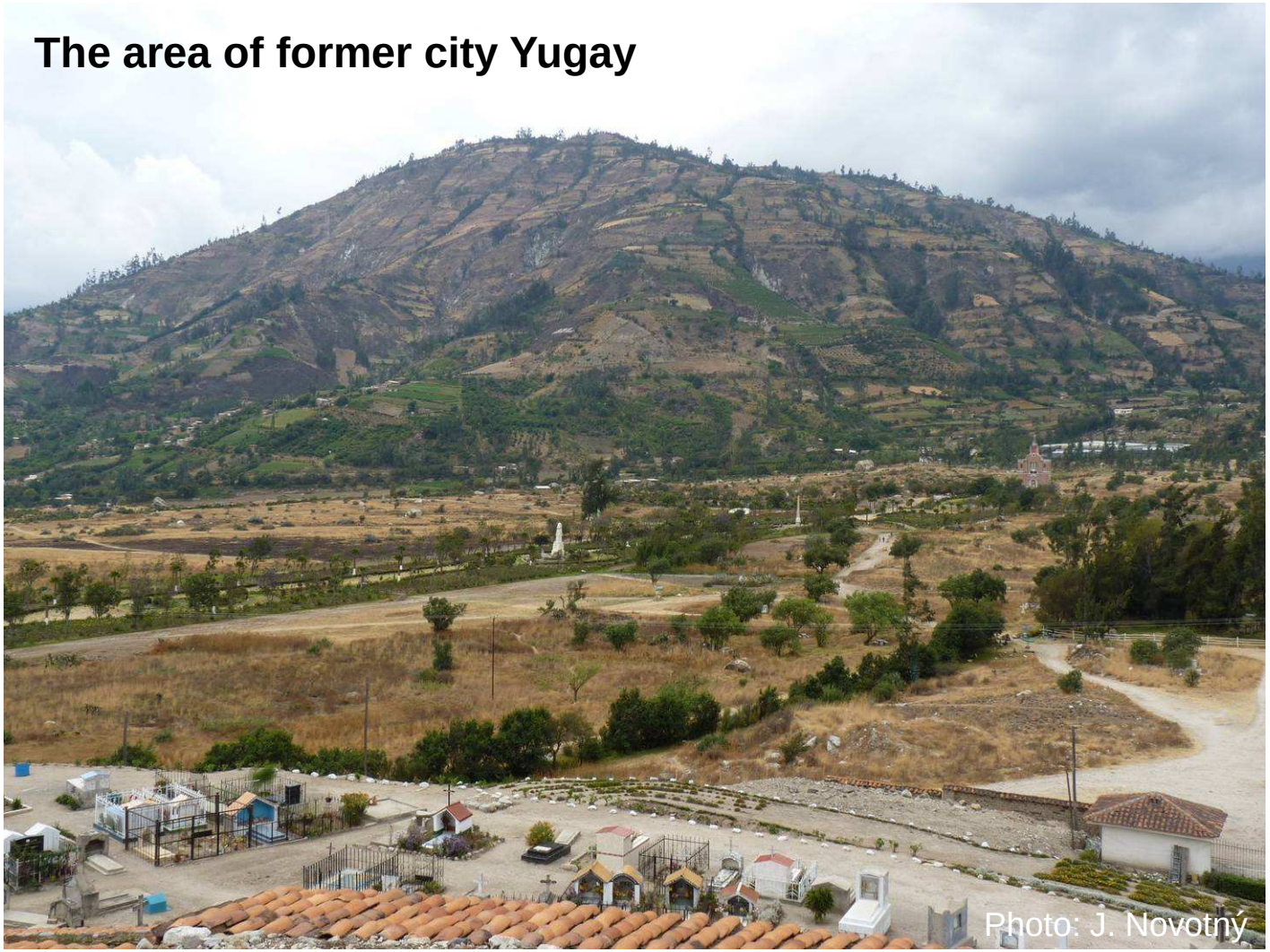
16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

This is a photograph showing the aftereffects of a multi-hazard event. It is an aerial view showing part of the Andes Mountains and Nevado Huascaran, the highest peak in Peru, South America. A massive avalanche of ice and rock debris, triggered by the May 31, 1970, earthquake, buried the towns of Yungay and Ranrahirca, killing more than 20,000 people, about 40 percent of the total death toll of 67,000. The avalanche started with a sliding mass of glacial ice and rock about 1,000 meters (3,000 feet) wide and 1.6 kilometers (one mile) long that swept downslope about 5.4 kilometers (3.3 miles) to Yungay at average speed of more than 160 kilometers per hour. The ice picked up morainal material of water, mud, and rocks. (Photograph by Servicio Aerofotográfico National, graphics by George Plafker, U.S. Geological Survey.) Photograph and information from the U.S. Geological Survey Photographic Archives: *http://libraryphoto.cr.usgs.gov/*

Nemčok, Pašek & Rybář (1972)

*creep : sliding : **flow** : fall*

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL



Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

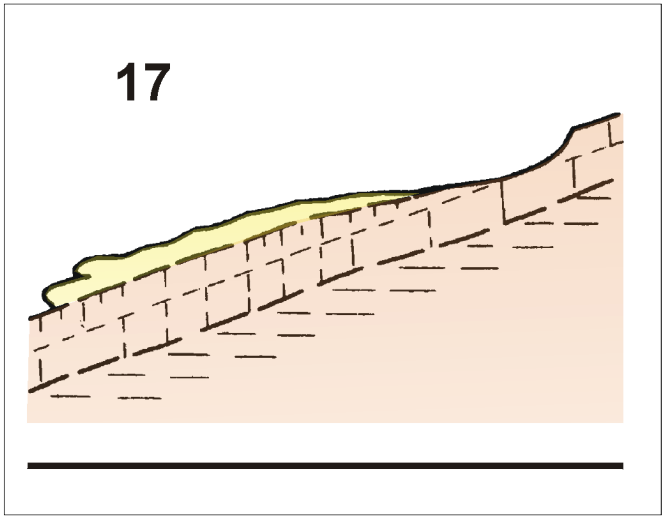
16) FLOW OF SILTY SOILS AND DEBRIS DUE TO THE IMPACT OF HEAVY RAINFALL

Instability of moraine slope **(slides)** can produce **debris flow**

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

17) **SUPERFICIAL FLOW** IN PERIODS OF EXCESSIVE PRECIPITATION OR IN PERIODS OF THAWING



Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : ***fall***

FALL

- Sudden slope movement, **moving masses lose their coherence and for a short time also their contact with the underlying rock**

- The distance of moved rocks is much higher in contrast to their volume
- Velocity **km /hour to 100 km/hour**

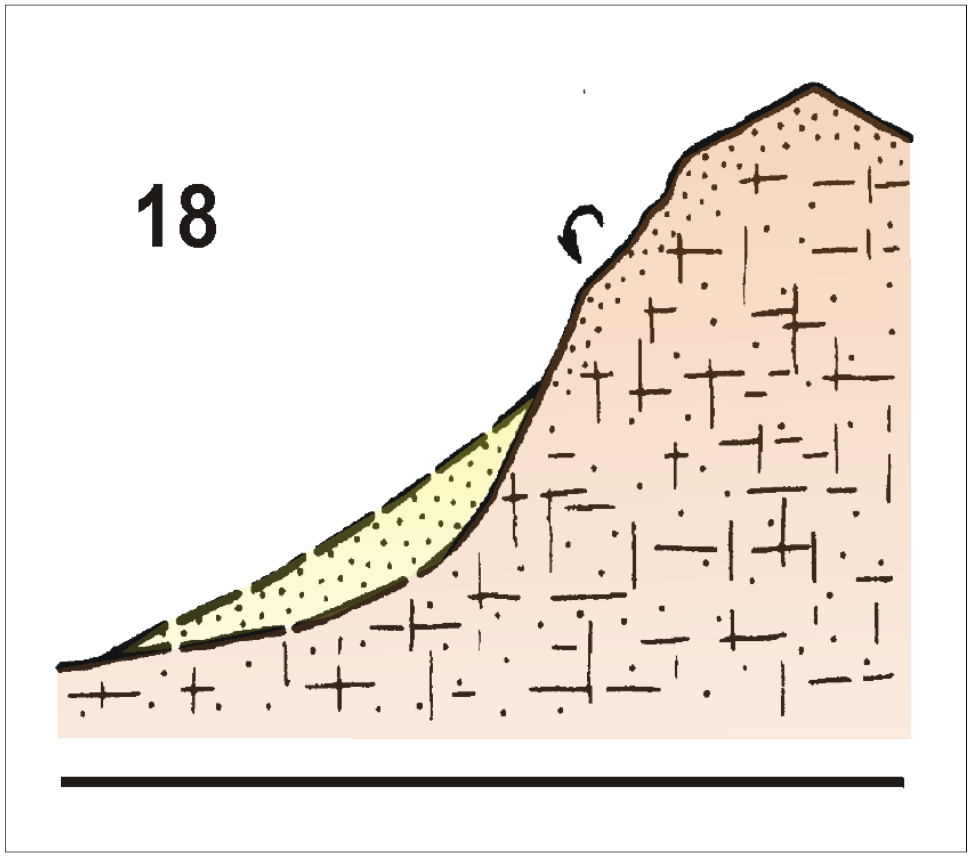
Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

FALL

New Zealand

18) FALL OF SMALL FRAGMENTS BY ROLLING DOWNSLOPE

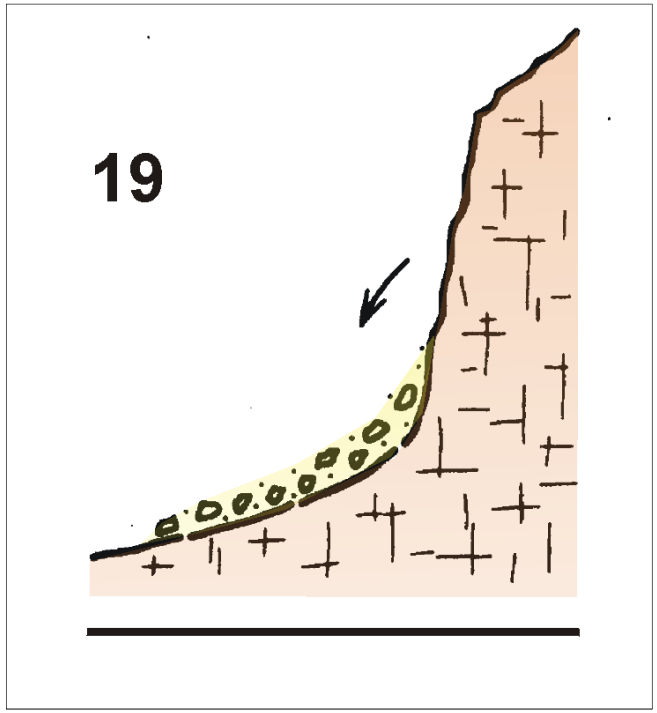


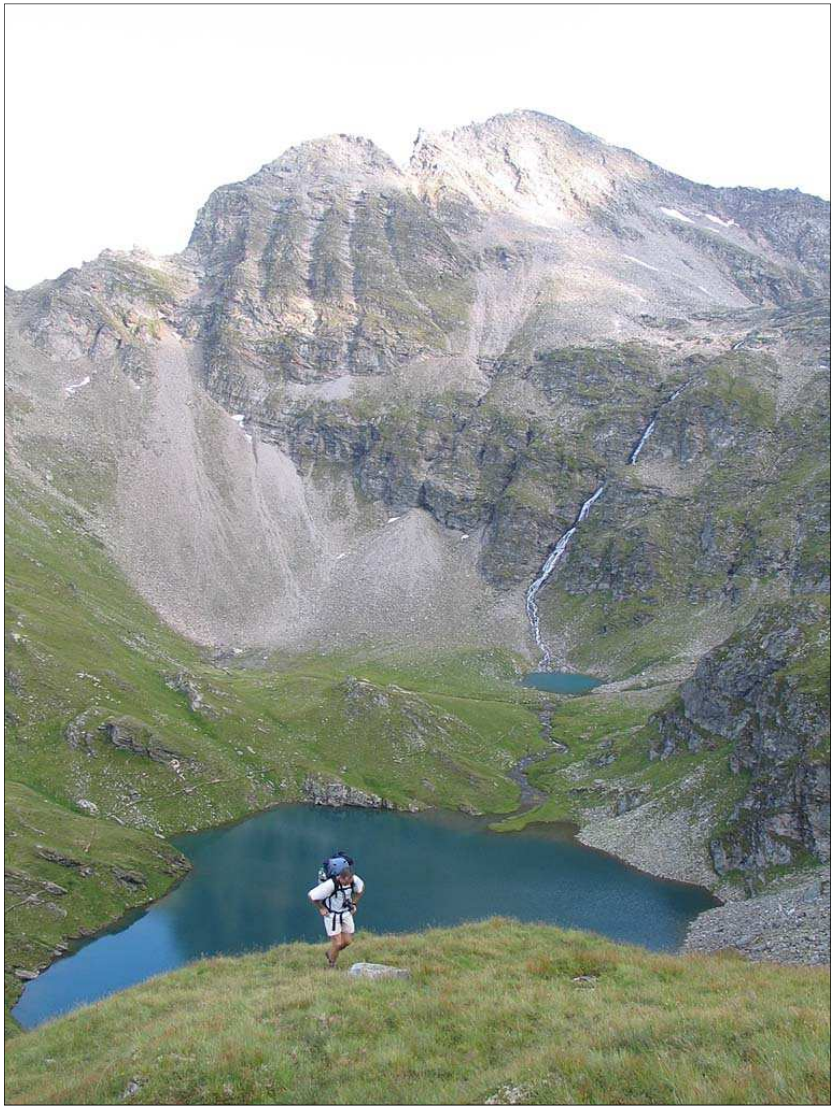
Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

19) **STONE FALL** ON STEEP ROCKY SLOPES

DEBRIS CONES, TALUS



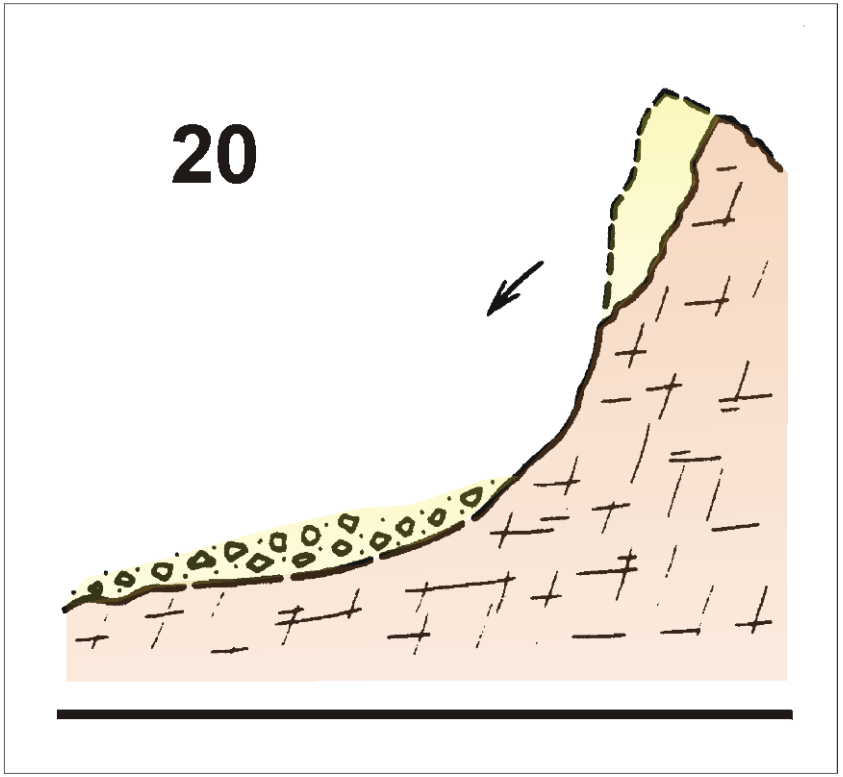


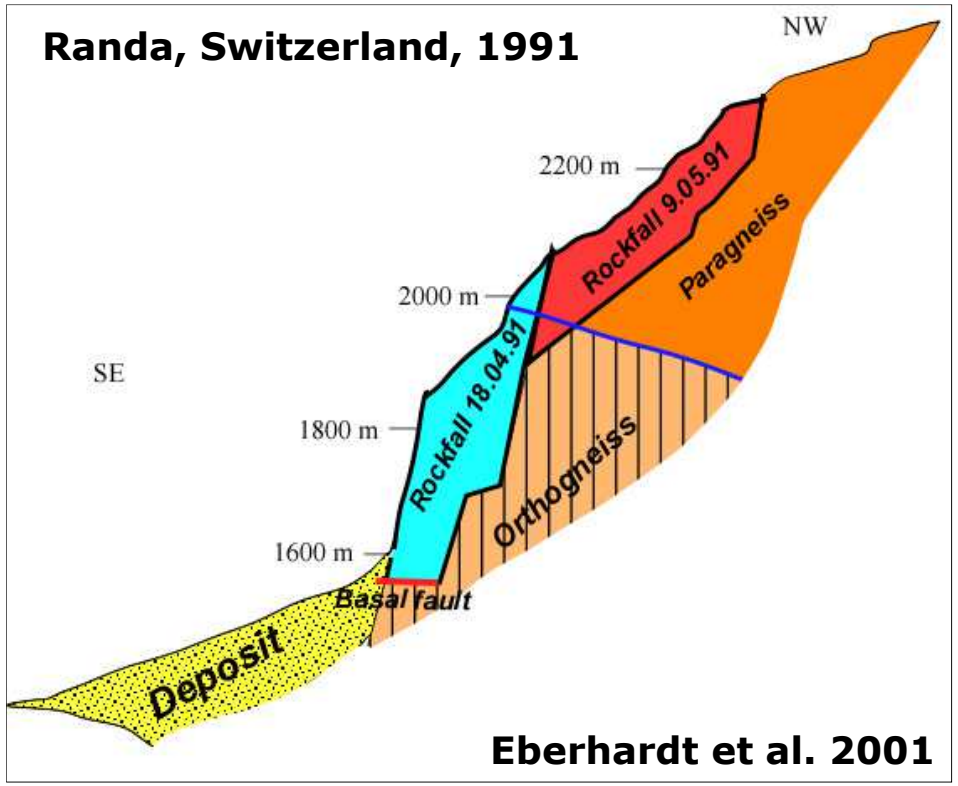
Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

20) ROCK FALL – PART OF ROCK WALL FALLS DOWNSLOPE BY PURE FREE FALL

ROCK FALL





20) ROCK FALL – PART OF ROCK WALL FALLS DOWNSLOPE BY PURE FREE FALL

Nemčok, Pašek & Rybář (1972)

creep : sliding : flow : fall

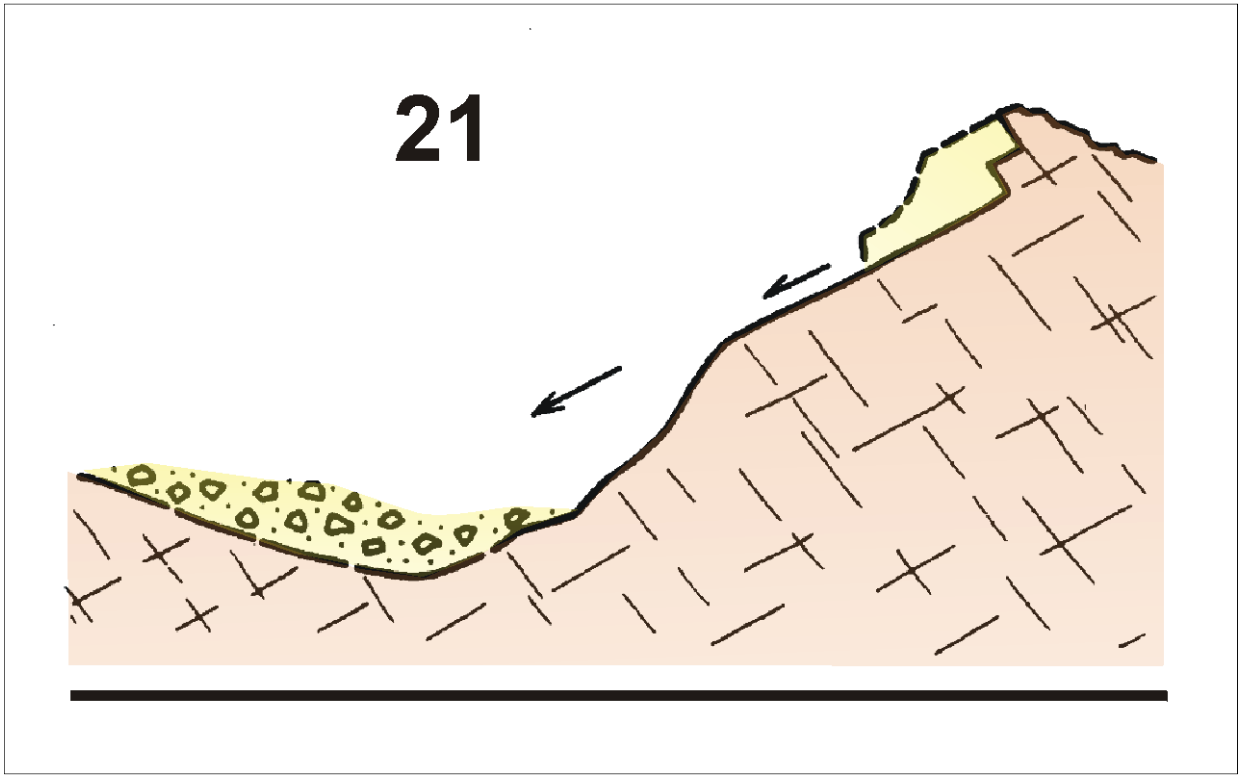
20) ROCK FALL – PART OF ROCK WALL FALLS DOWNSLOPE BY PURE FREE FALL

Nemčok, Pašek & Rybář (1972)

creep : *sliding* : *flow* : ***fall***

21) ROCK FALL COMBINED WITH TRANSLATION IN THE FIRST STAGE

PLANAR ROCKFALL



MASS MOVEMENT (SLOPE MOVEMENT)

X

LANDSLIDE

1) LANDLSIDE IS PRODUCT OF SLIDING

2) TERM „LANDSLIDE“ IS ALSO USED IN A SENCE OF MASS MOVEMENT

CHINA

Transition between types