ANALISI DI STABILITA' DI VERSANTE E MODELLAZIONE

www.syl.ru; www.blogspot.com

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A.A. 2021-2022

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Analisi di stabilità dei versanti: le escursioni

1) Le colate di detrito in Valcanale **18 marzo**

2) Dogna, monitoraggio frana con telecamera da pozzo, inclinometro, freatimetro…. Dott. Kranitz **8 aprile**

3) Le frane di scivolamento a Fresis - Sigilletto (Forni Avoltri) **????**

Analisi di stabilità dei versanti

Cos’è una frana?

Stabilità???

Taiwan-Landslide

Cos’è una frana?

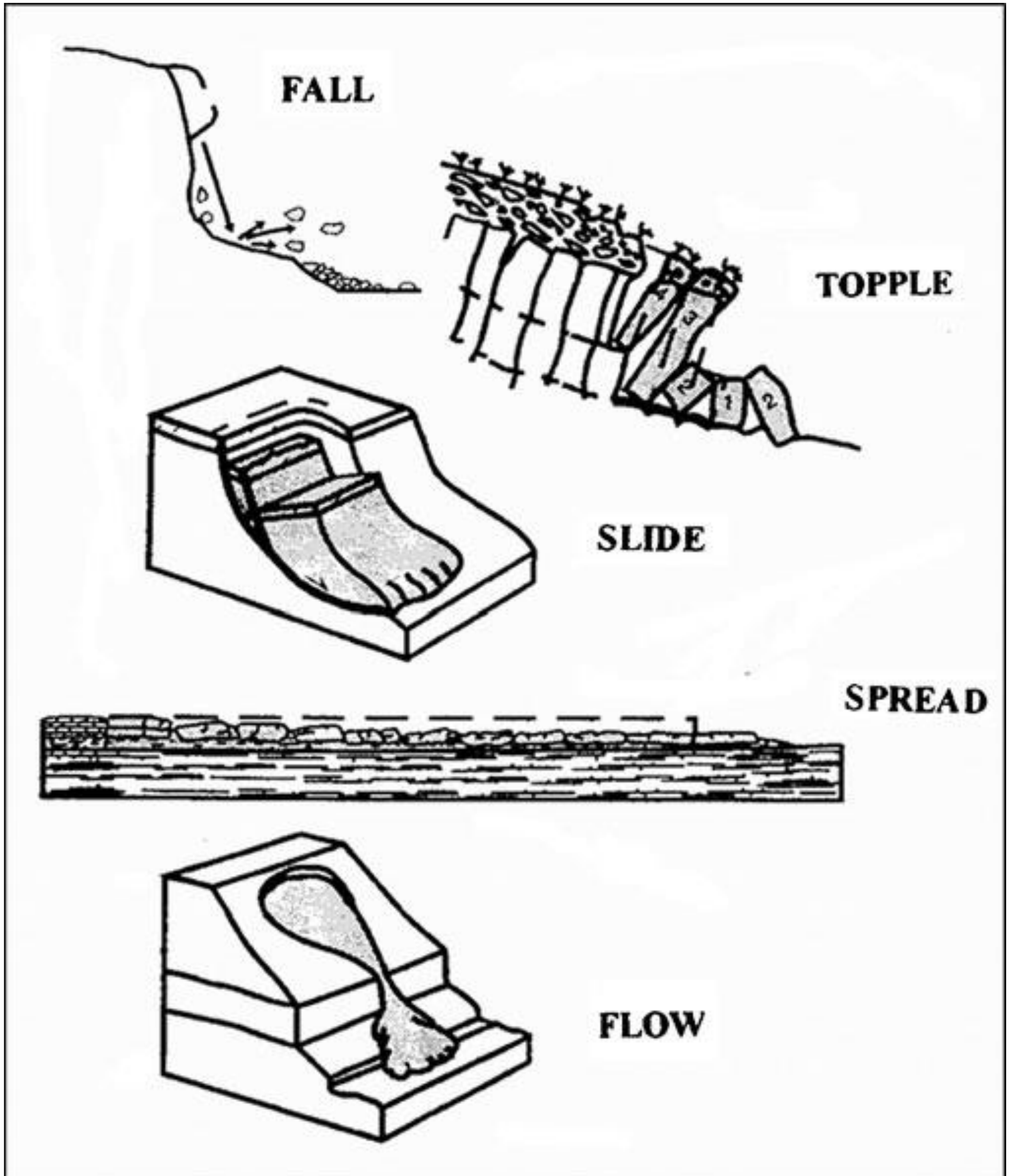
https://svs.gsfc.nasa.gov/20226

https://svs.gsfc.nasa.gov/11854

What causes a landslide? | Natural Disasters - Bing video

A landslide is a physical system that develops in time through several stages (e.g., Terzaghi 1950; Leroueil et al. 1996).

As reviewed by Skempton and Hutchinson (1969), the history of a mass movement comprises pre-failure deformations, failure itself and post-failure displacements. Many landslides exhibit a number of movement episodes, separated by long or short periods of relative quiescence.

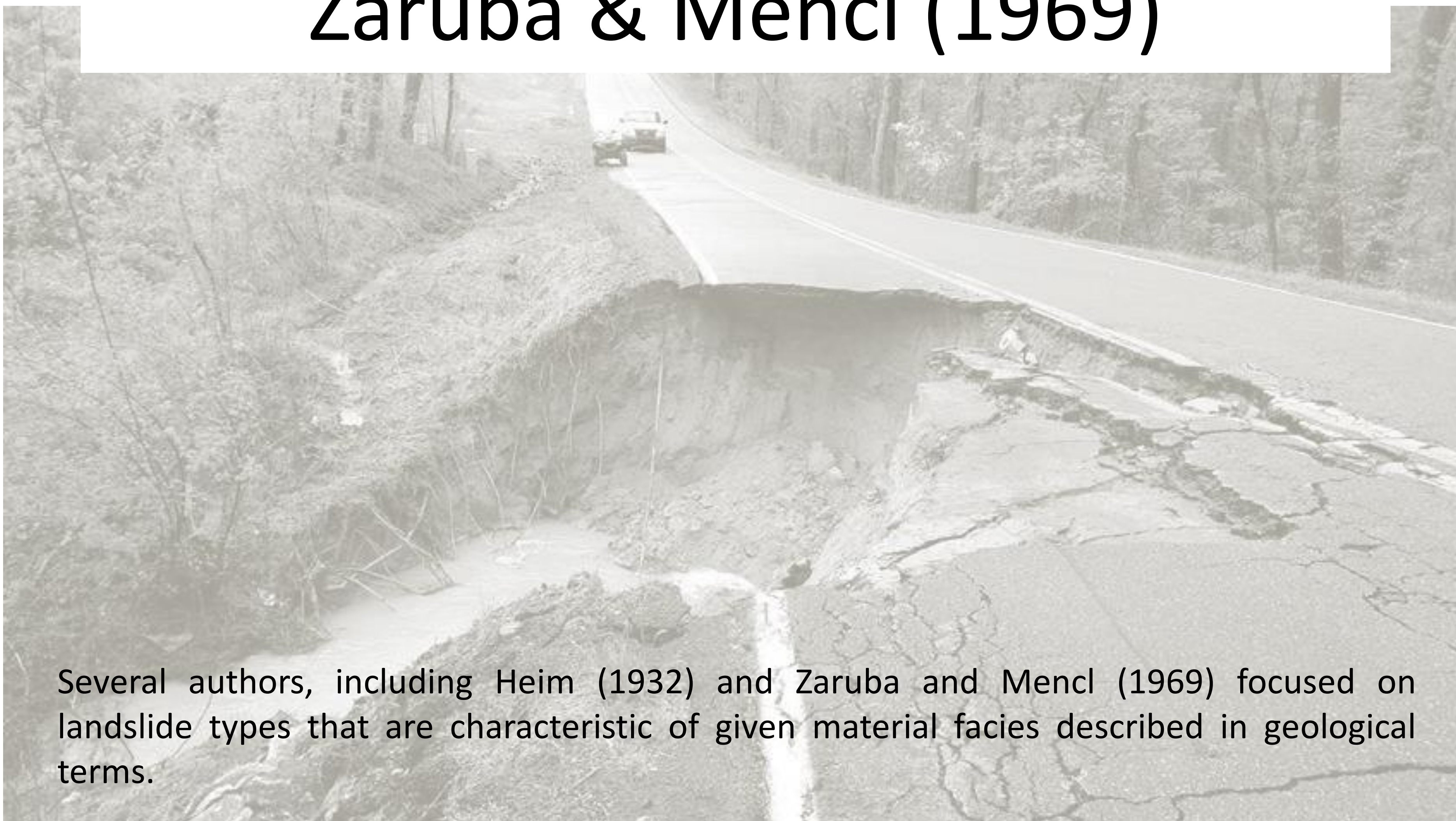


Baltzer (1875)

Some of the earliest landslide classification systems originated in the Alpine countries. Baltzer (1875) in Switzerland seems to have been the first to <u>distinguish between the various basic modes of motion: fall, slide, and flow.</u> This division persists to the present time, supplemented by toppling and spreading.

Heim (1932)

Zaruba & Mencl (1969)

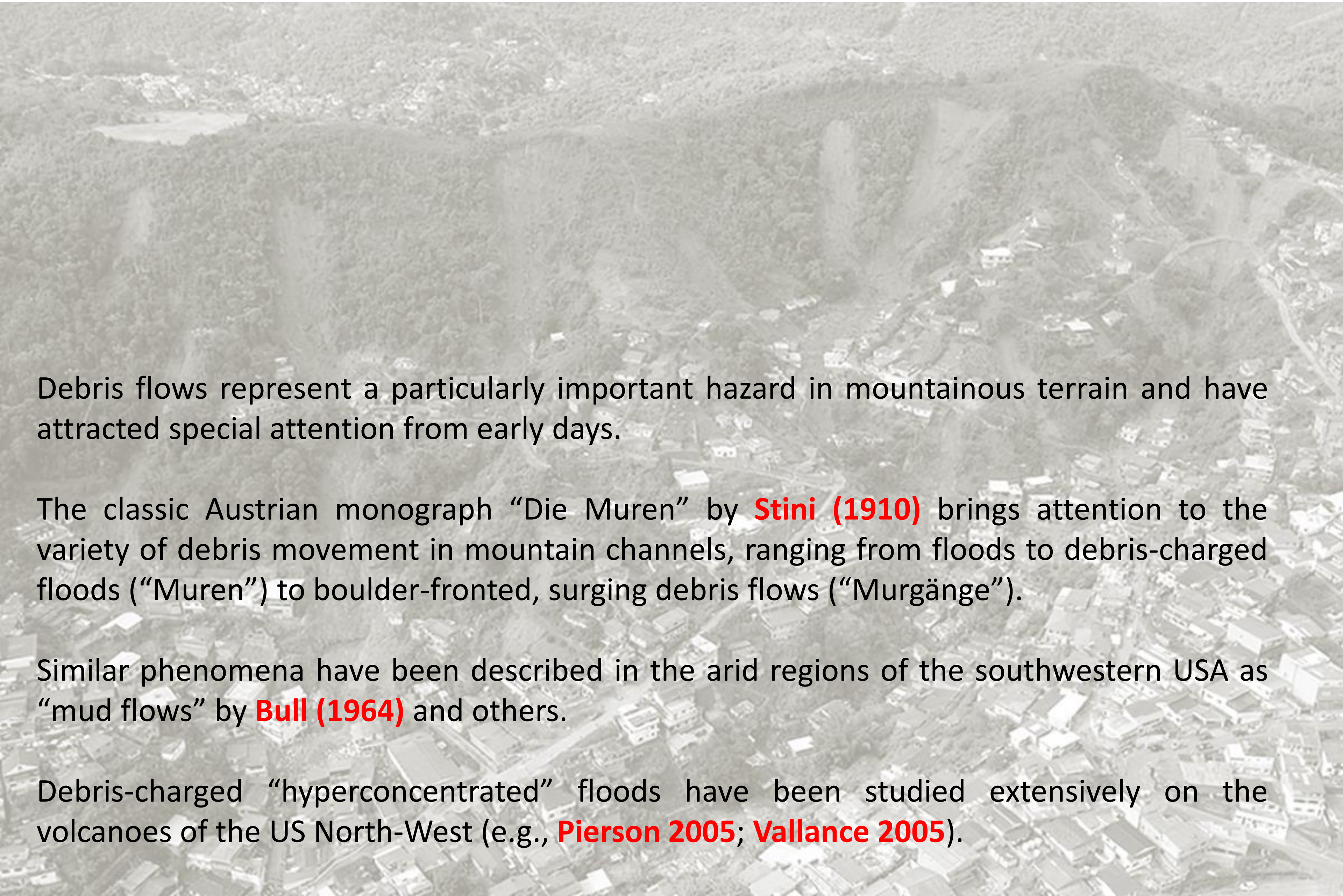


Several authors, including Heim (1932) and Zaruba and Mencl (1969) focused on landslide types that are characteristic of given material facies described in geological terms.

https://www.foxcarolina.com/news/some-roads-in-oconee-county-washed-out-after-heavy-rains/article_fa56c9fa-62ec-11e9-838e-dba28eff03da.html

Debris flow……

landslide | Geotechpedia blog



Debris flows represent a particularly important hazard in mountainous terrain and have attracted special attention from early days.

The classic Austrian monograph “Die Muren” by **Stini (1910)** brings attention to the variety of debris movement in mountain channels, ranging from floods to debris-charged floods (“Muren”) to boulder-fronted, surging debris flows (“Murgänge”).

Similar phenomena have been described in the arid regions of the southwestern USA as “mud flows” by **Bull (1964)** and others.

Debris-charged “hyperconcentrated” floods have been studied extensively on the volcanoes of the US North-West (e.g., **Pierson 2005**; **Vallance 2005**).

Sharpe (1938)

https://www.bing.com/images/search?view=detailV2&ccid=tqfEJDpl&id=919FE56C425A2F9BEE3BBAD3FB5984EB1801209B&thid=OIP.tqfEJDpln3khWznhTqzyrQHaE8&mediaurl=https%3a%2f%2fcdn.newsserve.net%2fen%2fknowledge%2fLandslide_20191210.jpg&cdnurl=https%3a%2f%2fth.bing.com%2fth%2fid%2fR.b6a7c4243a659f79215b39e14eacf2ad%3frik%3dmyABGOuEWfvTug%26pid%3dImgRaw%26r%3d0&exph=700&expw=1049&q=Type+of+Landslides&simid=608025712731641579&FORM=IRPRST&ck=AA42CE9C4F082B11C45F06567545ADF2&selectedIndex=36&ajaxhist=0&ajaxserp=0

In the USA, **Sharpe (1938)** introduced a tri-dimensional classification system recognizing type of movement, material and movement velocity.
He also coined (presumably) the important terms debris flow (channeled), debris avalanche (open-slope), and earth flow.

The term "**earth flow**" was reinforced and thoroughly described in the work of **Keefer and Johnson (1983)** and is used in North America as a synonym for the British "mudslide" (Hutchinson 1988). The latter word is frequently misused in media reports. Therefore, "earth flow" is preferable.

Varnes (1954, 1978)

Sharpe's framework was expanded by **Varnes (1954, 1978) in his influential articles prepared for the Transportation Research Board of the National Research Council in Washington.**

This was modified in 1996 by Cruden and Varnes, to concentrate on the type and rate of movement.

The 1978 version of the "**Varnes Classification System**" was widely accepted by workers in many countries, albeit usually with modifications (e.g., Highland and Bobrowsky 2008; Dikau et al. 1996).

Varnes (1954, 1978)

The "Varnes classification," is summarized in a poster-format. Here (Table 1), within the framework of a matrix whose rows represent the type of movement and columns the type of material, are 29 landslide type names or keywords.

A velocity scale, later updated by International Geotechnical Society's UNESCO Working Party on World Landslide Inventory (WP/WLI) (1995) and Cruden and Varnes (1996) completes the classification (Table 2).

Table 1

Movement type	Rock	Debris	Earth
Fall	1. Rock fall	2. Debris fall	3. Earth fall
Topple	4. Rock topple	5. Debris topple	6. Earth topple
Rotational sliding	7. Rock slump	8. Debris slump	9. Earth slump
Translational sliding	10. Block slide	11. Debris slide	12. Earth slide
Lateral spreading	13. Rock spread	–	14. Earth spread
Flow	15. Rock creep	16. Talus flow	21. Dry sand flow
		17. Debris flow	22. Wet sand flow
		18. Debris avalanche	23. Quick clay flow
		19. Solifluction	24. Earth flow
		20. Soil creep	25. Rapid earth flow
			26. Loess flow
Complex	27. Rock slide-debris avalanche	28. Cambering, valley bulging	29. Earth slump-earth flow

Varnes (1954, 1978)

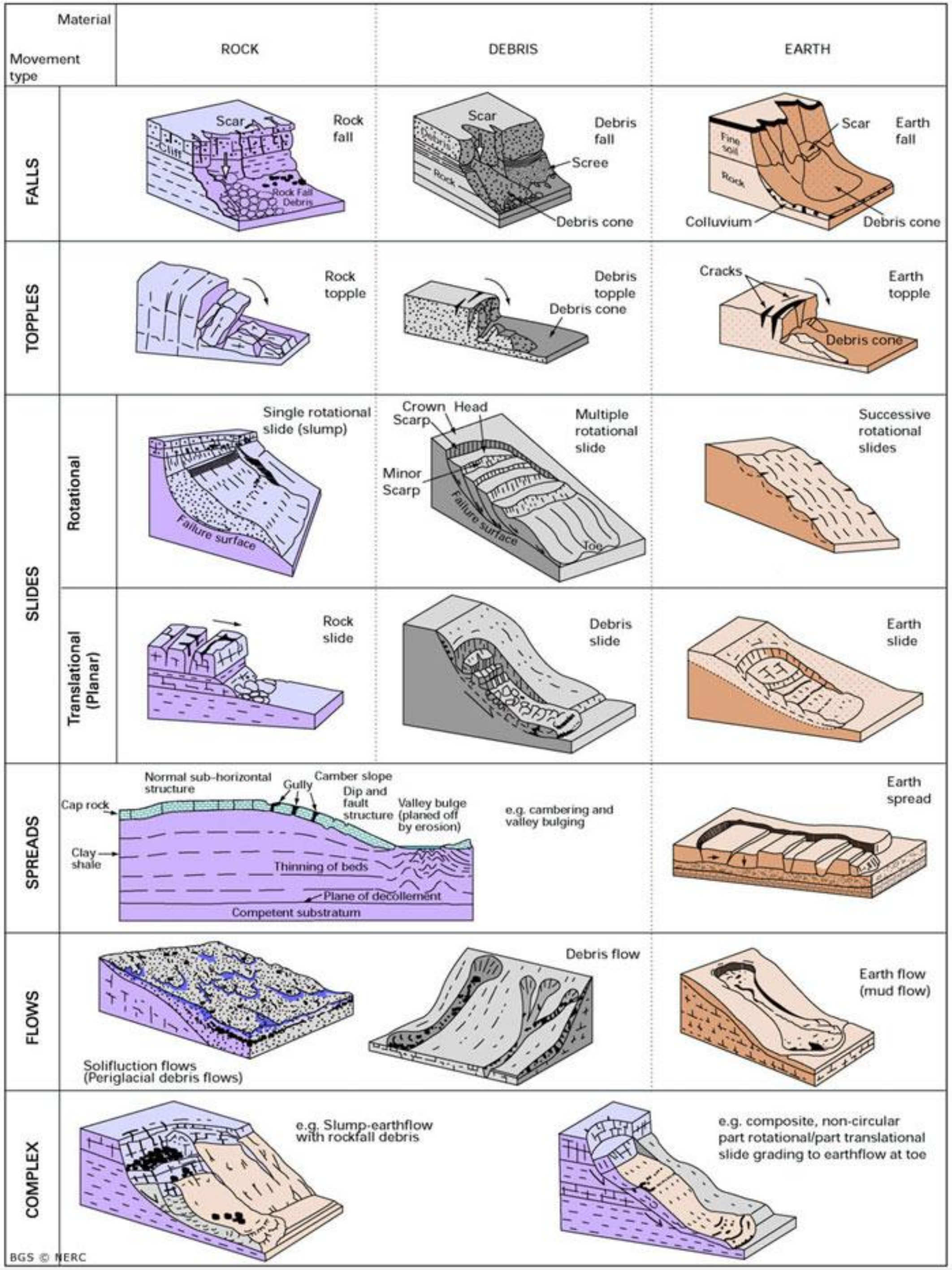
Table 2: scala delle velocità.

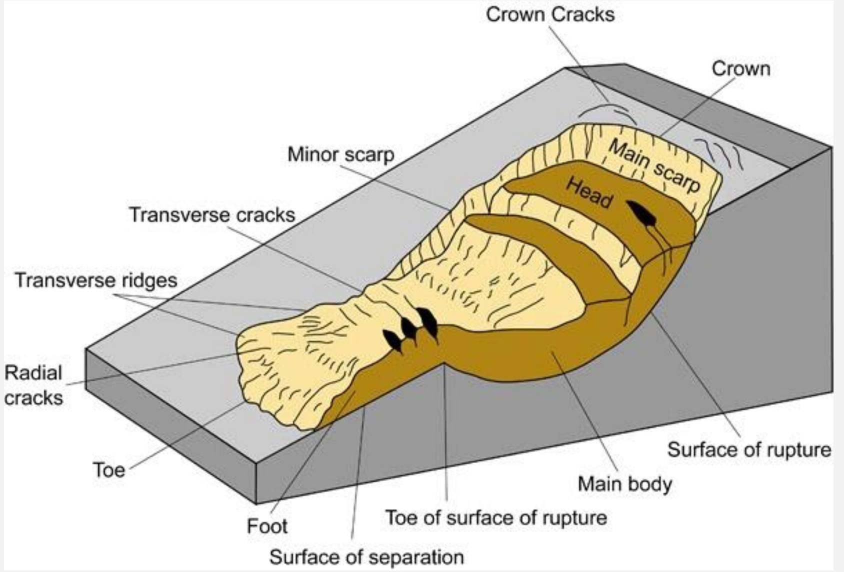
Table 2 Landslide velocity scale (WP/WLI 1995 and Cruden and Varnes 1996)

Velocity class	Description	Velocity (mm/s)	Typical velocity	Response[a]
7	Extremely rapid	5×10^{3}	5 m/s	Nil
6	Very rapid	5×10^{1}	3 m/min	Nil
5	Rapid	5×10^{-1}	1.8 m/h	Evacuation
4	Moderate	5×10^{-3}	13 m/month	Evacuation
3	Slow	5×10^{-5}	1.6 m/year	Maintenance
2	Very slow	5×10^{-7}	16 mm/year	Maintenance
1	Extremely Slow			Nil

[a] Based on Hungr (1981)

LE FRANE





https://www.geocaching.com/geocache/GC36T1A_angle-of-repose?guid=f8ea869c-9ca7-4890-8840-672f0399d83d

Varnes, 1978

Hutchinson (1968, 1988)

In England, **Hutchinson (1968, 1988)** developed a system without a matrix framework, utilizing multiple dimensions such as material, morphology, water content, rate, kinematics, and focusing on failure and propagation mechanisms.

An attempt to correlate Hutchinson's and Varnes' systems specifically for flow-like landslides was published by **Hungr et al. (2001).**

Hutchinson (1968, 1988)

A Working Party of the International Geotechnical Societies, sponsored by UNESCO, produced a series of “suggested methods” for the World Landslide Inventory (International Geotechnical Society’s UNESCO Working Party on World Landslide Inventory (WP/WLI 1990, 1991, 1993a, 1993b, 1994, 1995).

These documents provide useful methodologies for preparing landslide reports and describing landslide causes, degree of activity and movement rate.

WP/WLI (1990) International Geotechnical Societies UNESCO Working Party on World Landslide Inventory (Chairman: DM Cruden). **A suggested method for reporting a landslide**. Bull Eng Geol Environ 41:5–12

International Geotechnical Society’s UNESCO Working Party on World Landslide Inventory (WP/WLI) (1993) **A multi-lingual landslide glossary.** Bitech Publishers, Vancouver, 59p

WP/WLI (1994) International Geotechnical Societies’ UNESCO Working Party on World Landslide Inventory, Working Group on Landslide Causes (Chairman: ME Popescu). **A suggested method for reporting landslide causes**. Bull Eng Geol Environ 50:71–74

International Geotechnical Society’s UNESCO Working Party on World Landslide Inventory (WP/WLI) (1995) **A suggested method for describing the rate of movement of a landslide**. Bull Inter Assoc Eng Geol 52:75–78

VEDIAMOLI…….

Hungr et al., 2013

Review Article

Landslides
DOI 10.1007/s10346-013-0436-y
Received: 22 April 2013
Accepted: 23 September 2013

Oldrich Hungr · Serge Leroueil · Luciano Picarelli

The Varnes classification of landslide types, an update

1) Geotechnical material terminology

2) Geological material types classified by origin

3) Failure distribution and style

Landslide failure mechanisms can be complicated by interaction of adjacent sliding bodies in a variety of styles and distributions. Cruden and Varnes (1996) summarized a number of related descriptors, such as advancing, enlarging, retrogressive, multiple, or successive. Illustrations of some of these terms are shown by Hutchinson (1988). Such terms are a useful supplement to landslide type names.

4) Definitions of landslide types

Geotechnical material terminology

The authors' view is that geotechnical material terminology is most useful, as it relates best to the mechanical behavior of the landslide. To describe materials modified by geomorphic processes, including landsliding itself, it is necessary to supplement the geotechnical terms by names of mixed materials, namely "debris" and "mud."

Table 3 Landslide-forming material types

Material name	Character descriptors (if important)	Simplified field description for the purposes of classification	Corresponding unified soil classes	Laboratory indices (if available)
Rock	Strong	Strong—broken with a hammer		UCS>25 MPa
	Weak	Weak—peeled with a knife		2<UCS<25 MPa
Clay	Stiff	Plastic, can be molded into standard thread when moist, has dry strength	GC, SC, CL, MH, CH, OL, and OH	$I_p > 0.05$
	Soft			
	Sensitive			
Mud	Liquid	Plastic, unsorted remolded, and close to Liquid Limit	CL, CH, and CM	$I_p > 0.05$ and $I_l > 0.5$
Silt, sand, gravel, and boulders	Dry	Nonplastic (or very low plasticity), granular, sorted. Silt particles cannot be seen by eye	ML	$I_p < 0.05$
	Saturated		SW, SP, and SM	
	Partly saturated		GW, GP, and GM	
Debris	Dry	Low plasticity, unsorted and mixed	SW-GW	$I_p < 0.05$
	Saturated		SM-GM	
	Partly saturated		CL, CH, and CM	
Peat		Organic		
Ice		Glacier		

Geological material types classified by origin

However, it is not recommended to replace the material names of the first column of **Table 3** by geological terms, because there is often not sufficient equivalency between them. For example, an alluvial deposit may contain clay, silt, sand, or coarser materials. The goal is to stress the component that is the most important in determining the mechanical behaviour of the landslide during and post-failure.

Table 4 Supplementary material terms based on geomorphological analysis

Rock	Intrusive, volcanic, metamorphic, strong sedimentary, (carbonatic or arenaceous) and weak sedimentary (argillaceous)
Soil	Residual, colluvial, alluvial, lacustrine, marine, aeolian, glacial, volcanic, organic, random anthropogenic fills, engineered anthropogenic fills, mine tailings, and sanitary waste

The soil type names presented in italics and separated by a slash symbol are placeholders and only one or two should be used in forming the landslide name.

Hungr et al., 2013

Table 5 Summary of the proposed new version of the Varnes classification system. The words in italics are placeholders (use only one)

Type of movement	Rock	Soil
Fall	1. *Rock/ice* fall[a]	2. *Boulder/debris/silt* fall[a]
Topple	3. Rock block topple[a]	5. *Gravel/sand/silt* topple[a]
	4. Rock flexural topple	
Slide	6. Rock rotational slide	11. *Clay/silt* rotational slide
	7. Rock planar slide[a]	12. *Clay/silt* planar slide
	8. Rock wedge slide[a]	13. *Gravel/sand/debris* slide[a]
	9. Rock compound slide	14. *Clay/silt* compound slide
	10. Rock irregular slide[a]	
Spread	15. Rock slope spread	16. *Sand/silt* liquefaction spread[a]
		17. Sensitive clay spread[a]
Flow	18. *Rock/ice* avalanche[a]	19. *Sand/silt/debris* dry flow
		20. *Sand/silt/debris* flowslide[a]
		21. Sensitive clay flowslide[a]
		22. Debris flow[a]
		23. Mud flow[a]
		24. Debris flood
		25. Debris avalanche[a]
		26. Earthflow
		27. Peat flow
Slope deformation	28. Mountain slope deformation	30. Soil slope deformation
	29. Rock slope deformation	31. Soil creep
		32. Solifluction

For formal definitions of the landslide types, see text of the paper.

[a] Movement types that usually reach extremely rapid velocities as defined by Cruden and Varnes (1996). The other landslide types are most often (but not always) extremely slow to very rapid

There are now **32** landslide-type keywords, compared with **29** used in the 1978 Varnes Classification, thus the system remains simple.

Hungr O., Leroueil S., Picarelli L. (2013) The Varnes classification of landslide types, an update. Landslides, DOI 10.1007/s10346-013-0436-y, 29p.