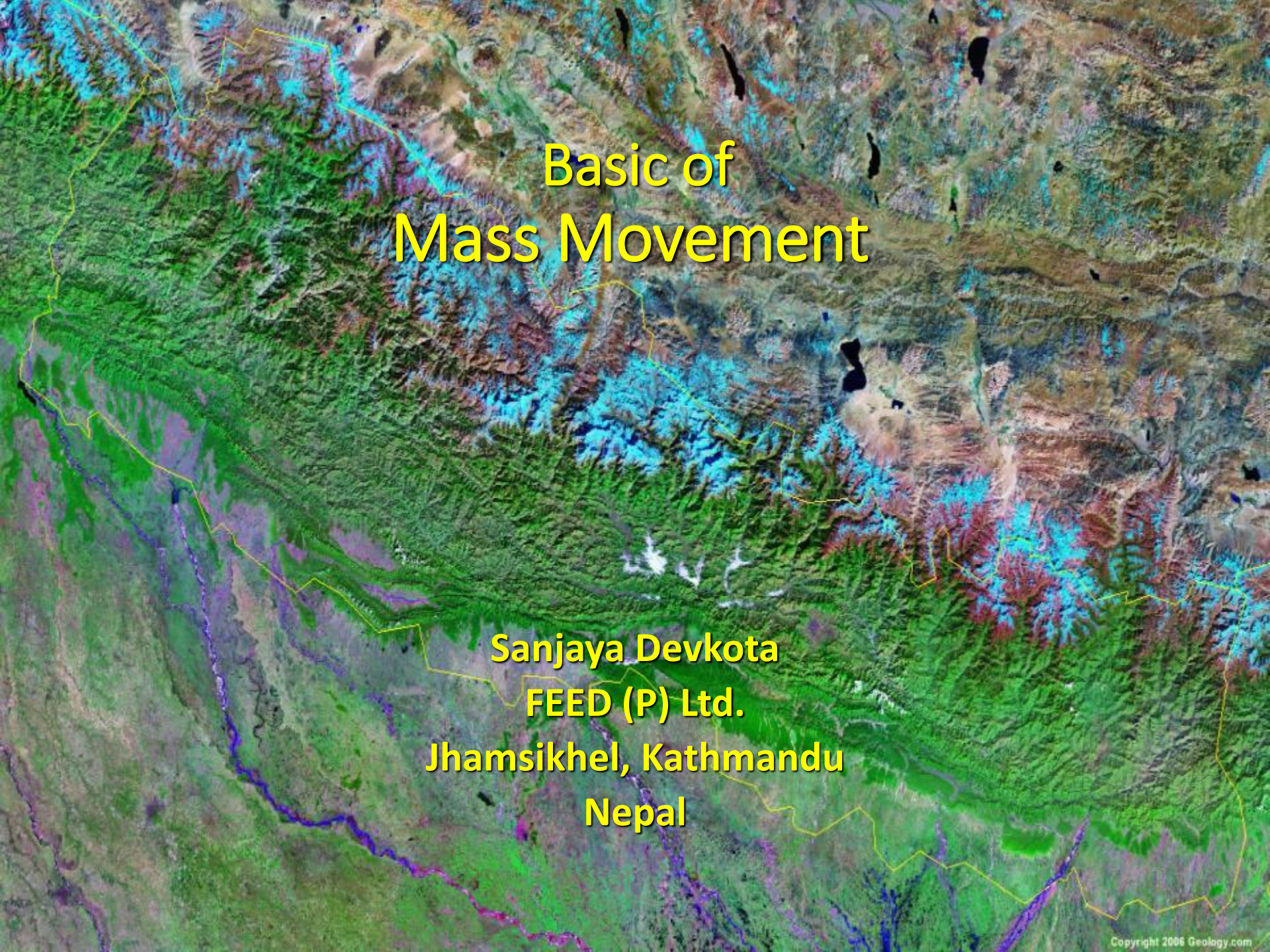
Basic of
Mass Movement
Sanjaya Devkota
FEED (P) Ltd.
Jhamsikhel, Kathmandu
Nepal
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Overview of Presentation:

A. Background
B. Classification of Mass Movement
C. Causes
D. Mechanism

Background

Mass Movement

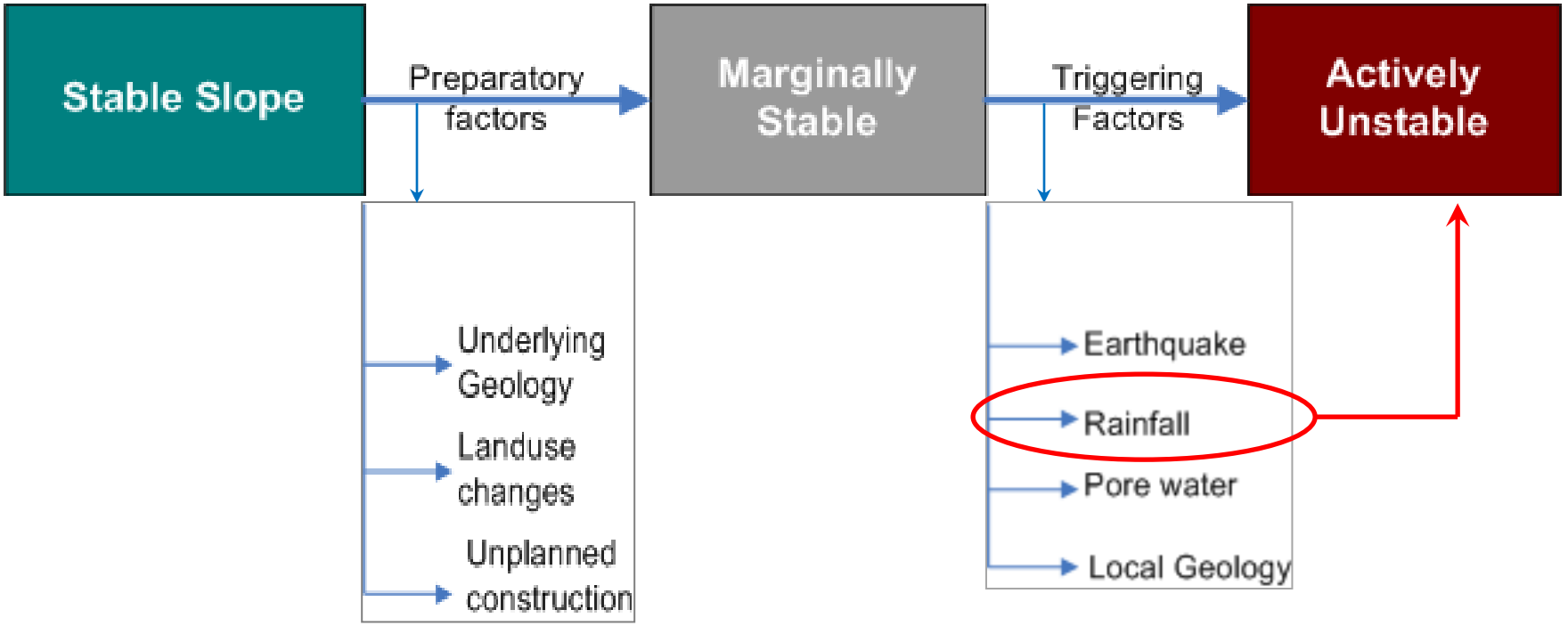
- Mass of earth materials (e. g. soil, fractured or weathered rock) which moves along the slip surface downward under the influence of gravity is termed as Mass Movement (Landslide). The term landslide is widely used for almost *all slope movements*.

The driving force of the movements is gravity, which is assisted by rain, erosion, water pressure, expansion & contraction forces, earthquake human interference & Local Geology.

Background - Landslides

- **Landslides are frequently occurring hazards but highly neglected …undermining the development, environment, ecosystem services, most often losses of lives & properties**

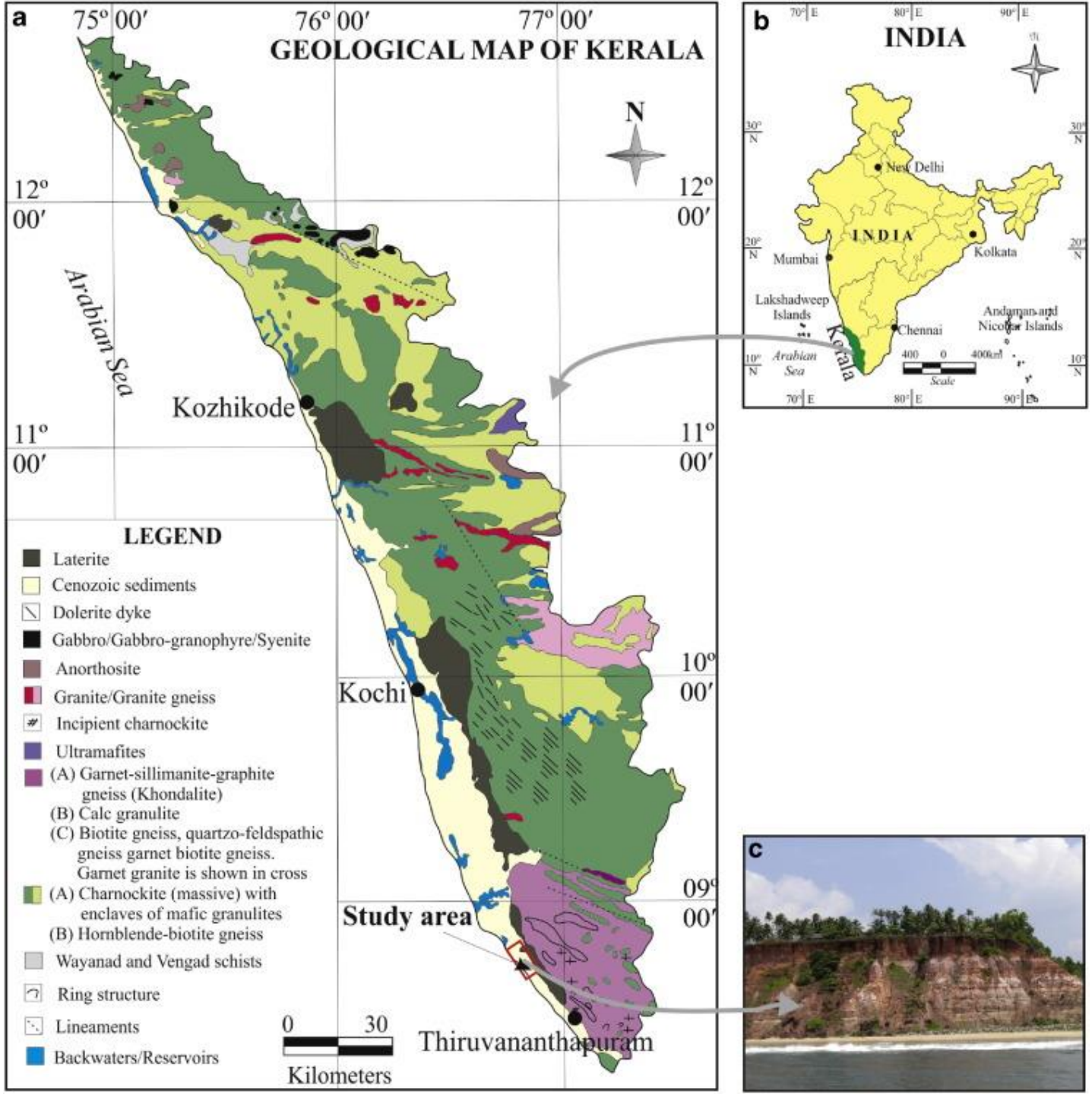
- **Causal & Triggering Factors of Landslides:**



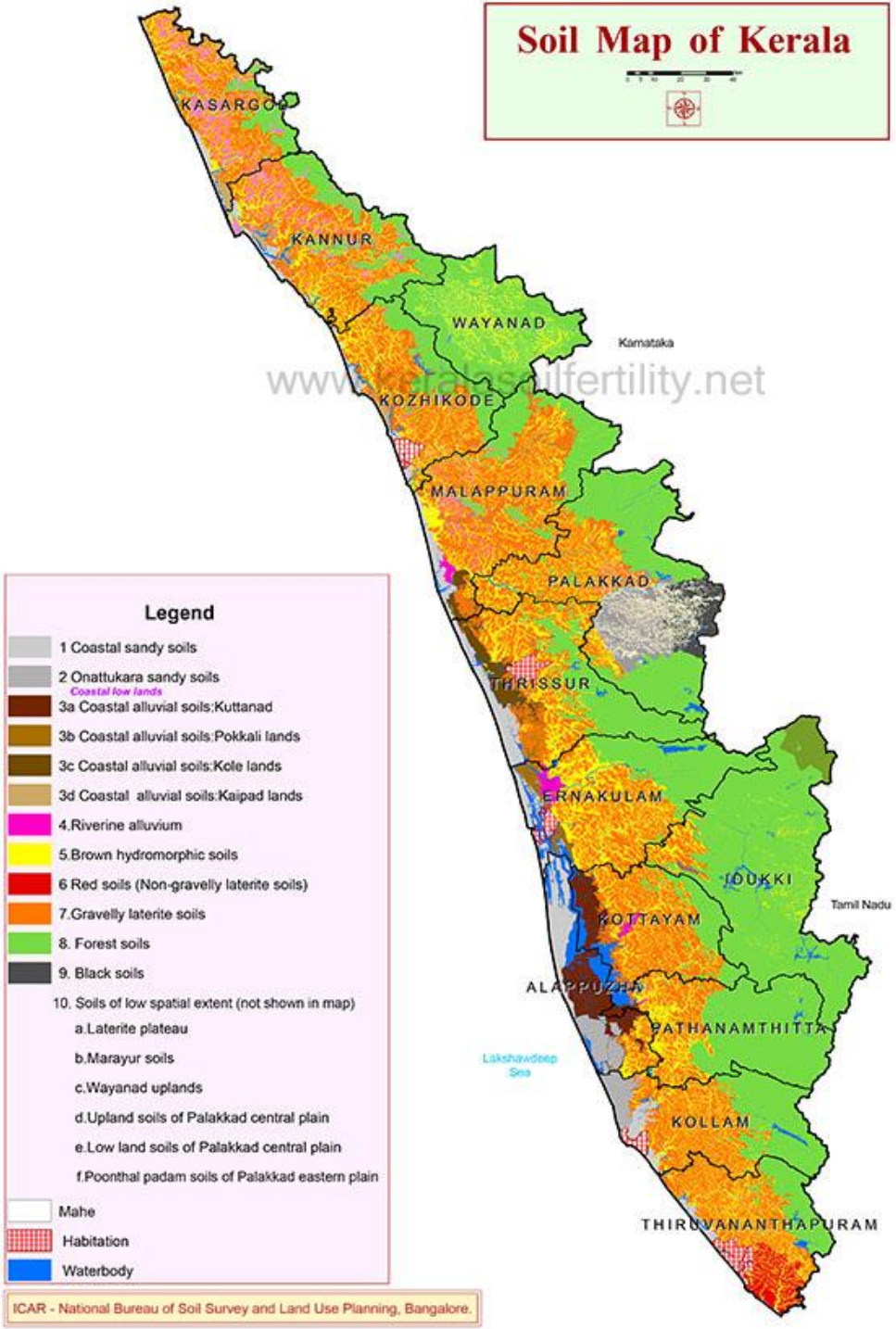
Background - Landslides

The elements which play the Major Role to the Mass Movement (Landslide): the Triggering Factors

- **Rainfall, (Surface and Ground water);**
- **Local Geological & Geomorphologic condition (Weathering, erosion, toe cutting);**
- **Earthquake:**
- **anthropogenic activities (e. g. mining, road excavation, etc.).**


a
GEOLOGICAL MAP OF KERALA
75° 00′
76° 00′
77° 00′
12° 00′
11° 00′
10° 00′
09° 00′
N
Arabian Sea
Kozhikode
Kochi
Study area
Thiruvananthapuram
0 30
Kilometers
LEGEND
Laterite
Cenozoic sediments
Dolerite dyke
Gabbro/Gabbro-granophyre/Syenite
Anorthosite
Granite/Granite gneiss
Incipient charnockite
Ultramafites
(A) Garnet-sillimanite-graphite gneiss (Khondalite)
(B) Calc granulite
(C) Biotite gneiss, quartzo-feldspathic gneiss garnet biotite gneiss. Garnet granite is shown in cross
(A) Charnockite (massive) with enclaves of mafic granulites
(B) Hornblende-biotite gneiss
Wayanad and Vengad schists
Ring structure
Lineaments
Backwaters/Reservoirs
b
INDIA
New Delhi
INDIA
Mumbai
Kolkata
Chennai
Lakshadweep Islands
Andaman and Nicobar Islands
Kerala
Arabian Sea
Scale
c

Soil Map of Kerala



ICAR - National Bureau of Soil Survey and Land Use Planning, Bangalore.


ANI

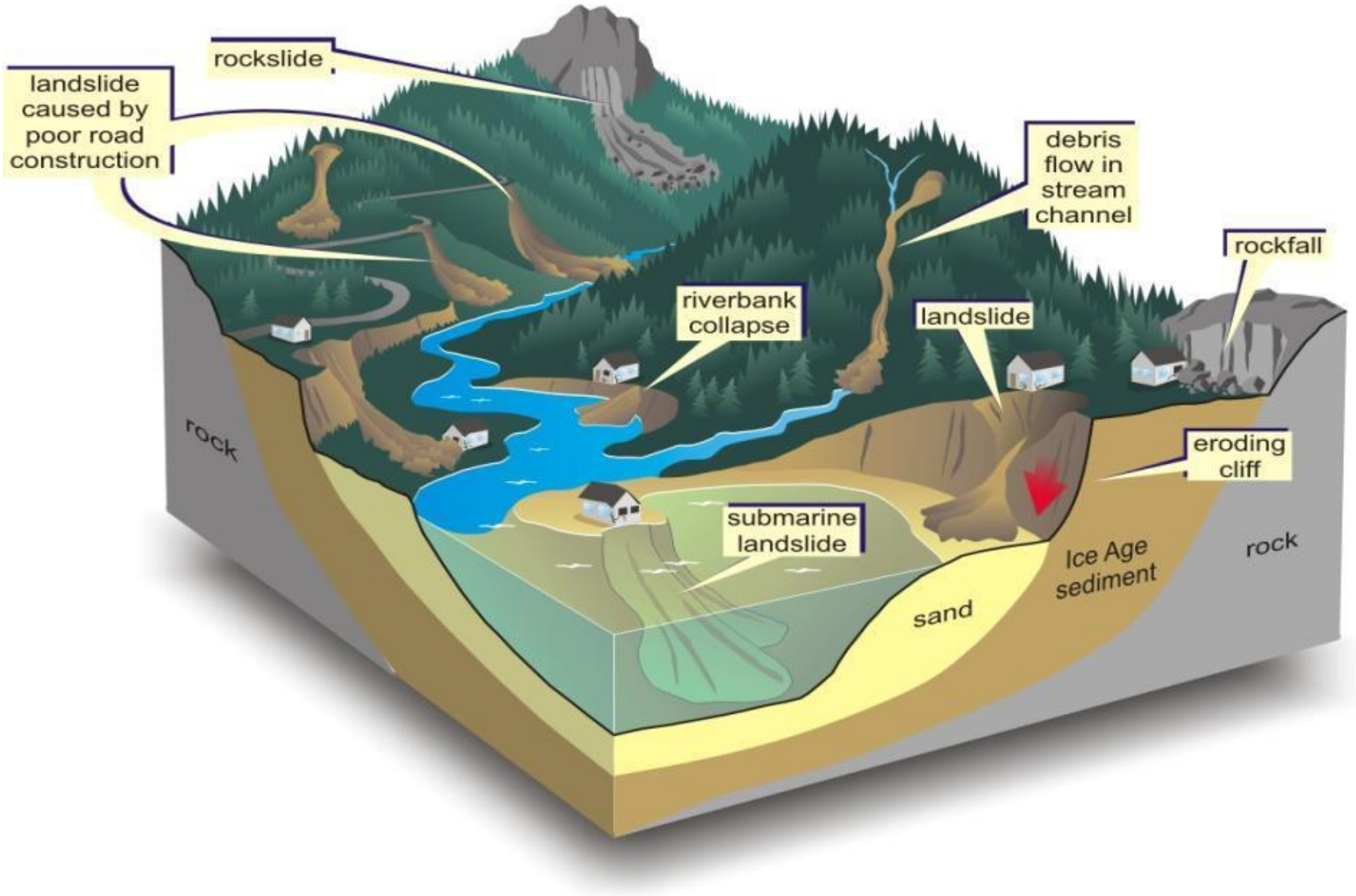
Classification

Classification Mass Movement (Landslide)

Two types of Classification:

- **VARNE's Classification of Mass Movement;**
- **Preventive Classification (Field disaster oriented)**

Classification of Mass Movement (Landslide)



VARNE's Classification of Mass Movement

Type of Movements	Type of material		
	Bed Rock	Engineering soil	
		Predominantly Coarse	Predominantly Fine
1. Falls	Rock Fall	Debris Fall	Earth Falls
2. Topples	Rocks Topple	Debris Topple	Earth Topples
3. Slides a.Rotational b.Transnational	Rock Slump Rock Slides	Debris Slump Debris Slides	Earth Slump Earth Slides
4. Lateral Spreads	Rock Spread	Debris Spread	Earth Spread
5. Flows	Rock Flow	Debris Flow	Earth Flow
Complex	Combination of two or more principal types of movement		

(Varnes 1978)

Fall

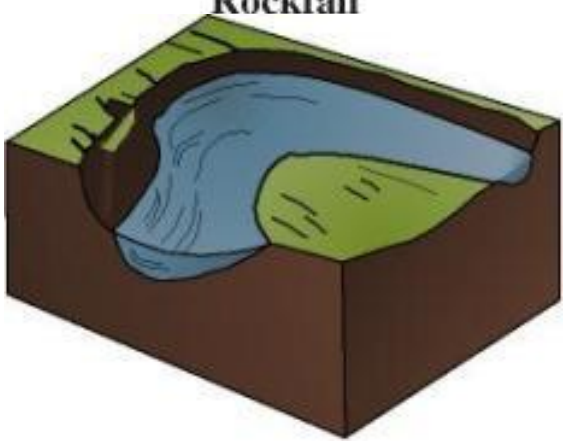
- **Falls are masses of rock and/or soil that move down slope by *falling or bouncing through the air*. They are most common on steep road cuttings.**

- **The slope is generally more than *45°***

- **The movement is very rapid to extremely rapid. The *velocity* is more than *3m/second*.**

photo by BAREPP

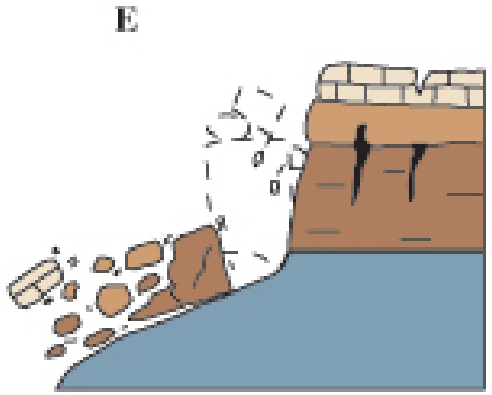
Rockfall



Rock Fall

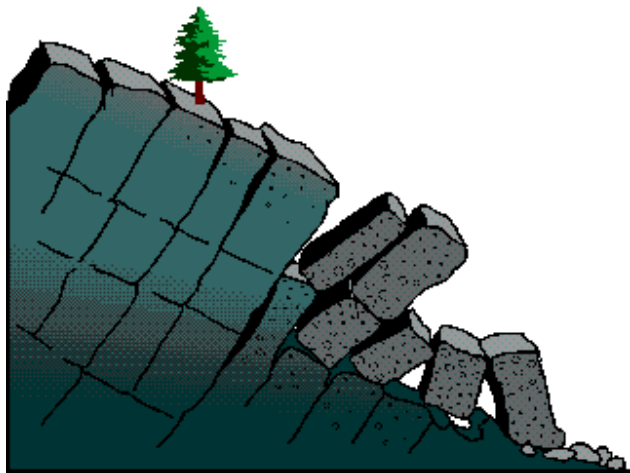
Topple

- **Topple** denotes the ***overturning or tilting*** of a block of rock ***on a pivot or hinge***. Finally, it separates from the main mass resulting in a fall or slide.



Topple

- **Fractural toppling occurs most notably in *Slate, Phyllite, and schist*.**



Topple:

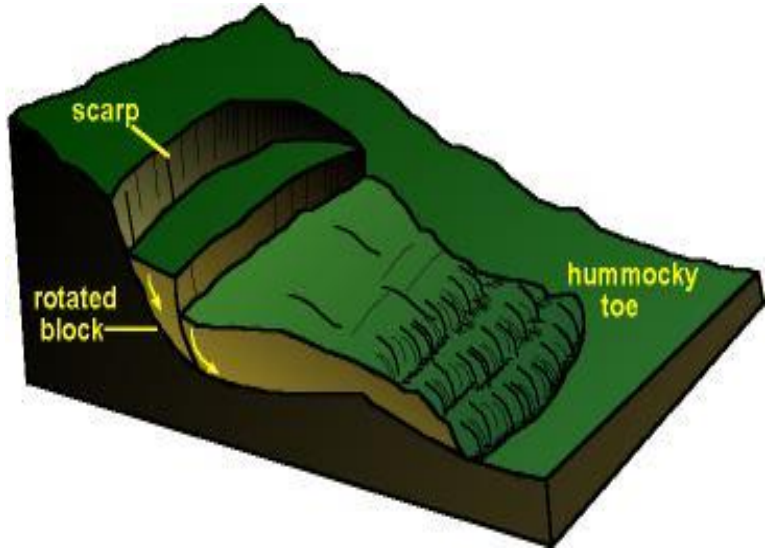
Slides

- **The slide is a mass movement process in which a presence of *distinct surface of rupture* or *slip surface is available*.**

- **There are two types of slides:**
  - **Rotational, &**
  - **Translational**

Rotational Slide

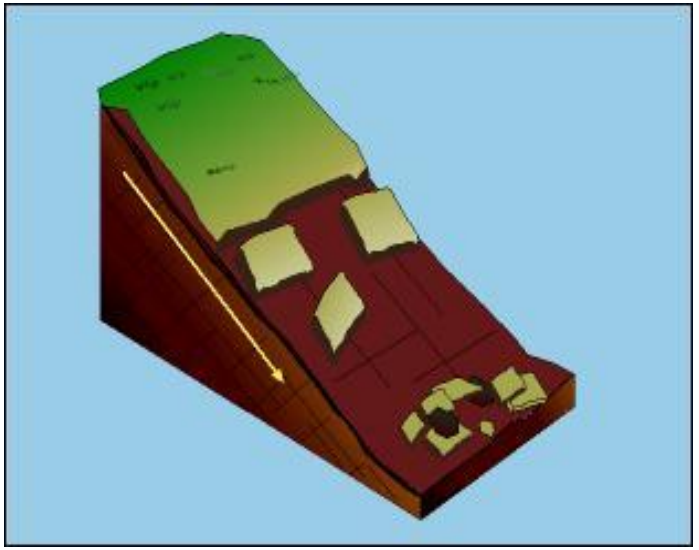
- **Rotational slide moves along the surface of rupture that is *curved concave or spoon shape slip surface*.**



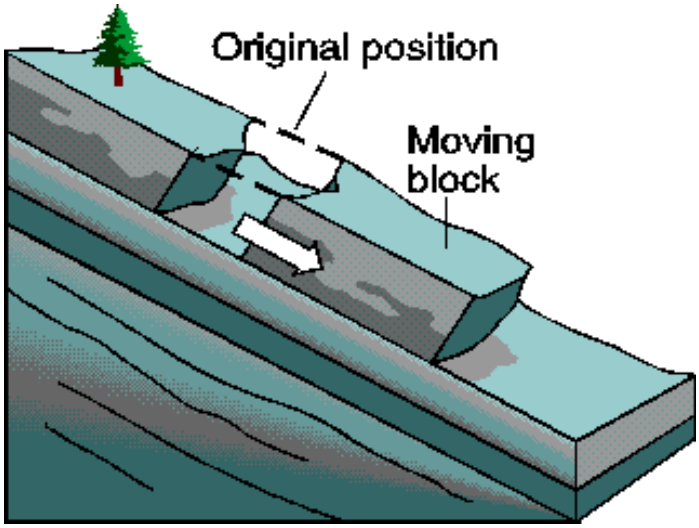
- **Rotational landslides generally occur in *homogeneous* materials.**

Translational Slide

- **Translational slide is non-circular movement on *planner slip surface*.**

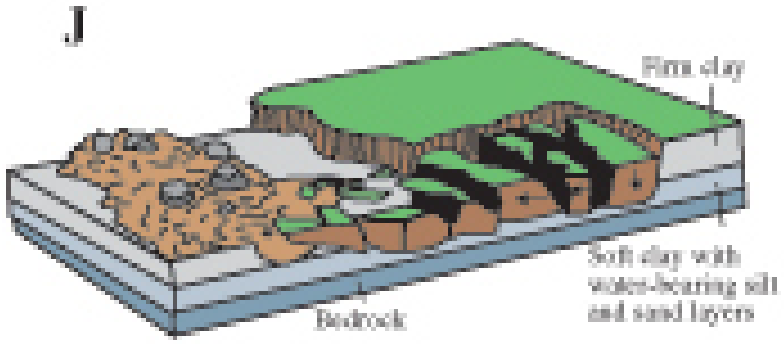


- **It is relatively *shallower than rotational slide*.**



Lateral Spreading

- **The spreads are failures caused by *liquefaction,* the process whereby water-saturated sediments transform into a liquid state.**



Lateral spread

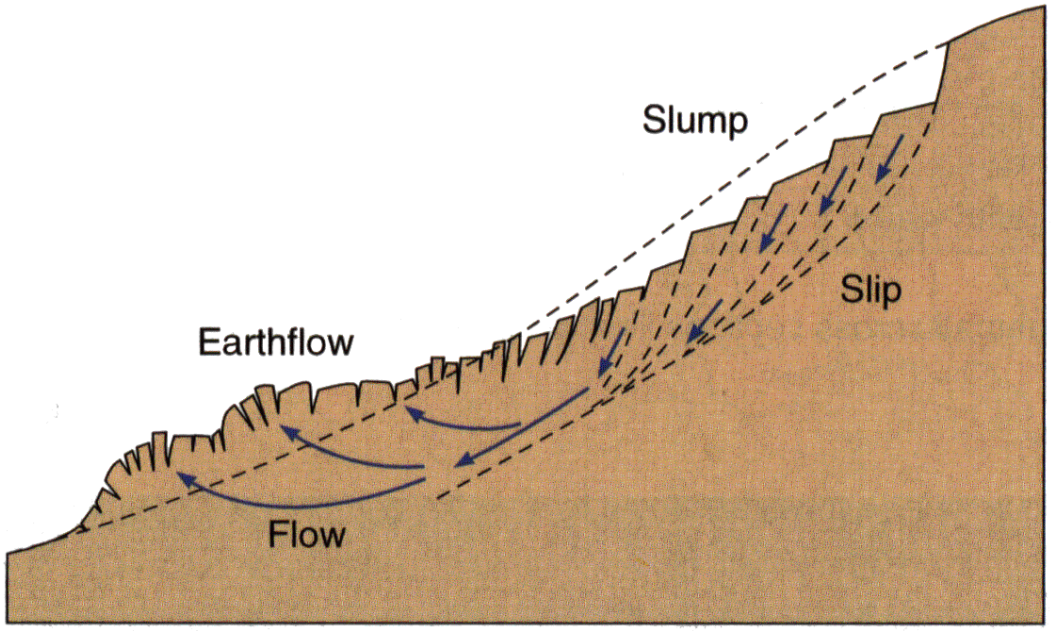
- **Spreads may result from *liquefaction or flow* of the soften material.**

Flow (Debris flow)

- **The movement is similar to flow of a *viscous fluid*.**
- ***In this case, slip surface is almost absent*.**
- **Due to *high slope*, the movement of debris flow may be *extremely rapid* (upto *40-50Km/hr* in speed)**
- **Generally debris flow occurs near the *foothill along the rivulets***

Complex

- **The combination of *two or more types of mass movement (landslides)*.**

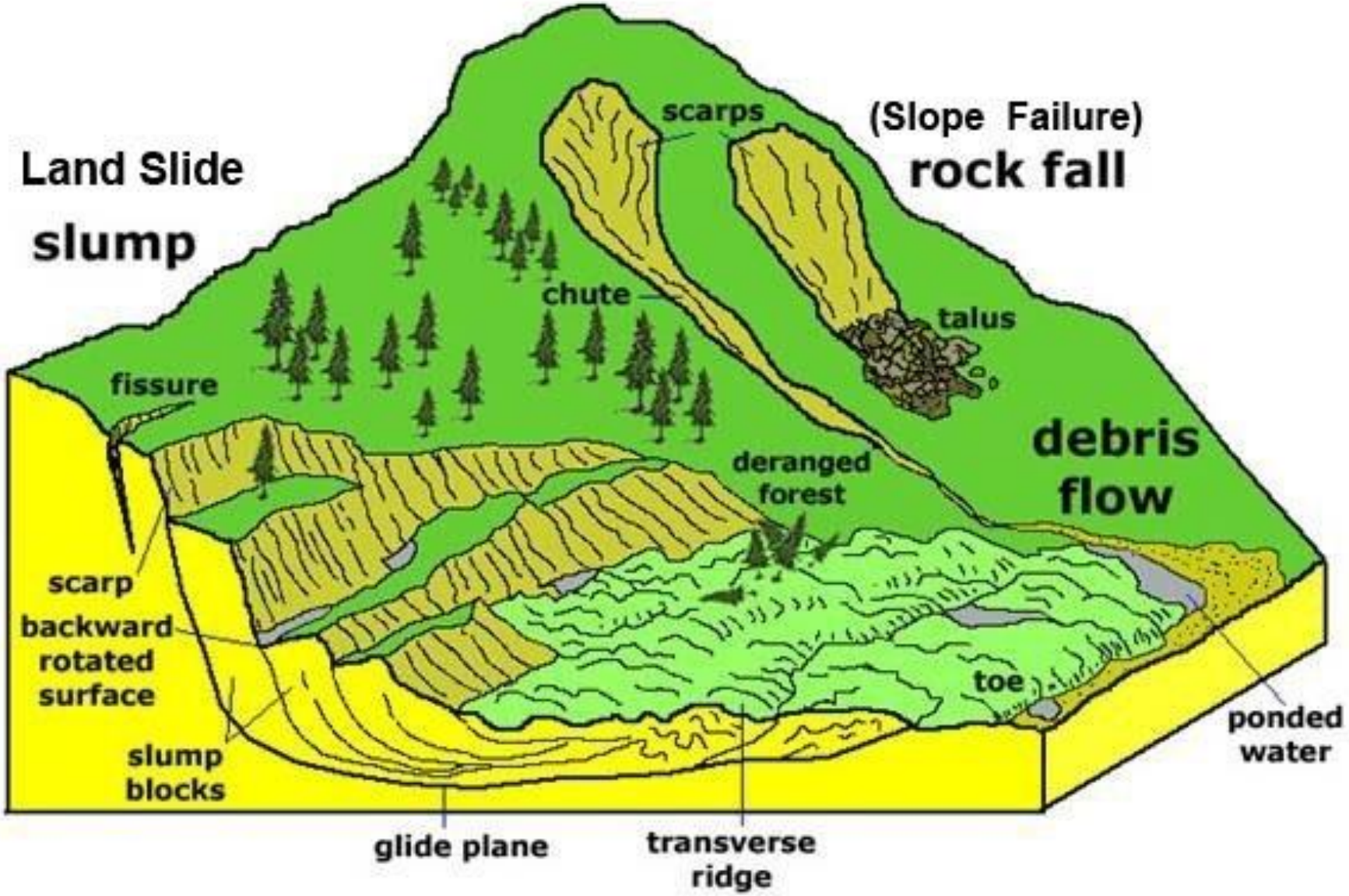


Cross section of a complex landslide characterized by slumping at the top and earthflow at the base.

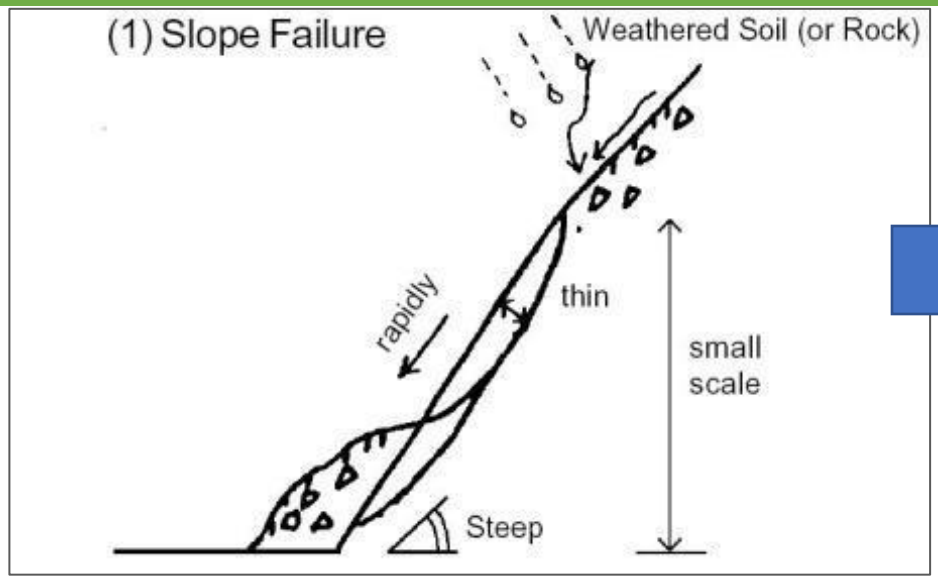
Preventive Classification (Field Disaster Oriented)

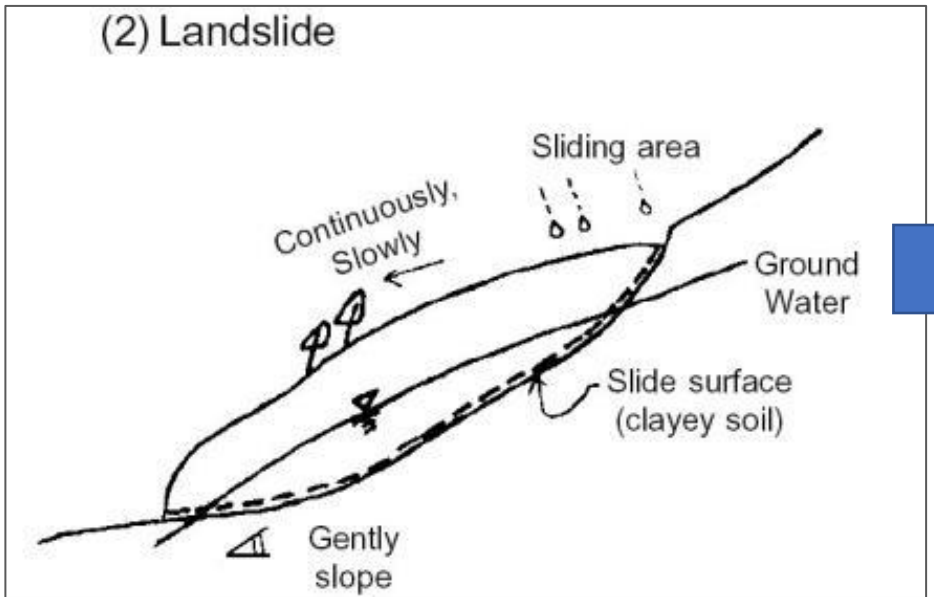
Mass Movement		
Slope failure	**Landslide**	**Debris Flow (Debris, Earth & Peat)**
Movement of weathered surface soil layer / rock of steep slope. **(Small dimension and rapid movement).**	**Movement of large sediment block which has clear slide surface.** **Large Dimension, slow and continuous movement mainly affected by ground water.**	**Movement of deposited or eroded sediment along the stream flow.** **Rapid movement including large volume of water through the stream.**

Types of Mass Movement: Preventive Classification



Landslide and Slope Failure: Differences





Landslide and Slope Failure: Differences

Conditions	Landslide	Slope Failure
Relation to Geology and Geological Structure	Much related	Not much related
Gradient of slope	Takes place in gently slope (5-20°)	Take place in steep slope over 30°
Causes of movement	Influenced by ground water	Heavy Rainfall, Earthquake
Scale of Dimension	Large (1-100ha)	Small
Rate of Movement	Generally low 0.001-10 mm/day	Extremely high over 10mm/day
Condition of Movement	Continuous and recurrent	Occurs suddenly
Condition of Soil mass	Disturbance of the soil mass is small	Soil mass is disturbed
Sliding Surface	Mainly in Clayey Soil	in weathered surface of soil (sandy soil)

Landslide and Slope Failure: Differences

Description of Movement with relation to Speed and Type

Speed	Rate	Water Content	Material	Type
Extremely rapid	3.0m/second	Dry	Rock	Fall
Very Rapid	0.3m/minute	Moist	Soil	Topple
Rapid	1.5m/day	Wet	Earth	Slide
Moderate Slow	1.5m/month	Very wet	Debris	Spread
Very slow	1.5m/year			Creep
Extremely slow	0.3m/5year			

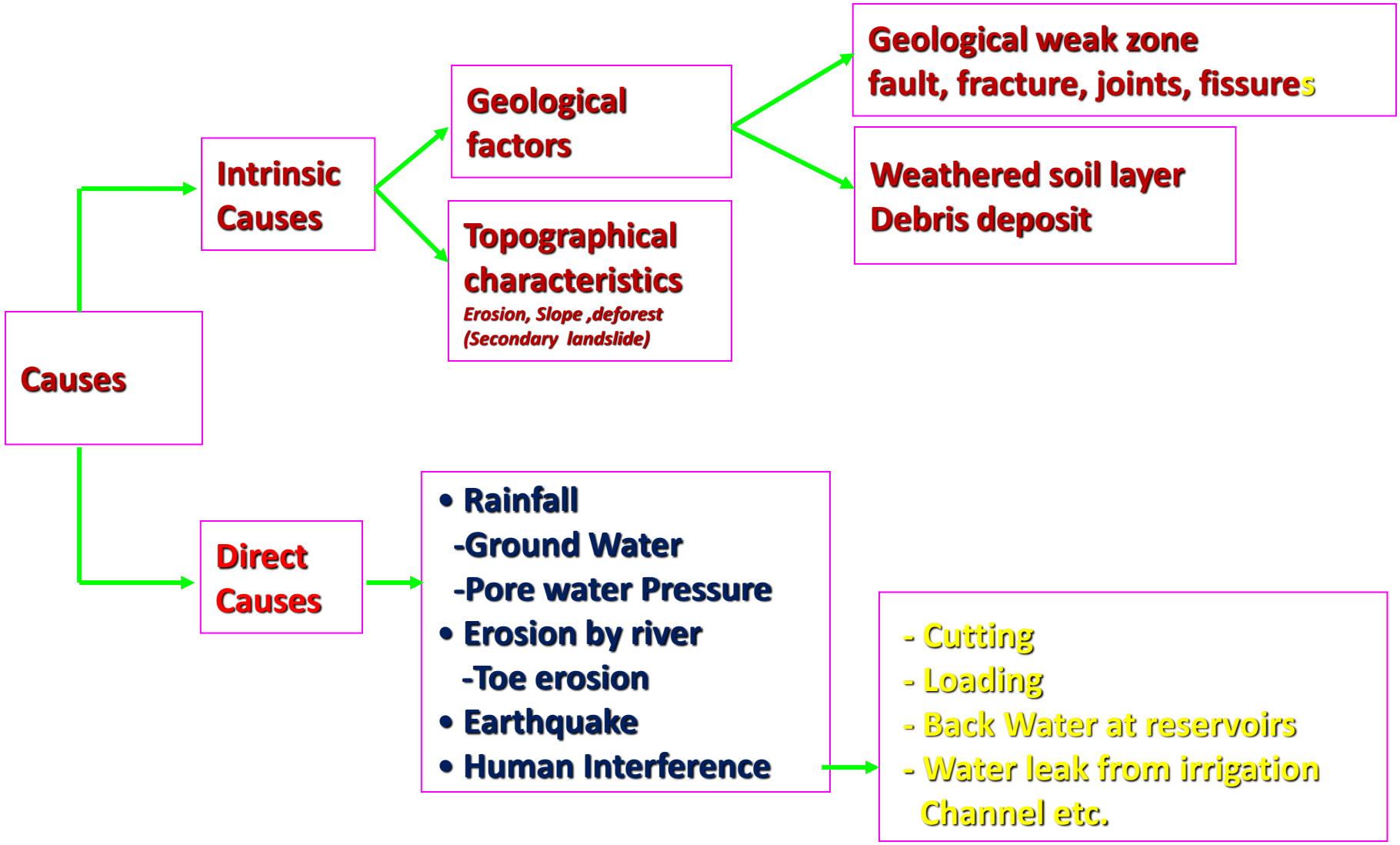
(After Bell, 1993)

Causes

Landslides & Slope Failure: Causes

- **Intrinsic Causes &**
- **Direct causes**

Causes of Mass Movement (Landslide)



Mechanism

Mechanism of Mass Movement (Landslide)

- **Driving force or, Shear Stress (T) is down slope movement of material due to gravity, (The slope angle, slope material, climate,, chemical weathering and ground water contribute to the effect of gravity).**

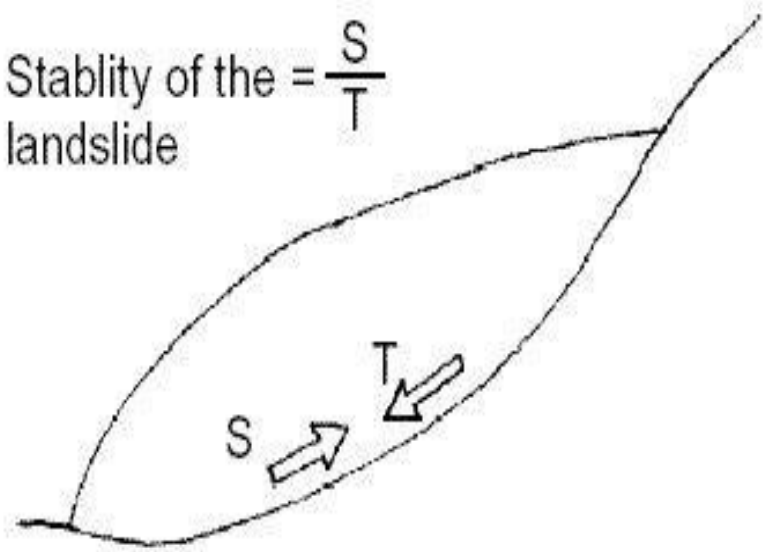
- **Resisting force or, Shear Strength (S) stops or prevents the movement.**

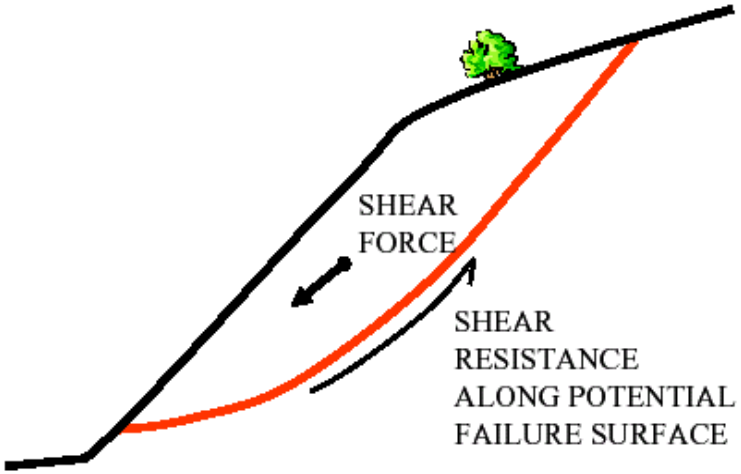
when *driving forces overcome resisting forces,* the slope is unstable and results mass wasting.

Mechanism of Mass Movement (Landslide)

Factor of Safety (FS)

The ratio of resisting forces to driving forces





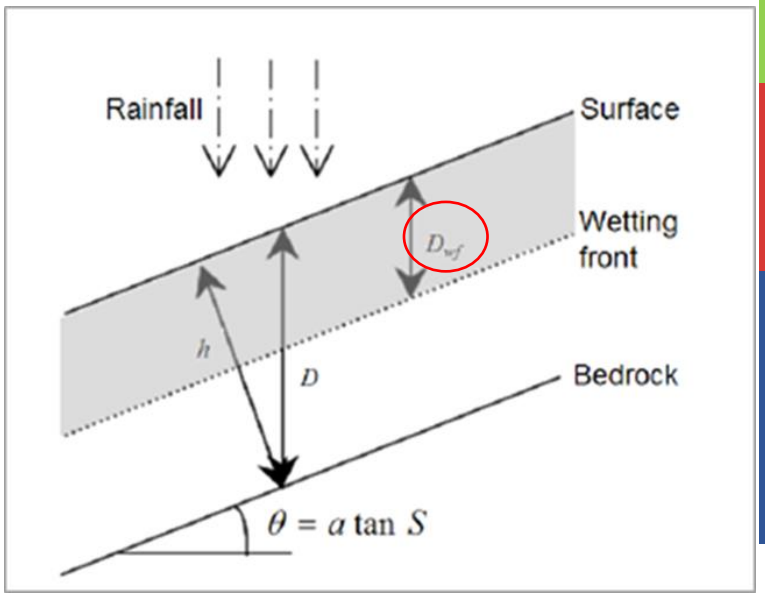
$$\frac{\text{SHEAR RESISTANCE}}{\text{SHEAR FORCE}} = \text{FACTOR OF SAFETY}$$

FS > 1.5 : Stable
FS =1 – 1.5 : Marginally stable
FS < 1 : Unstable

FS: Rainfall Induced Slope Instability

Factor of Safety (FS): Physically based infinite slope stability model (Chae et al. 2015):

$$FS = \frac{(c_s + c_r) + \cos^2\theta [A] \tan\phi}{D\rho_t g \sin\theta \cos\theta}$$

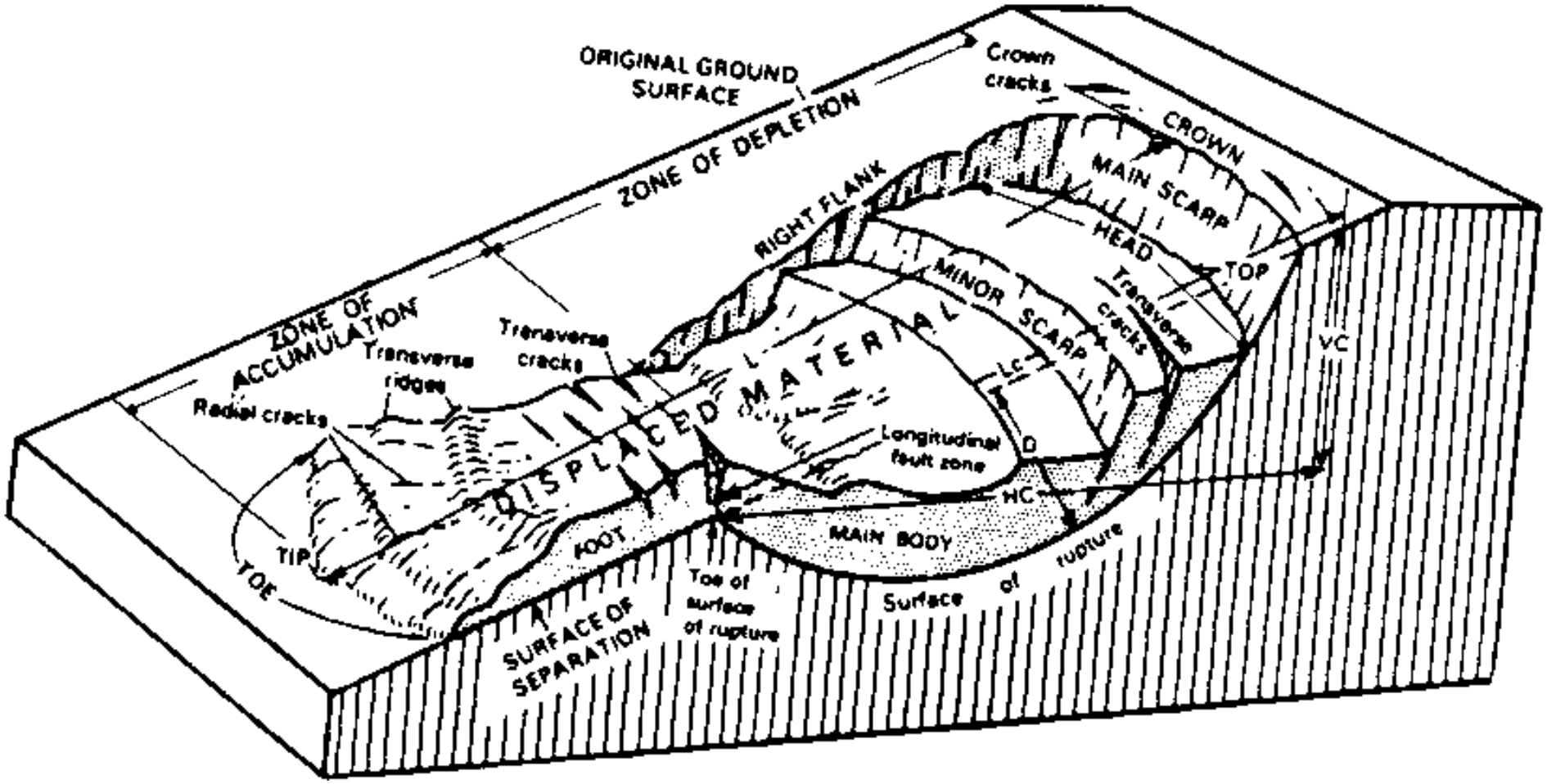


where,

$$A = [\rho_t g(D + D_{wf}) + (\rho_t g - \rho_w g) D_{wf}]$$

'c_r' is the plant roots cohesion (N/m^2), 'c_s' is the soil cohesion (N/m^2), 'θ' is the slope gradient (^{0}), 'ρ_t' is the soil density (kg/m^3), 'ρ_w' is the density of water (kg/m^3), 'g' is the acceleration due to gravity (9.81m/s^2), D is the depth of the soil layer (m), 'D_{wf}' is the vertical height of the water table (m) and 'ϕ' is the internal friction angle of the soil (^{0}).

Landslide Features



Thank You !!!