Lunsjpresentasjon Klima 2050

Debris flows or muddy floodwater: does it really matter to make a difference?

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8 June 2017

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Introduction

About incidents in Sri Lanka last week:

« Most of the deaths in the latest floods were caused by landslides» (BBC, 28 May 2017)

Source: Sri Lankan Red Cross

Introduction

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2017 Sri Lanka floods

From Wikipedia, the free encyclopedia

The **2017 Sri Lanka floods** resulted from a heavy southwest monsoon, beginning around 18 to 19 May 2017.[1] Flooding was worsened by the arrival of the precursor system to Cyclone Mora,[2] causing flooding and landslides throughout Sri Lanka during the final week of May 2017.[3] The floods affected 15 districts, killed at least 208 people and left a further 78 people missing. As of 3 June, 698,289 people were affected, while 11,056 houses were partially damaged and another 2,093 houses completely destroyed.[4] According to Al Jazeera, about 600,000 people have been displaced due to the floods.[5]

2017 Sri Lanka flood and landslide

Date	May 2017 (*ongoing*)
Location	15 districts of Sri Lanka
Cause	Flood and Landslide
Deaths	224
Non-fatal injuries	72
Missing	78
Property damage	2,093 houses fully and 11,056 houses partially destroyed

The flooding severely affected Sri Lanka's Western Province, Sabaragamuwa Province, Southern Province and part of Central Province.[6] The worst-affected districts were Kalutara,[3] Matara and Ratnaputra.[7] In Kalutara, flooding of the Kalu River also triggered several mudflows.[8] Agalawatte, a town within Kalutara District, reported 47 deaths and 62 people missing as of 29 May, with many areas made inaccessible by landslides.[6] The Ratnaputra District had recorded 79 deaths by 30 May.[7]

Introduction

- 1999 Venezuela disaster (> 20 000 deaths) is recorded as a flood, but most fatalities due to landslides (debris and mud flows)

- «Number of casualties due to landslides … is grossly underestimated» (Nadim et al., 2006) – often reported as casualties due to storms, floods or volcanoes.

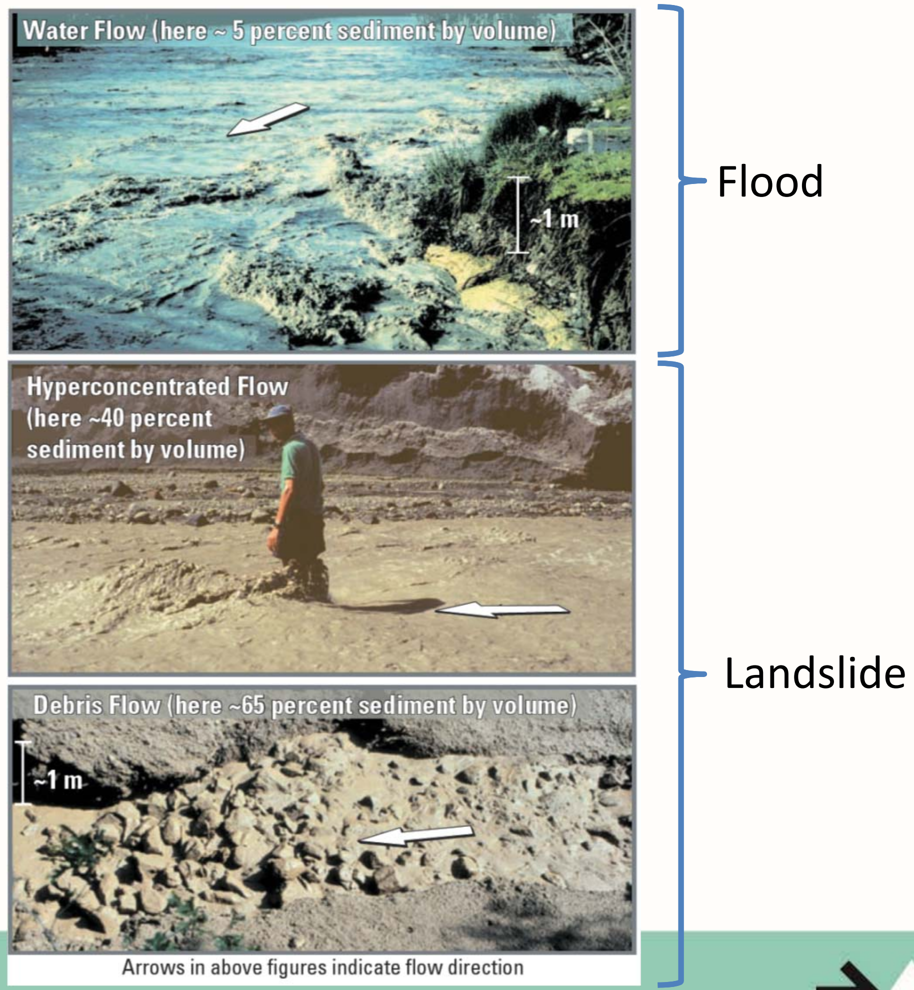
Source: US Geological Survey

Introduction

- Are there any undesired consequences of these mix-ups between landslides and floods?
- Do these mix-ups end here?
- What to do next?

Landslides vs floods

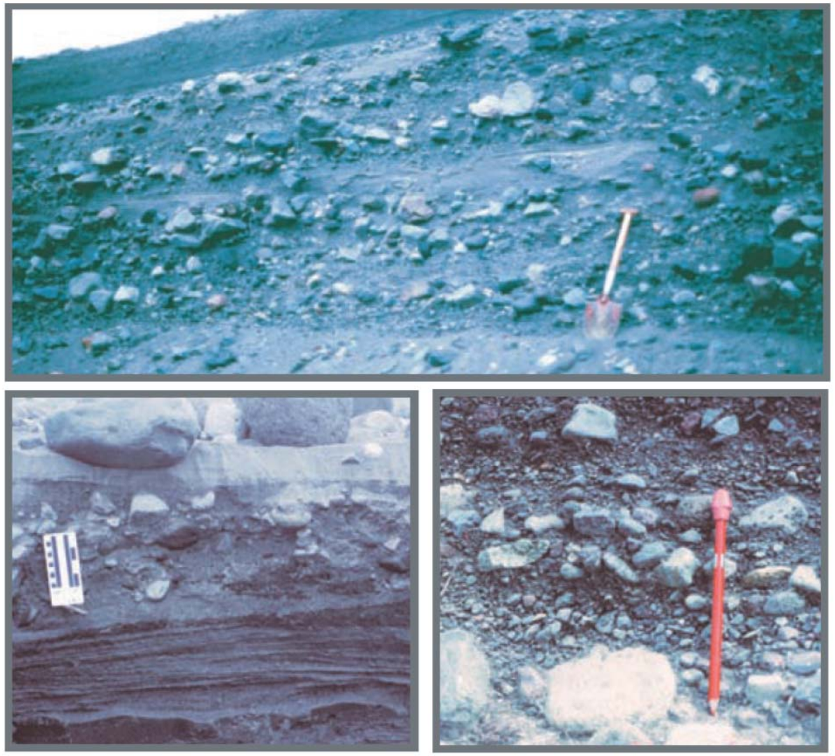
Behaviour during movement



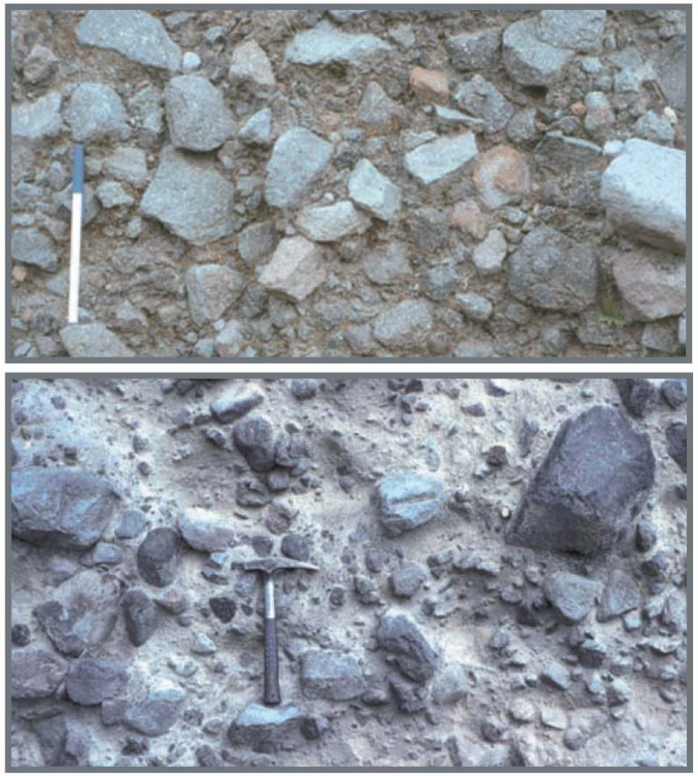
Source: US Geological Survey

Landslides vs floods

Flood deposits



Landslide deposits



Source: US Geological Survey

Landslide initiation by water

Possible initiation processes:

A. **Rupture along a surface**: (1) Water infiltration (rainfall + snow melting) + increase of ground water table → (2):
   - Increase of weight due to saturation
   - Increase of pore water pressures leading to reduction of shear strength

B. Runoff → **erosion** → bulking with entrained sediments (landslide when sediment content per volume > 20%)

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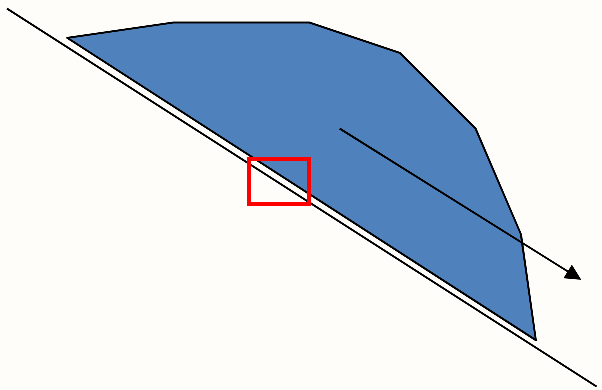
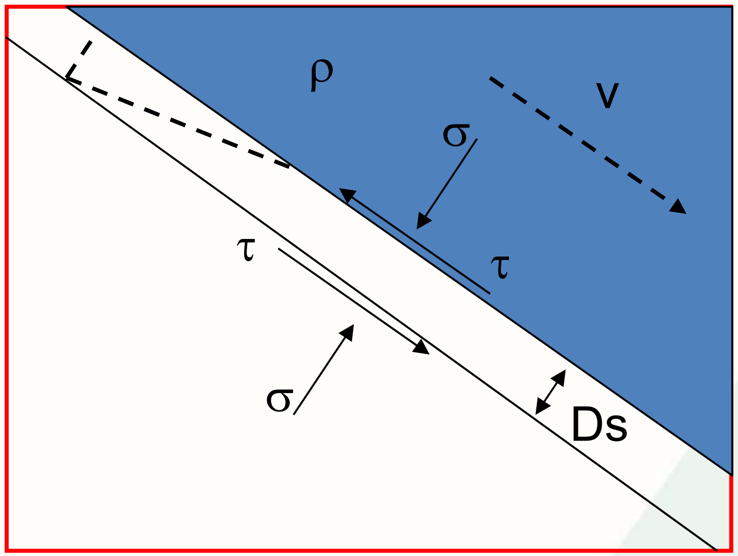
Rheology: calculation of stresses at the base of sliding mass.





γ= v / Ds   Shear Rate

Types of rheologies:

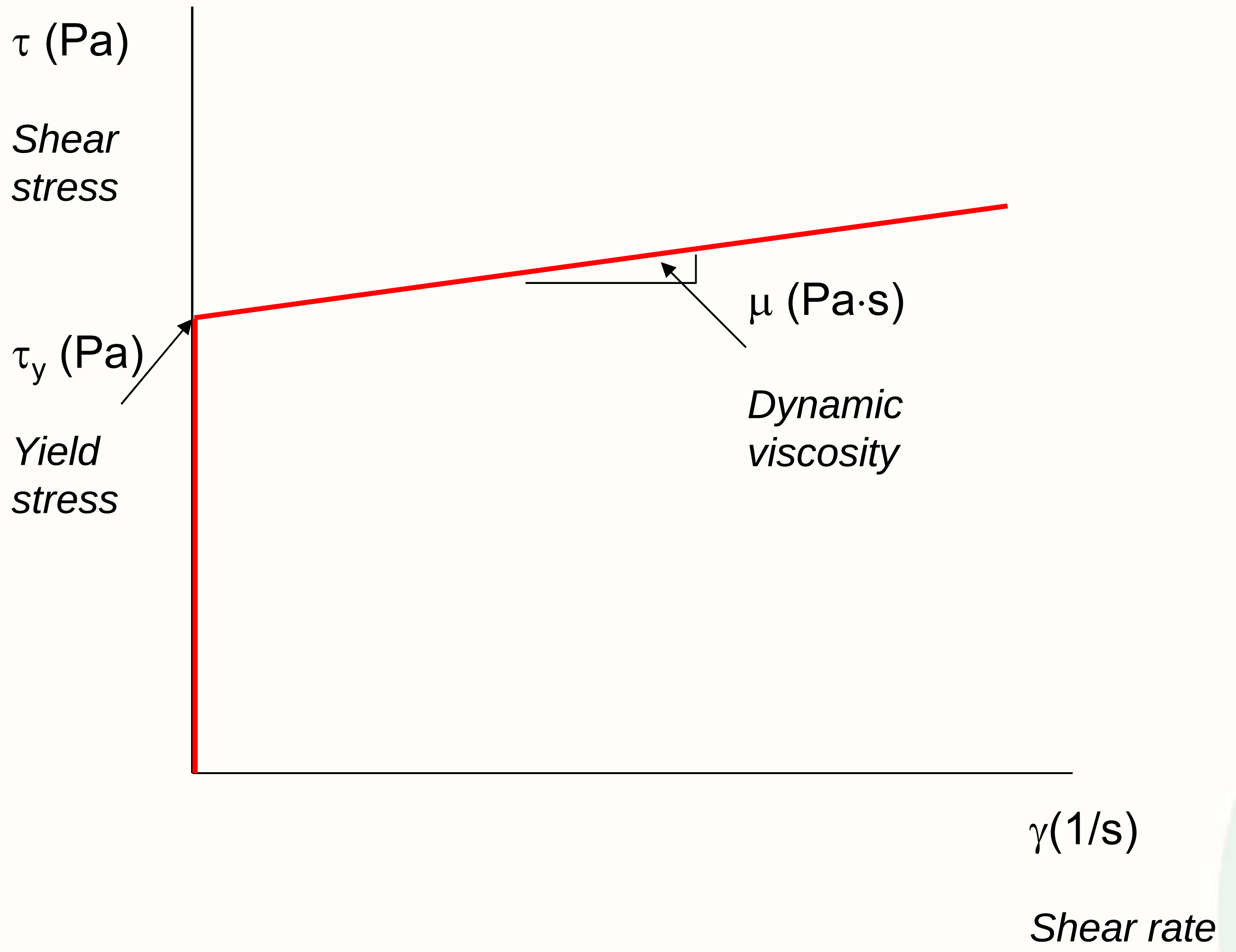
Frictional: τ = f(σ, *friction coeff.*)

Voellmy: τ = g(σ, *friction coeff.*, v, *turbulent coeff.*)

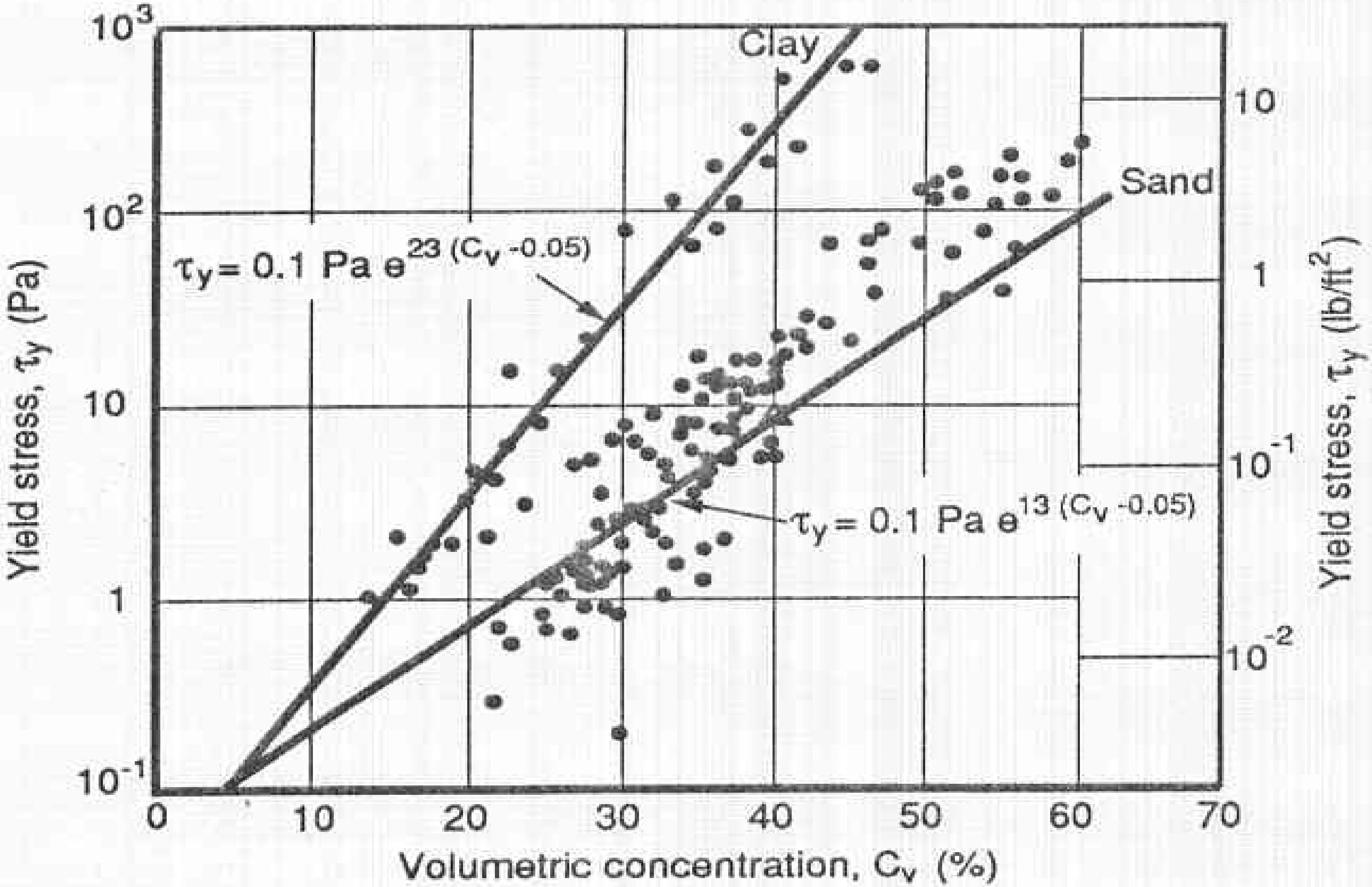
Bingham: τ = h(*yield stress*, *viscosity*, γ)

Note: material properties.

Bingham rheology

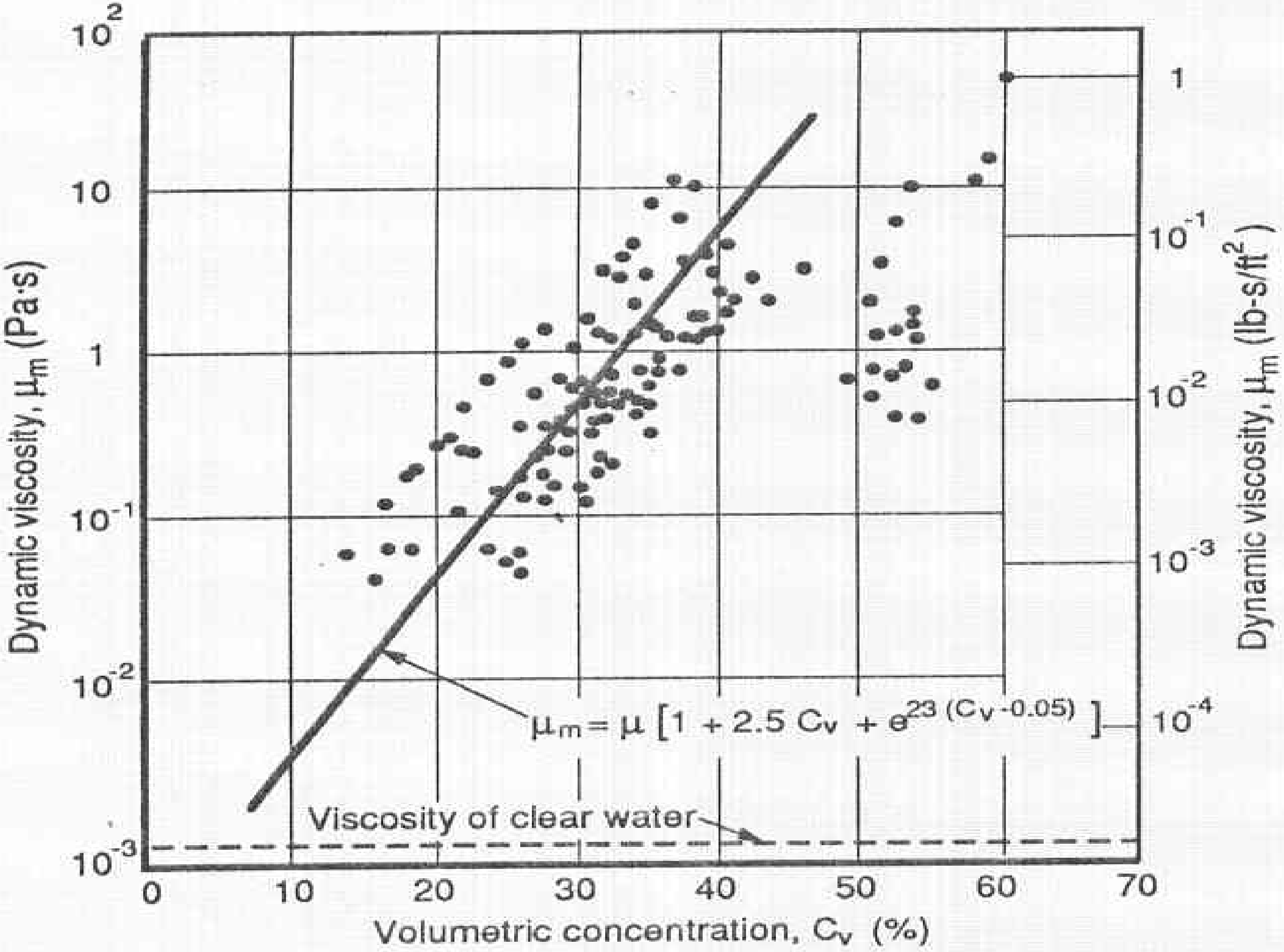


Yield stress vs. Sediment concentration



Source: Flo2d (2006)

Viscosity vs. Sediment concentration



Source: Flo2d (2006)

Landslide runout and hazard intensities

- High mobility:
  - Long runout distances (several km)
  - High velocities (several tens of km/h)
- High density and thickness (depth)

Impact force ↑ = *f* (Velocity ↑ , Density ↑, Thickness ↑)

Table 2.2. Classification of flow type landslides.

Hungr et al. (2001).

Material	Water content[1]	Special condition	Velocity	Name
Silt, sand, gravel, and debris (talus)	Dry, moist, or saturated	No excess pore-pressure Limited volume	Various	*Non-liquefied sand (silt, gravel, debris) flow*
Silt, sand, debris, and weak rock[2]	Saturated at rupture surface	Liquefiable material[3] Constant water content	Extremely rapid	*Sand (silt, debris, rock) flow slide*
Sensitive clay	At or above liquid limit	Liquefaction *in situ*[3] Constant water content[4]	Extremely rapid	*Clay flow slide*
Peat	Saturated	Excess pore-pressure	Slow to very rapid	*Peat flow*
Clay or earth	Near plastic limit	Slow movements Plug flow (sliding)	Less than rapid	*Earth flow*
Debris	Saturated	Established channel[5] Increased water content[4]	Extremely rapid	*Debris flow*
Mud	At or above liquid limit	Fine-grained debris flow	Greater than, very rapid	*Mud flow*
Debris	Free water present	Flood[6]	Extremely rapid	*Debris flood*
Debris	Partly or fully saturated	No established channel[5] Relatively shallow, steep source	Extremely rapid	*Debris avalanche*
Fragmented rock	Various, mainly dry	Intact rock at source Large volume[7]	Extremely rapid	*Rock avalanche*

Flomskred

[1] Water content of material in the vicinity of the rupture surface at the time of failure.
[2] Highly porous, weak rock (examples: weak chalk, weathered tuff, pumice).
[3] The presence of full or partial *in situ* liquefaction of the source material of the flow slide may be observed or implied.
[4] Relative to *in situ* source material.
[5] Presence or absence of a defined channel over a large part of the path, and an established deposition landform (fan). *Debris flow* is a recurrent phenomenon within its path, while *debris avalanche* is not.
[6] Peak discharge of the same order as that of a major flood or an accidental flood. Significant tractive forces of free flowing water. Presence of floating debris.
[7] Volume greater than 10,000 m^3 approximately. Mass flow, contrasting with fragmental rock fall.

Table 2.3. Landslide velocity scale.

After Cruden and Varnes (1996).

Velocity class	Description	Velocity (mm/sec)	Typical velocity
7	Extremely rapid		
	↓	5×10^{3}	5 m/sec
6	Very rapid		
	↓	5×10^{1}	3 m/min
5	Rapid		
	↓	5×10^{-1}	1.8 m/hr
4	Moderate		
	↓	5×10^{-3}	13 m/month
3	Slow		
	↓	5×10^{-5}	1.6 m/year
2	Very slow		
	↓	5×10^{-7}	16 mm/year
1	Extremely slow		

Runout and inundation zones

Volumes:

- Floods: larger
- Landslides: smaller (for example up to 1 million m^3 for 500-year events)

Depth:

- Floods: thinner
- Landslides: thicker

Velocities:

- Floods: lower
- Landslides: higher

Vulnerability curves

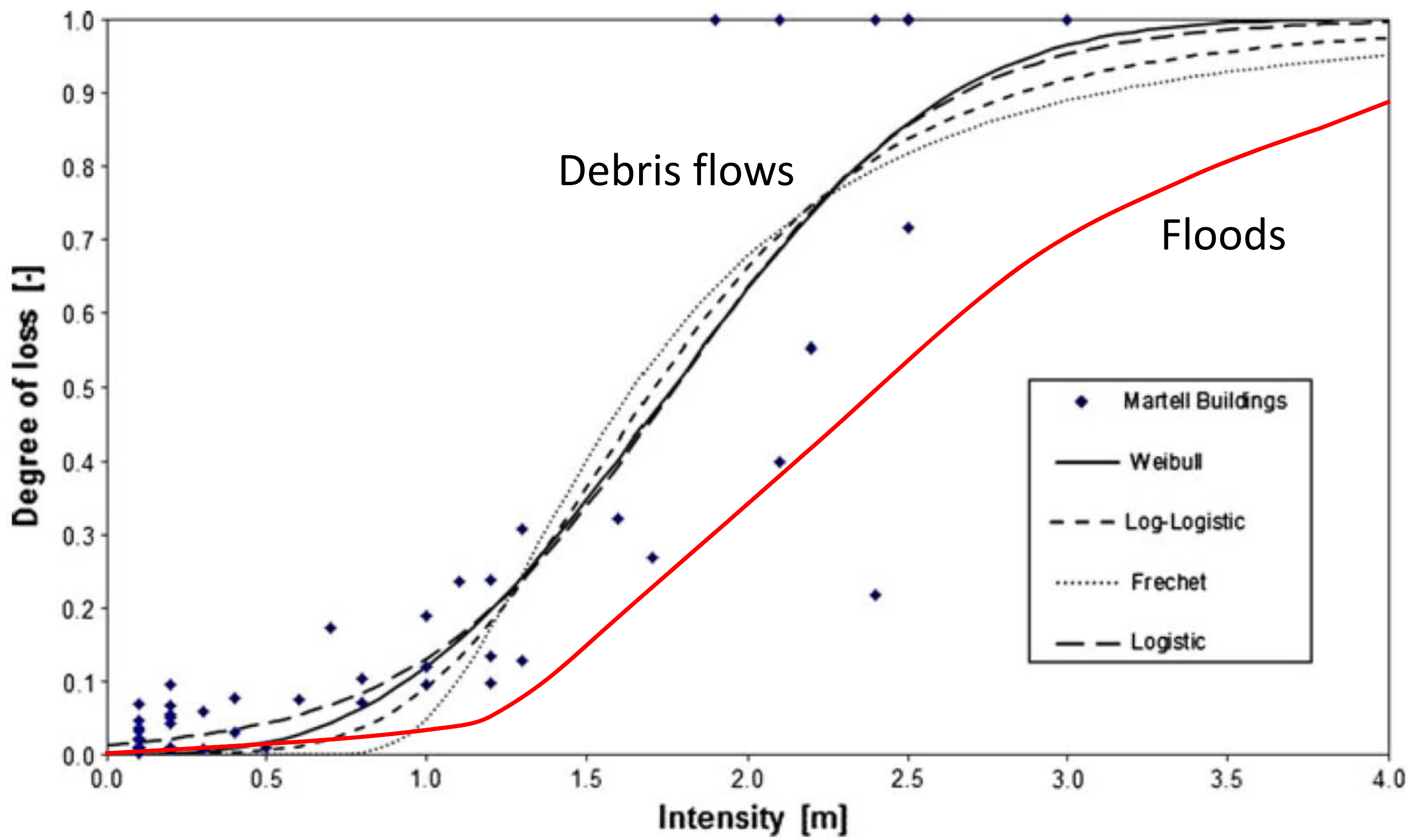


Fig. 4 The development of four different best-fitting functions based on the information of debris flow intensity expressed as deposition height and degree of loss for buildings in the Martell valley, South Tyrol

Papathoma-Köhle et al. (2012)

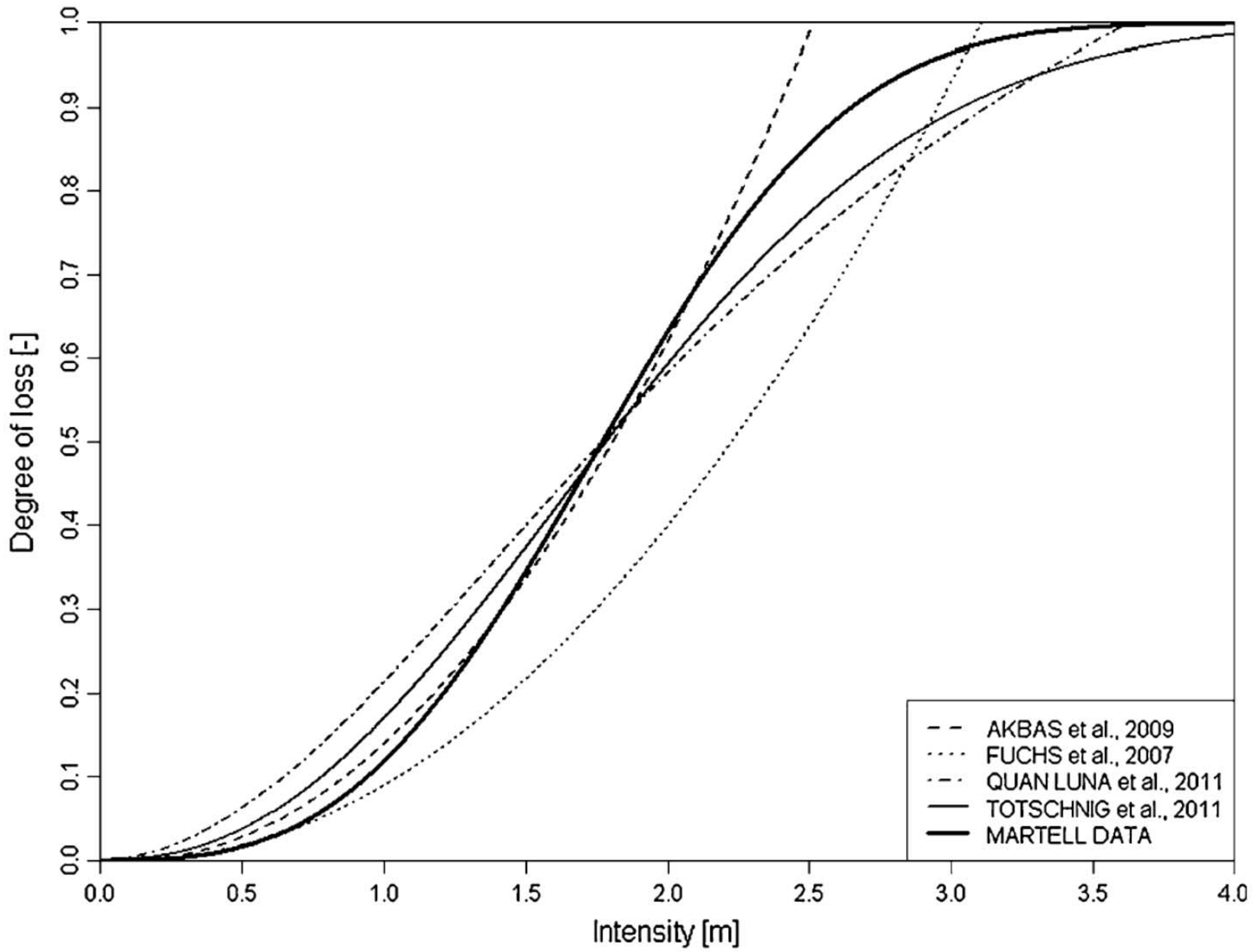


Fig. 6 Comparison of the developed vulnerability curve with existing vulnerability curves for debris flows from the literature

Papathoma-Köhle et al. (2012)

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Early Warning Systems

Table 2.3. Landslide velocity scale.
After Cruden and Varnes (1996).

Velocity class	Description	Velocity (mm/sec)	Typical velocity	Typical human response
7	Extremely rapid			Nil
	↓	5×10^{3}	5 m/sec	
6	Very rapid			Nil
	↓	5×10^{1}	3 m/min	
5	Rapid			Evacuation
	↓	5×10^{-1}	1.8 m/hr	
4	Moderate			Evacuation
	↓	5×10^{-3}	13 m/month	
3	Slow			Maintenance
	↓	5×10^{-5}	1.6 m/year	
2	Very slow			Maintenance
	↓	5×10^{-7}	16 mm/year	
1	Extremely slow			Nil

Range of flash floods

Floods

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	↓	5×10^{-5}	1.6 m/year	
2	Very slow			Maintenance
	↓	5×10^{-7}	16 mm/year	
1	Extremely slow			Nil

EWS for debris flows and flash floods

Range of flash floods

Floods

EWS for floods

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Remarks

- Distinction between landslides and floods is important for:
  - Calculation of initiation
  - Runout asssesment

  And most importantly:
  - Loss estimation
  - Early warning systems

- Conceptual note in preparation (WP3.1.B) as input for new PhD on EWS (starting after summer 2017)


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RISK REDUCTION THROUGH CLIMATE ADAPTATION
OF BUILDINGS AND INFRASTRUCTURE