Landslide Hazard Assessment & Mitigation

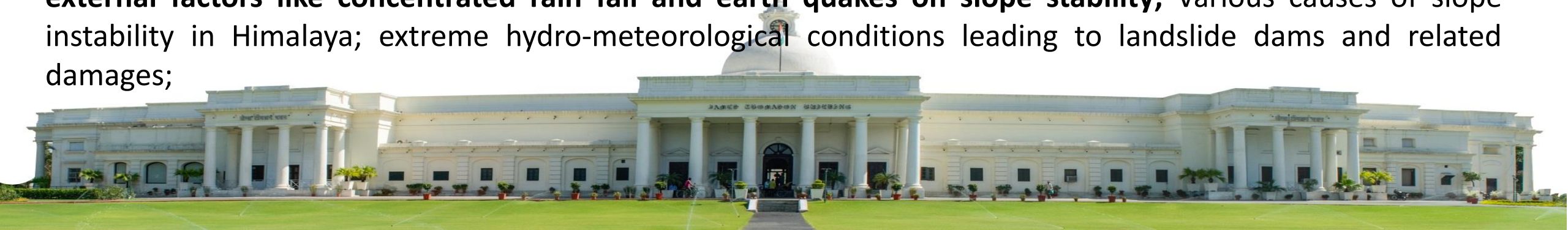
DML – 502 Lecture - 7

Subject Code: DML-502
Course Title: Landslide Hazard Assessment & Mitigation

"To understand mapping and hazard assessment techniques of landslides and protection against landslide."

S. No 2

Causative factors of landslides – natural including inherent factors and external factors as well as anthropogenic factors; Impacts of natural causative factors like lithology, structure, slope morphometry, relative relief, hydrogeological conditions and land use and land cover on stability of slopes ; **Impacts of external factors like concentrated rain fall and earth quakes on slope stability;** Various causes of slope instability in Himalaya; extreme hydro-meteorological conditions leading to landslide dams and related damages;

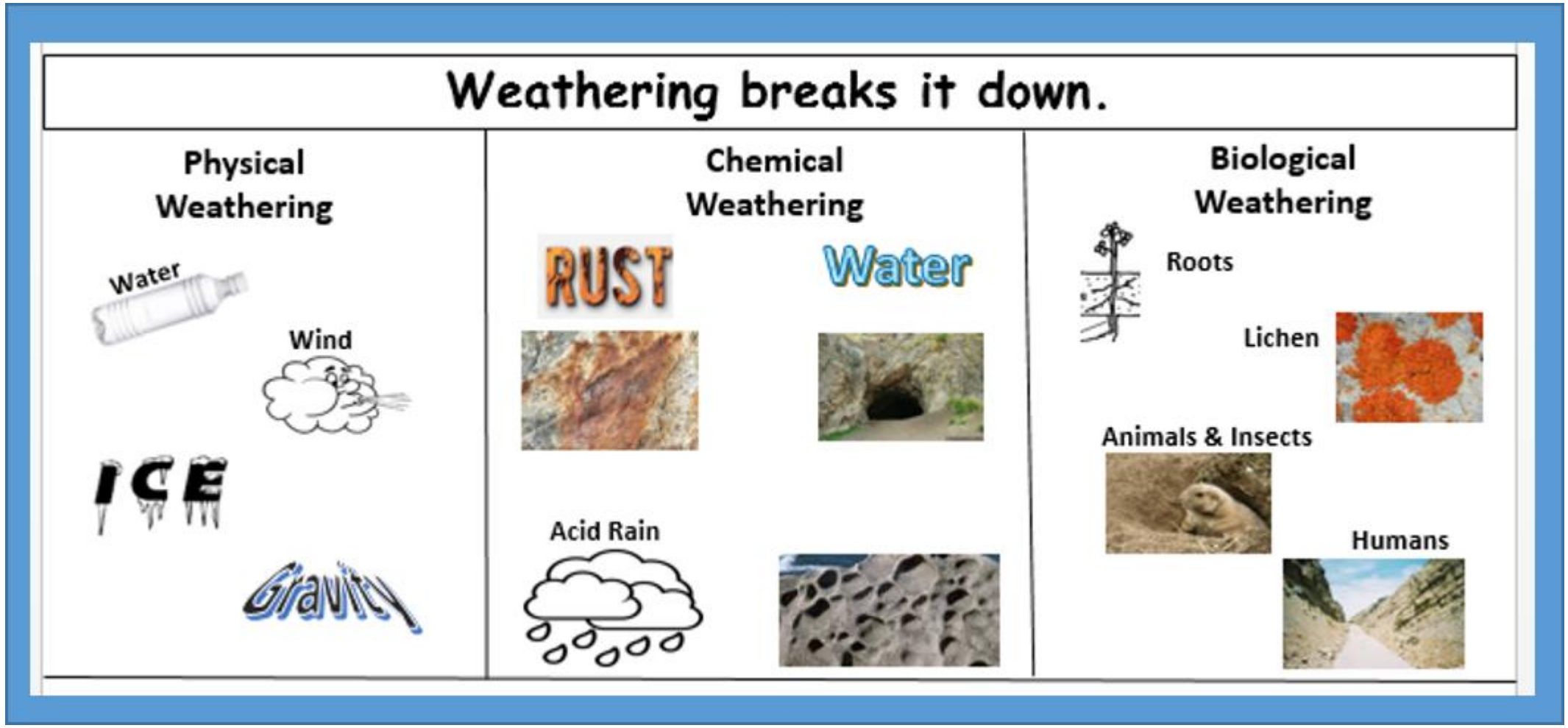


Bedrock exposed to surface is **Outcrop**

Weathering

What is weathering?

the breakdown of rocks at or near the surface through physical, chemical and biological processes.



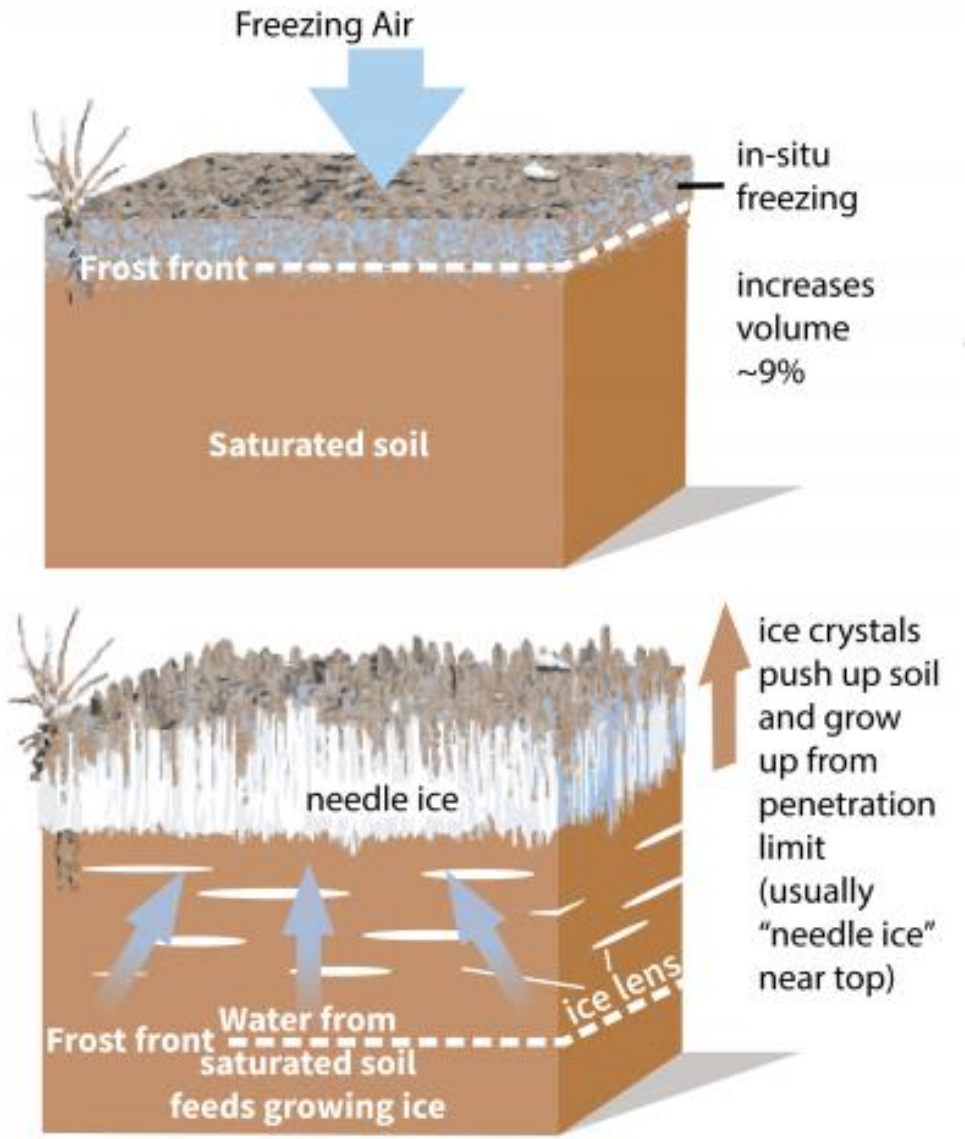
Physical Weathering

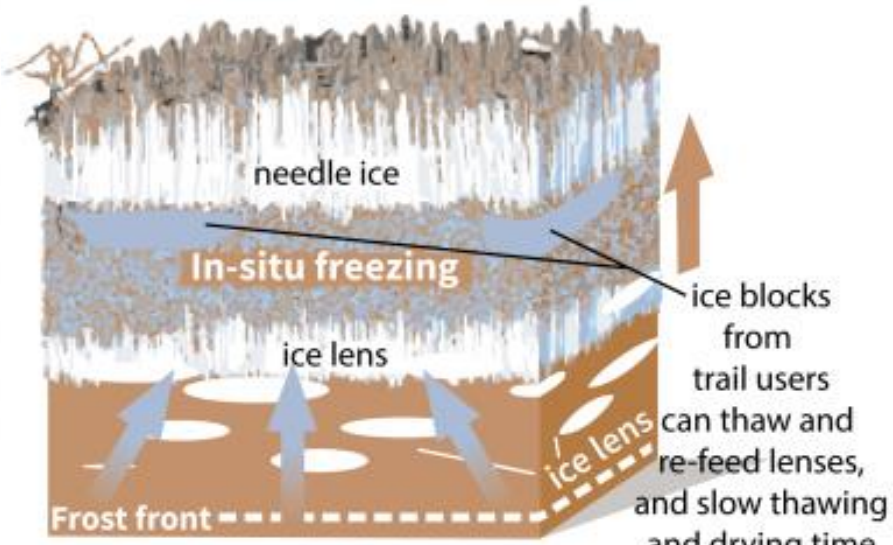
Physical Weathering: the mechanical or physical breakdown of rock into smaller pieces(sediments), without a change in the mineral's chemical composition.

Frost action: water freezes in a crack of the rock surface, expanding and splitting the rock. Changes-alternating hot and cold temperatures weaken the rock as it expands and contracts.

Physical Weathering

Alternate freezing and thawing form potholes and frost heave.





Weakening of rock is a long process

Physical Weathering

- Plants and Animals-plant roots force their way into cracks, animals uncover rock and expose it to the elements.

Environmental conditions play big role

Physical Weathering

- Exfoliation Dome- layers of rock peel off the main body of the rock.

- Abrasion-pieces of rock collide with each other due to transportation by wind, ice, water and gravity.

Chemical reactions take place under suitable conditions

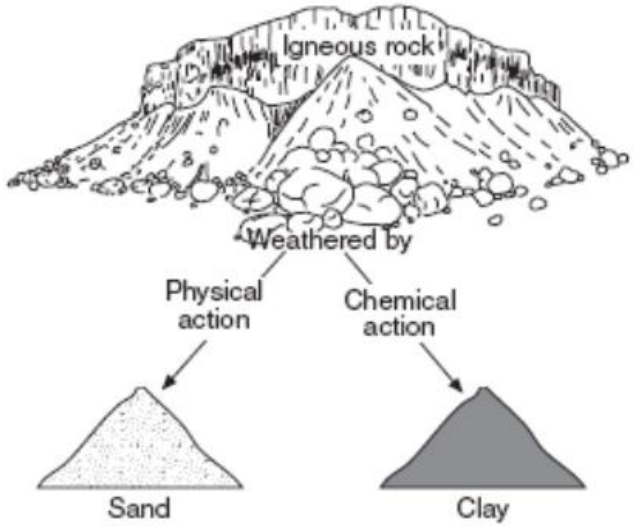
Chemical Weathering

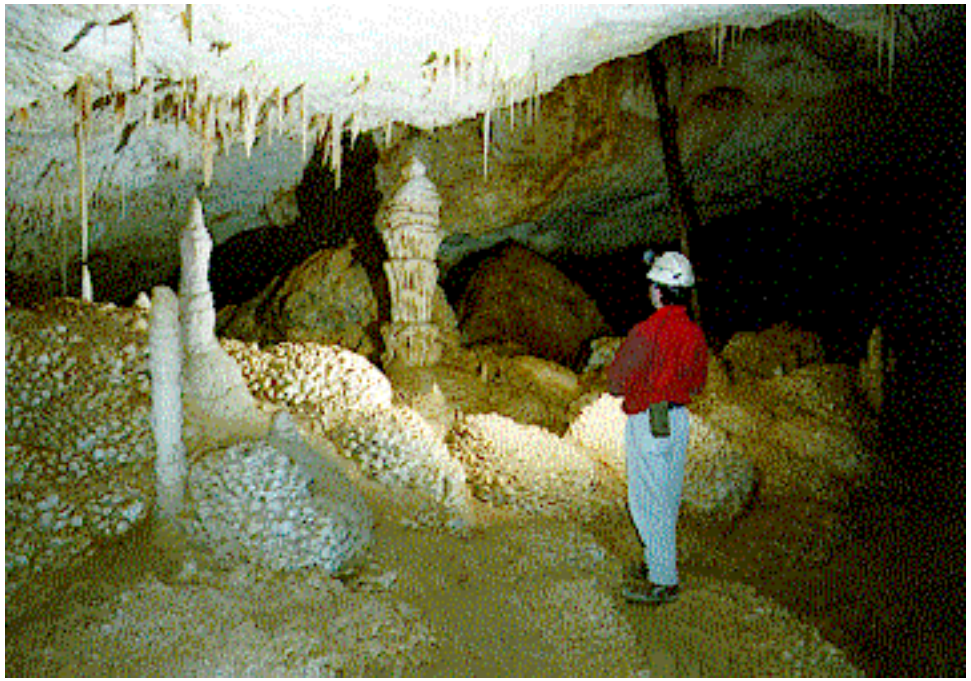
- Chemical Weathering-the process by which chemicals breakdown rock through a change in the mineral's composition, happens fastest in a hot, moist climate.
- Oxidation-occurs when oxygen from the air combines with iron-rich minerals of the rock, oxidation = RUST

Chemical Weathering

Presence of water is required for chemical weathering

- Carbonation-occurs when water combines with carbon dioxide in the air to form carbonic acid.
- Carbonic acid easily dissolves rocks like limestone and marble.
- Hydrolysis-water combines with minerals i.e., mica and feldspar found in granite, to form clay, the rock weakens and deforms.

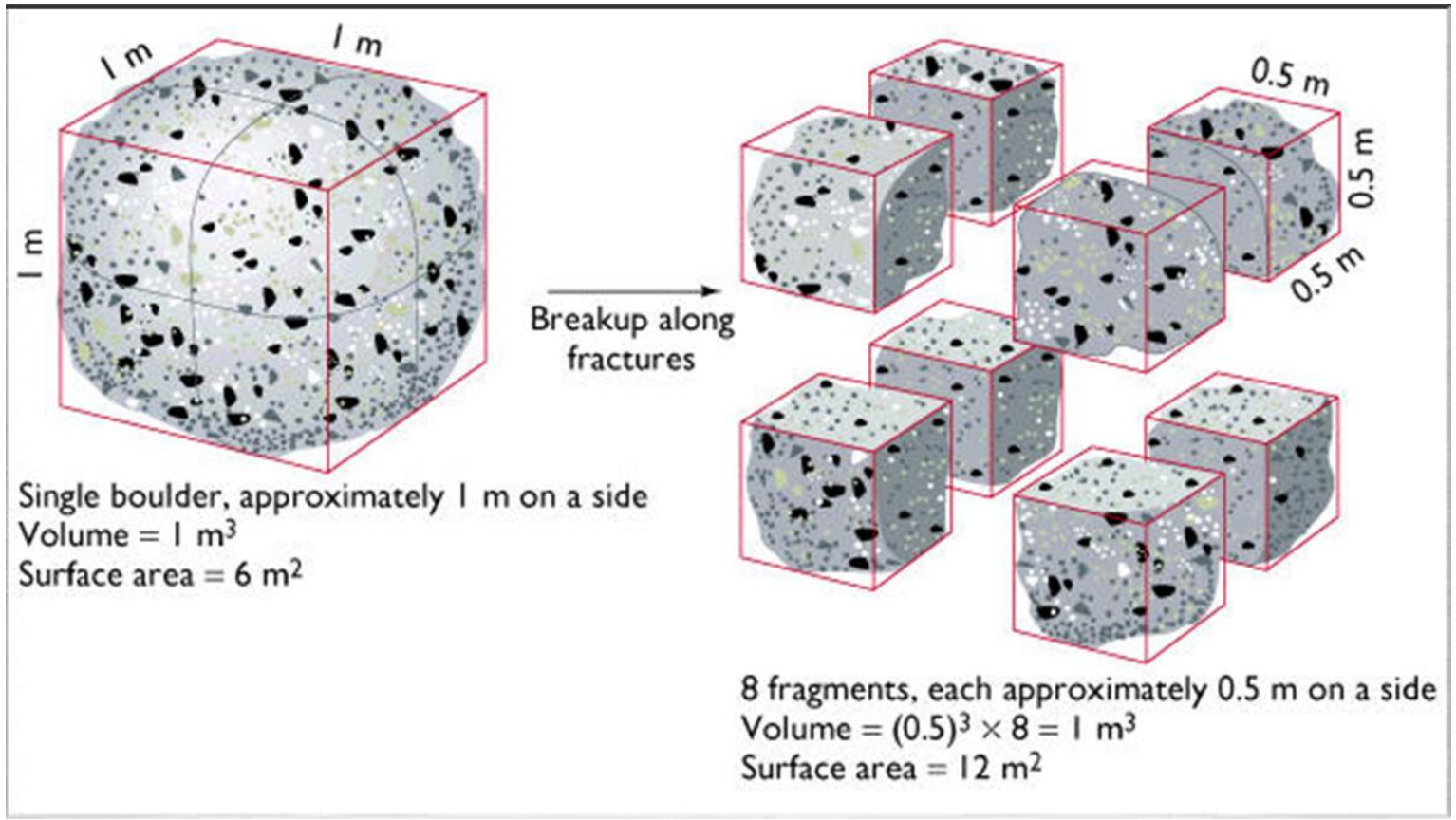




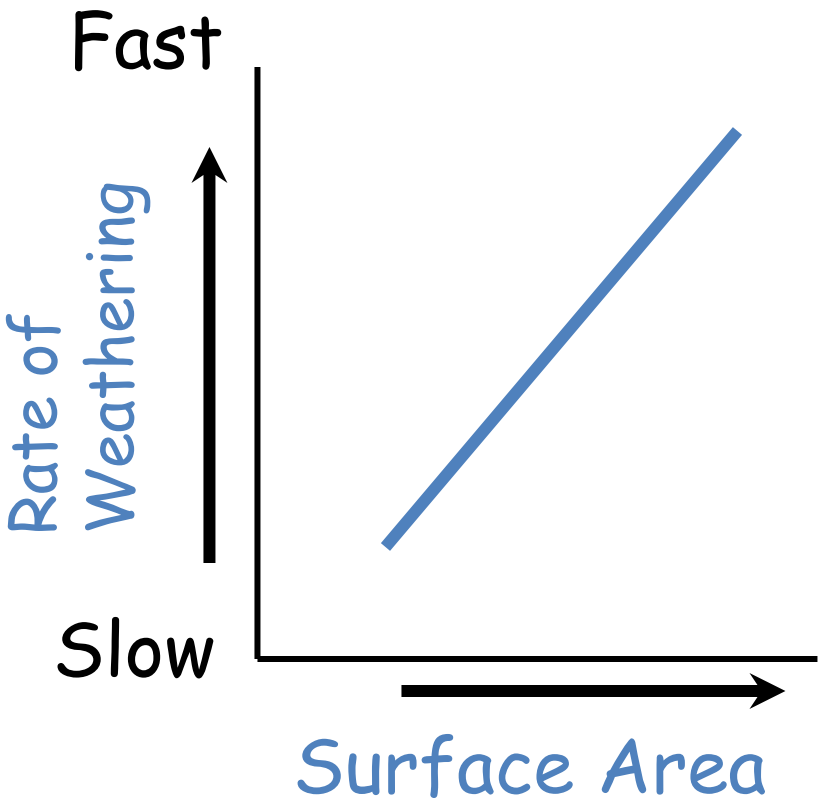
Factors affect weathering are many

Rate of Weathering

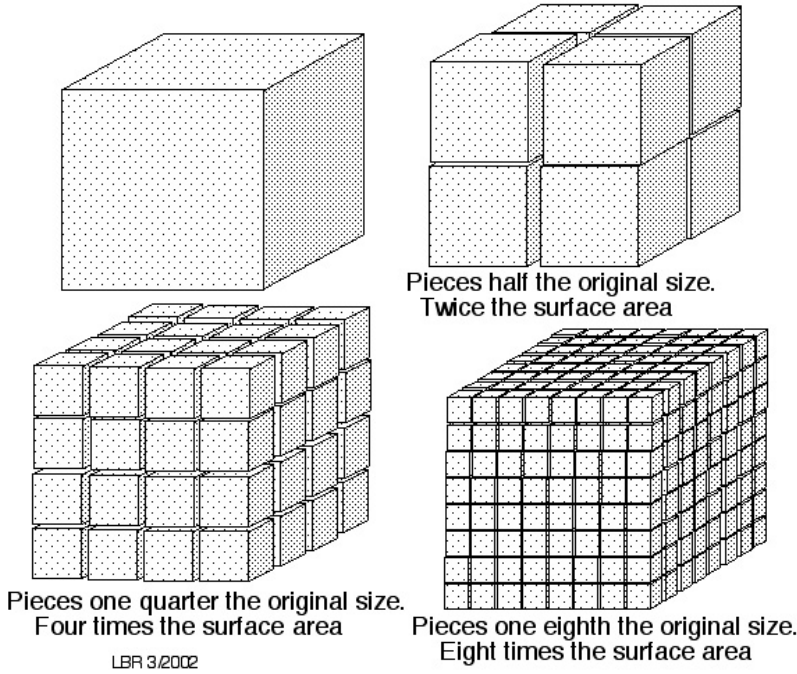
- Factors Affecting the Rate of Weathering
- Exposure-rate and type of weathering are dependent on exposure to air, water and living things.
- Particle Size-an increase in surface area increases the rate of weathering

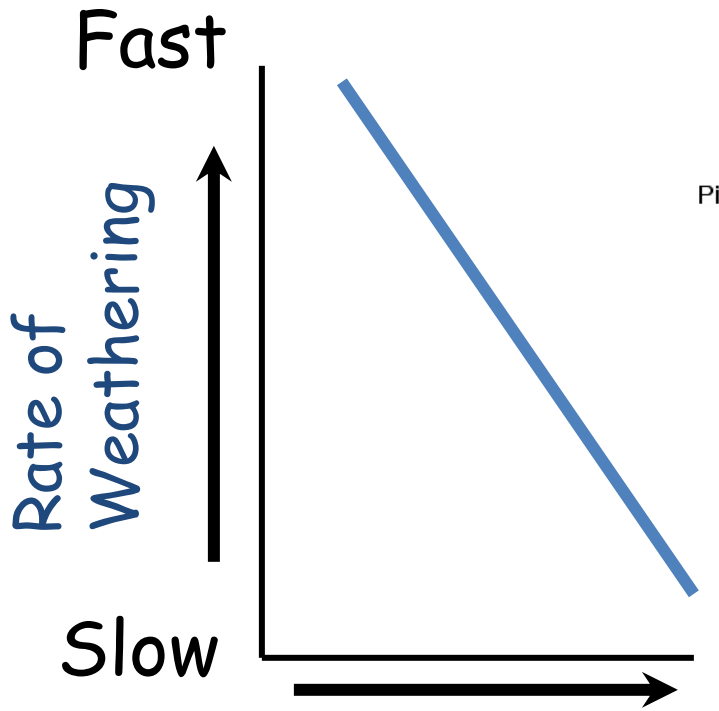


Fast and slow weathering



Rate of Weathering



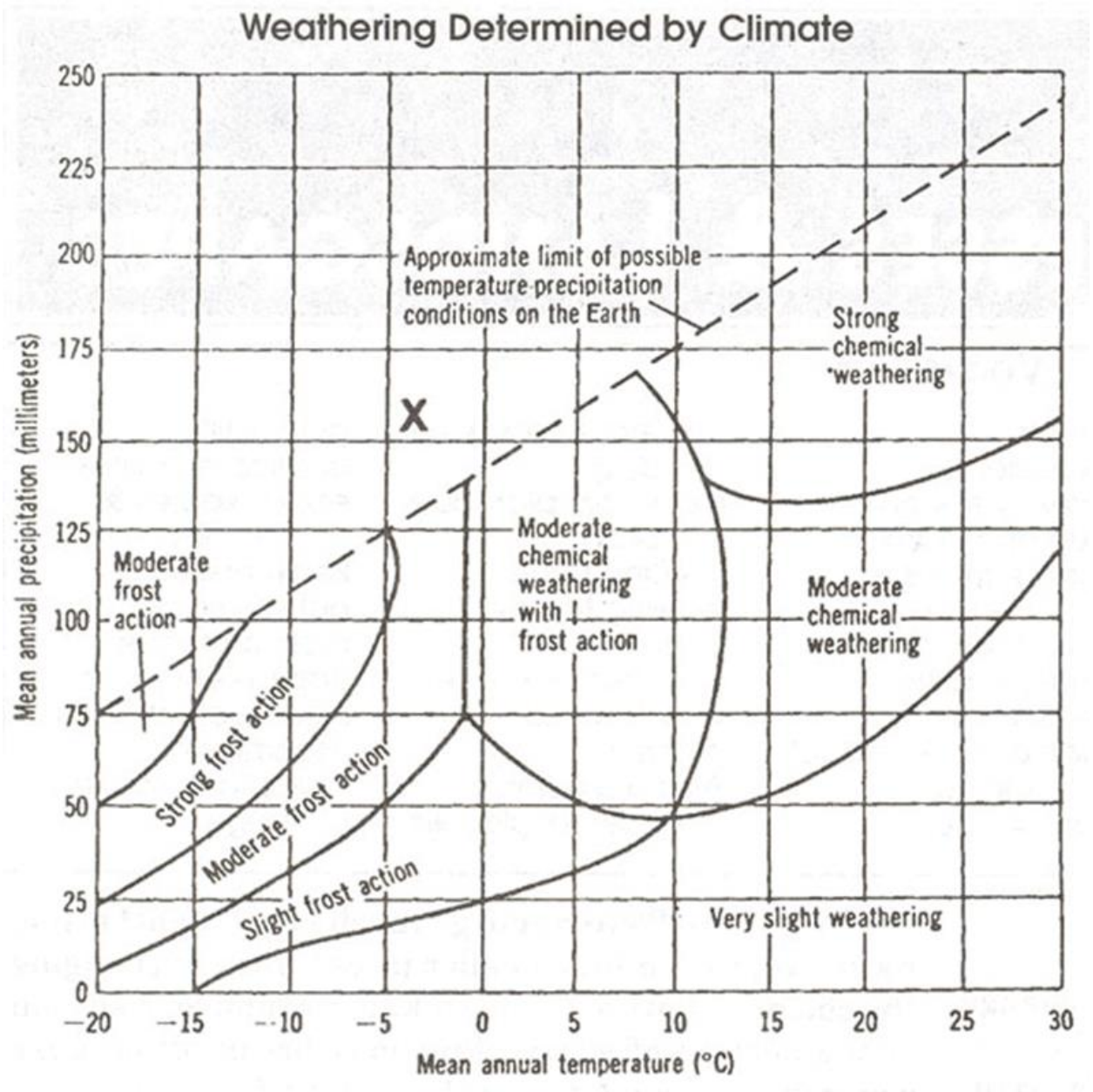


Mineral Composition-rocks made of harder minerals weather slower than rocks made of softer minerals.

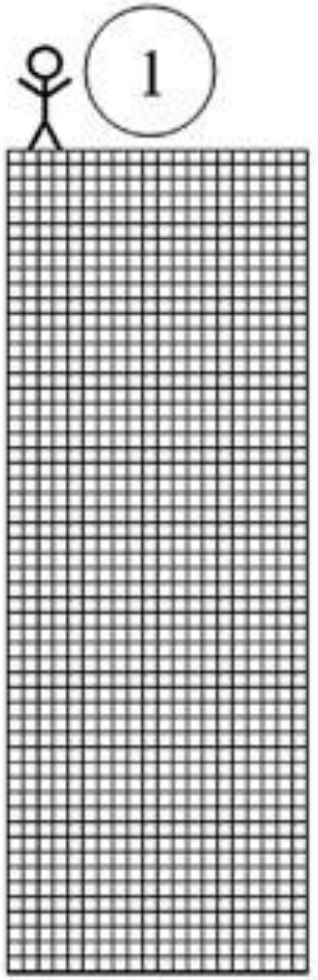
Weathering: function of weather/climate!

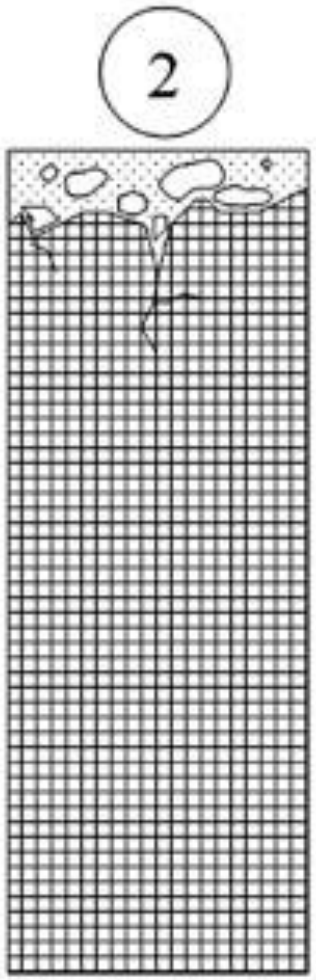
Rate of Weathering

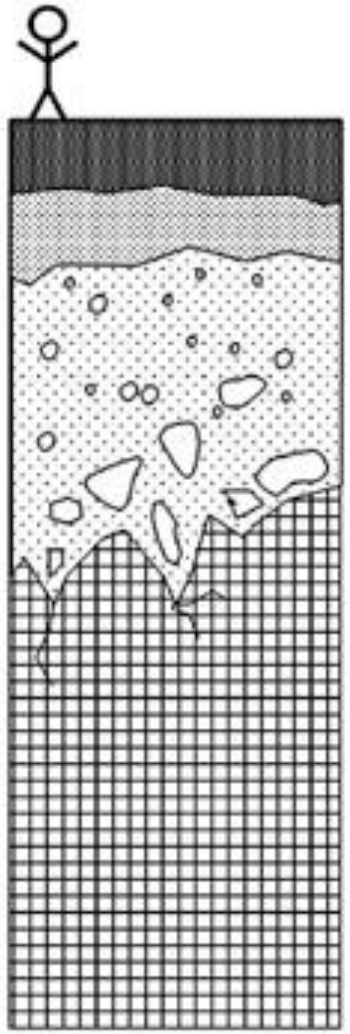
- Climate: physical and chemical weathering are affected by climate.
- In cold and moist climates, physical weathering is dominant.
- In hot and moist climates, chemical weathering is dominant.
- In both cases, water is the major ingredient that promotes weathering



Soil Formation-end product of weathering and biologic activity







A-Horizon — top soil

B-Horizon — sub-soil

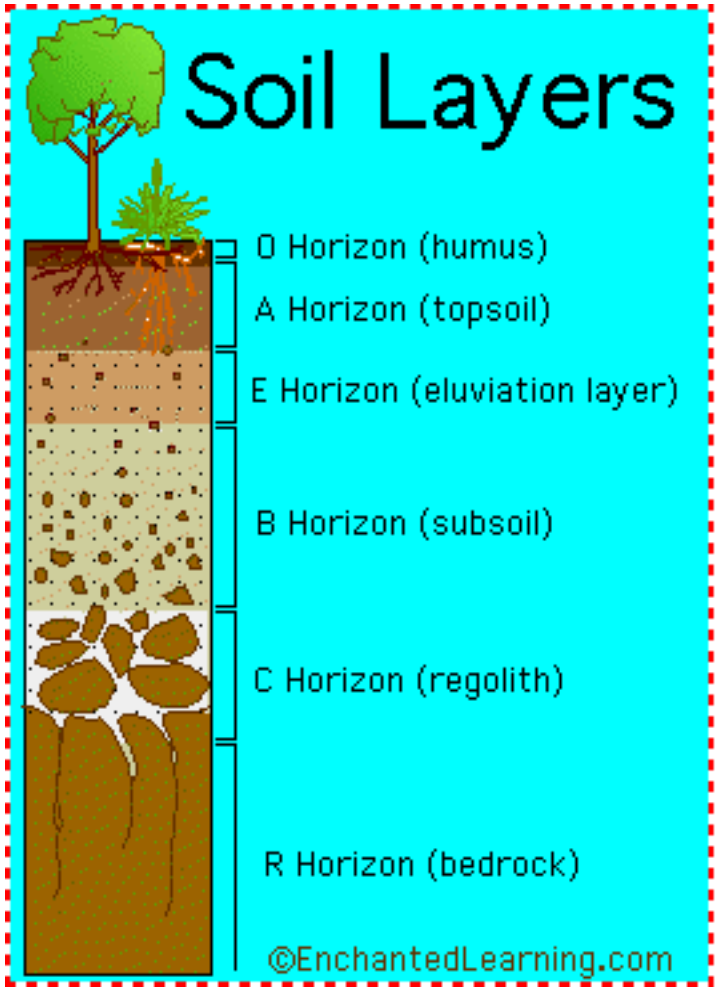
C-Horizon — partly weathered bedrock

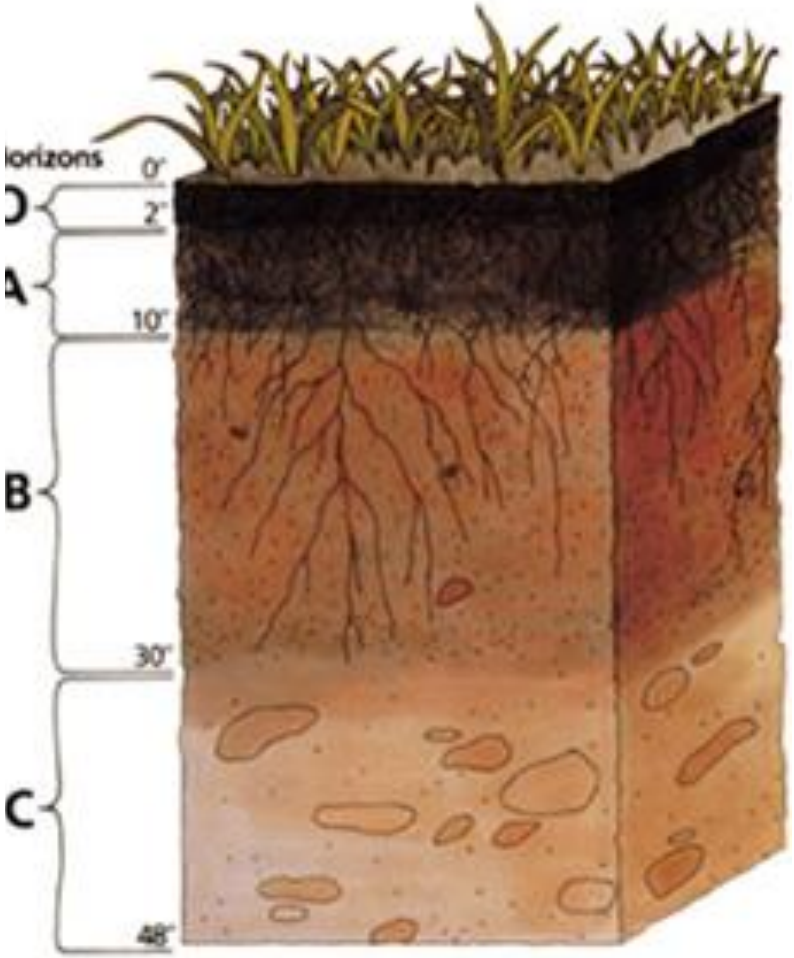
Bedrock — solid bedrock

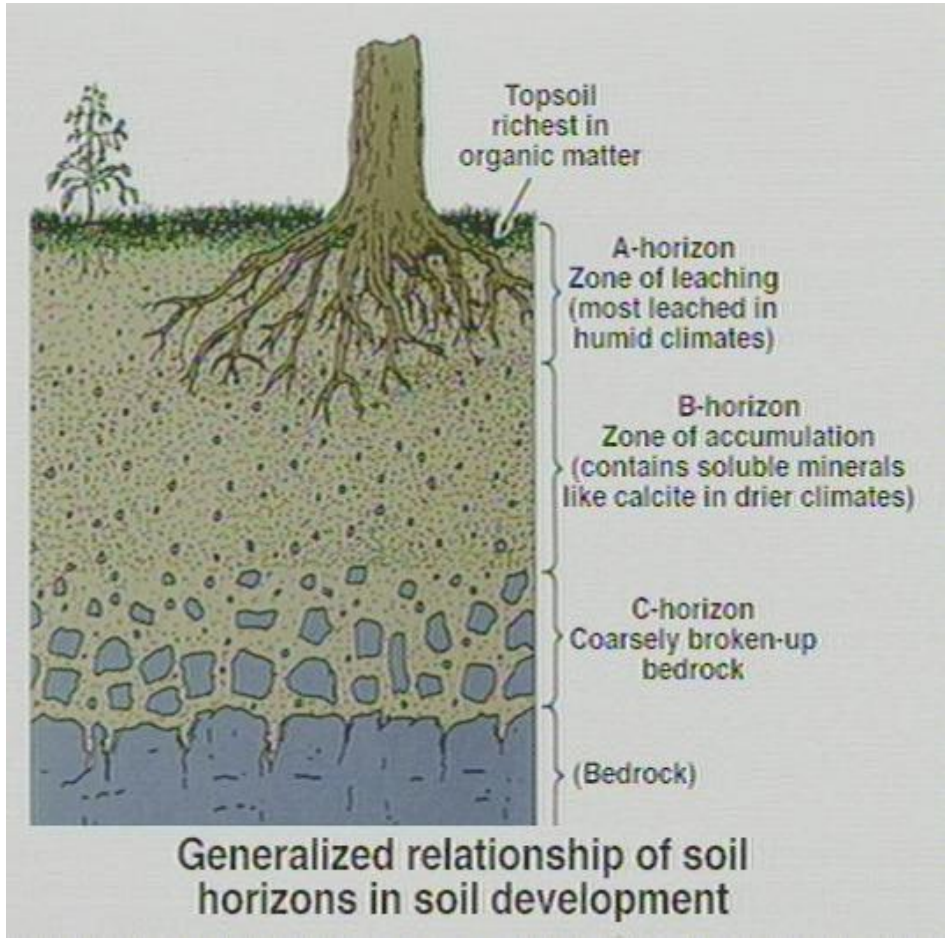
Time increases

Soil Formation

Soil Formation-end product of weathering and biologic activity





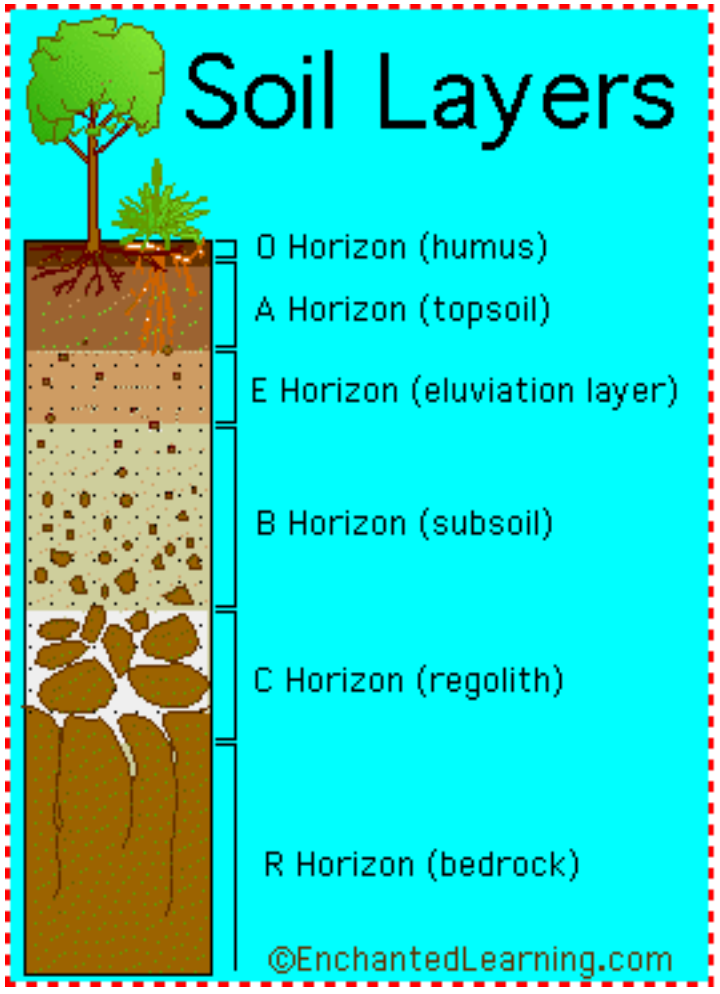


Generalized relationship of soil horizons in soil development

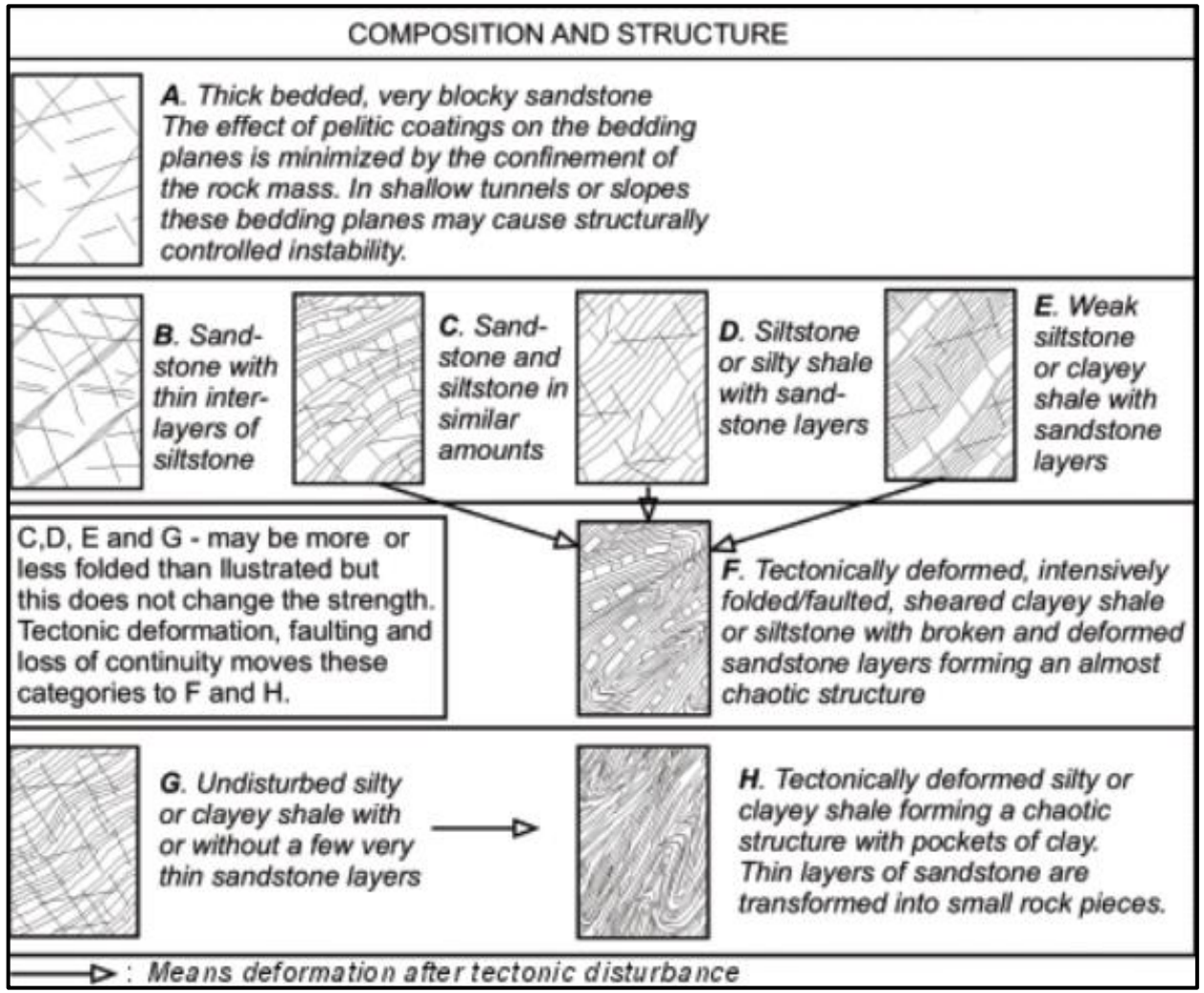
Newer geological formations experience more erosion

Soil Formation

Soil Formation-end product of weathering and biologic activity



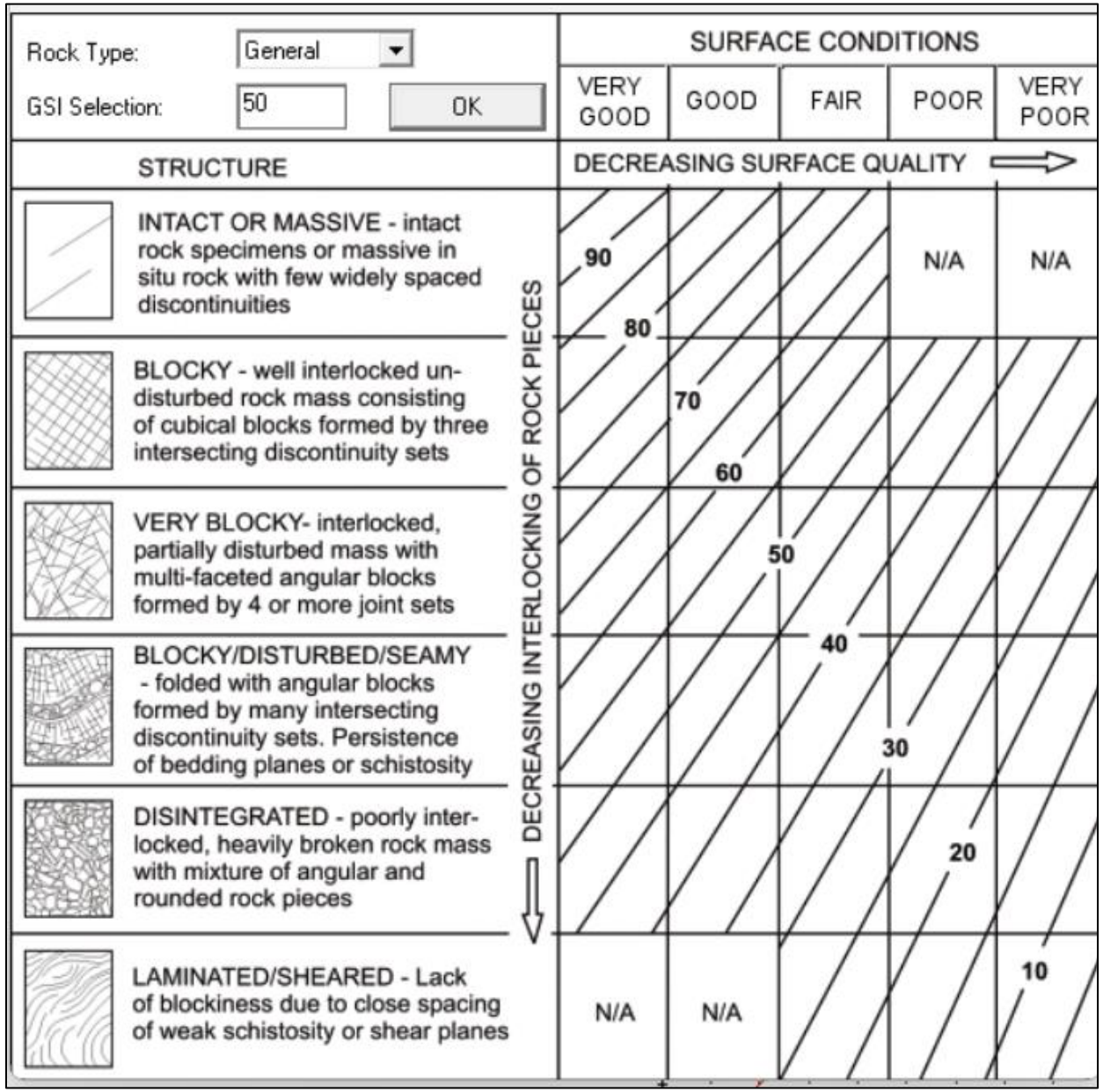
Erosion removes top/sub soil



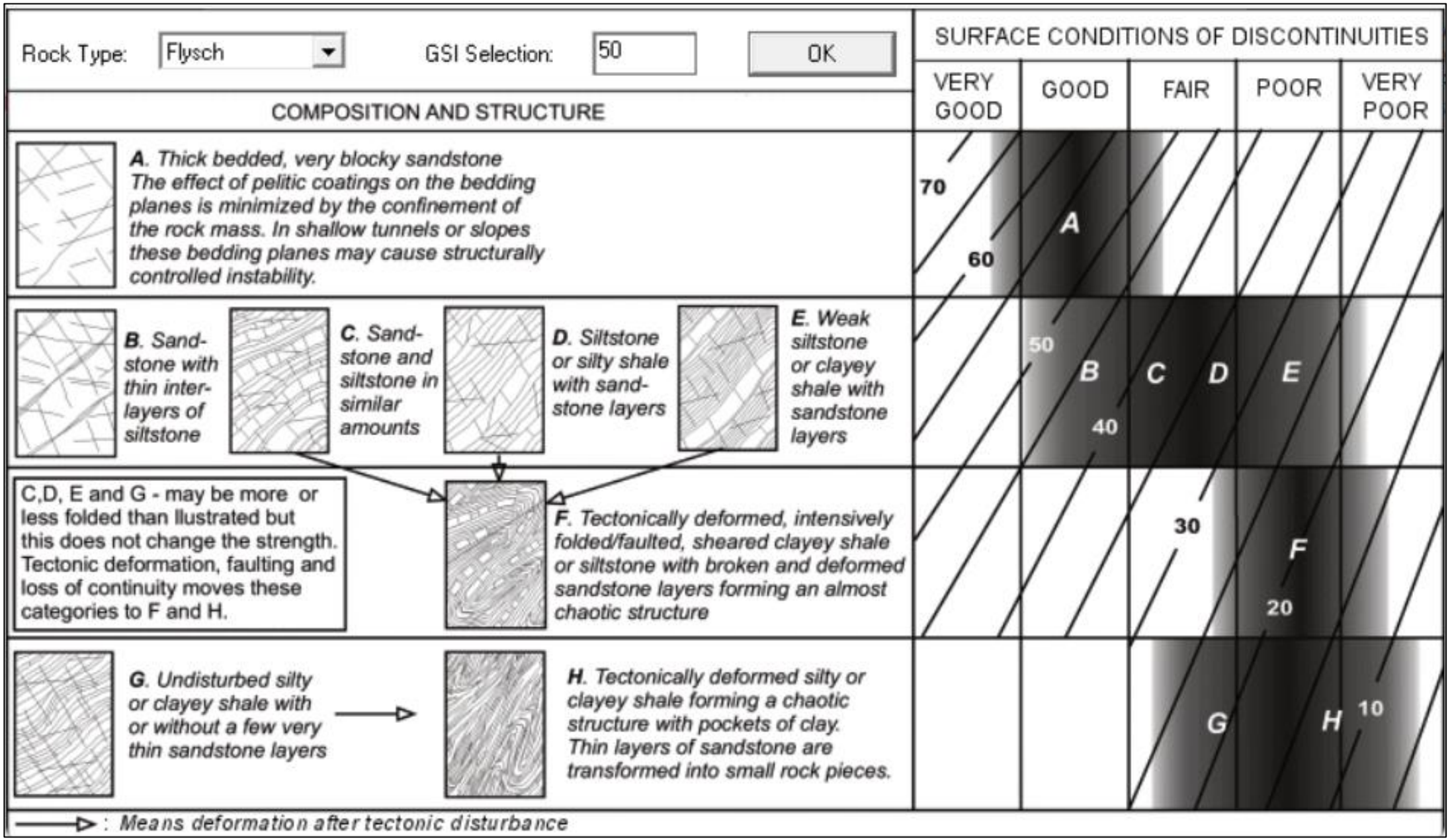
Rock outcrop is conditioned by surface weakness

Intact Uniaxial Compressive Strength

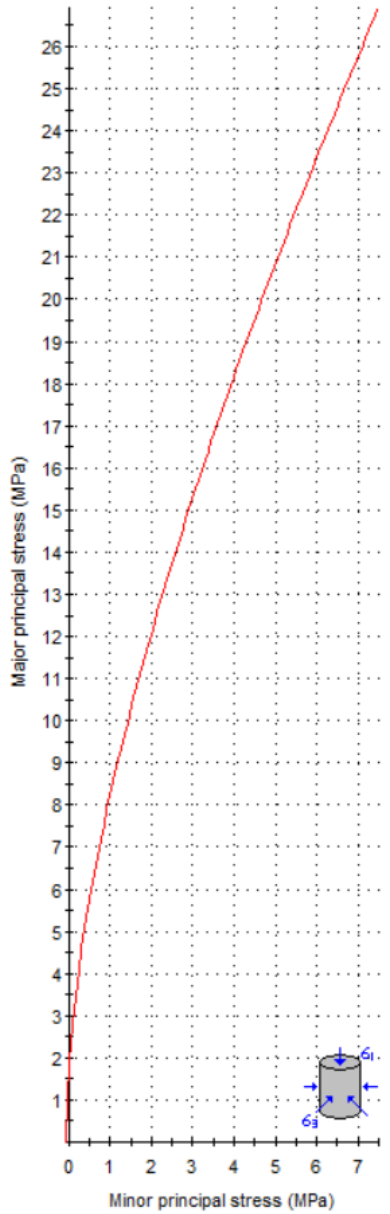
Field Estimate of Strength	Examples	Strength (MPa)
Specimen can only be chipped with a geological hammer.	Fresh basalt, chert, diabase, gneiss, granite, quartzite.	>250
Specimen requires many blows of a geological hammer to fracture it.	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, limestone, marble, rhyolite, tuff.	100-250
Specimen requires more than one blow of a geological hammer to fracture it.	Limestone, marble, phyllite, sandstone, schist, shale.	50-100
Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer.	Claystone, coal, concrete, schist, shale, siltstone.	25-50
Can be peeled with a pocket knife with difficulty, shallow indentation made by firm blow with point of a geological hammer.	Chalk, rocksalt, potash.	5-25
Crumbles under firm blows with point of a geological hammer, can be peeled by a pocket knife.	Highly weathered or altered rock.	1-5
Indented by thumbnail.	Stiff fault gouge.	0.25-1



Geological Strength Index (GSI)



Indirect estimation of rock strength



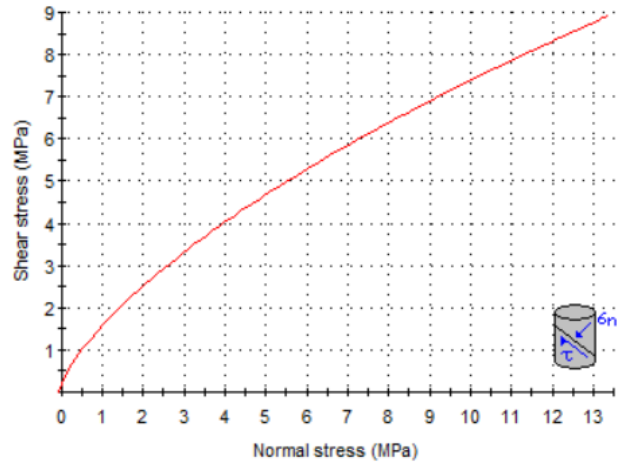
Analysis of Rock Strength using RocLab

Hoek-Brown Classification
intact uniaxial comp. strength (sigci) = 30 MPa
GSI = 50 mi = 10 Disturbance factor (D) = 0
intact modulus (Ei) = 12000 MPa

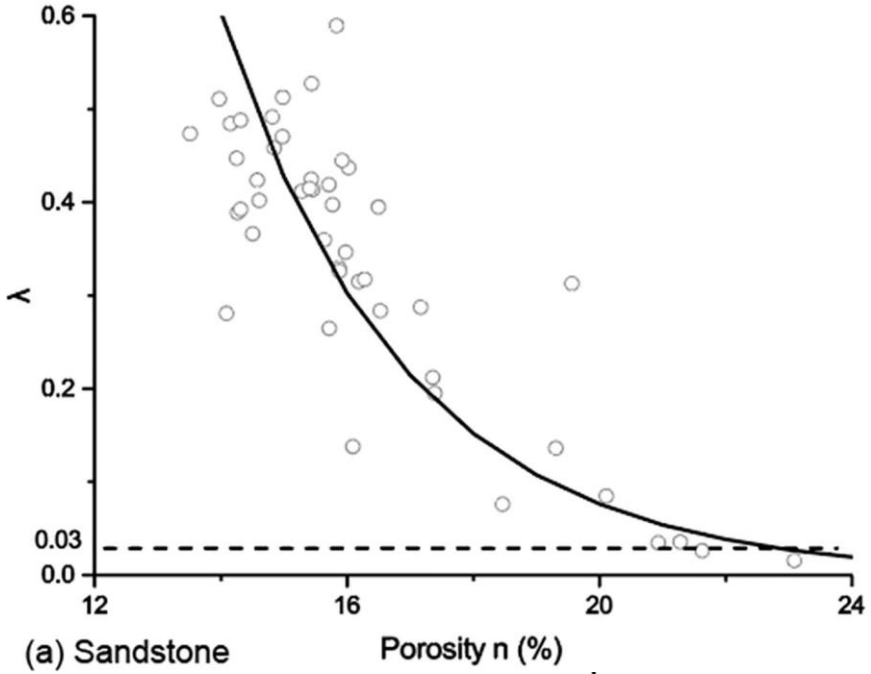
Hoek-Brown Criterion
mb = 1.677 s = 0.0039 a = 0.506

Mohr-Coulomb Fit
cohesion = 1.494 MPa friction angle = 30.52 deg

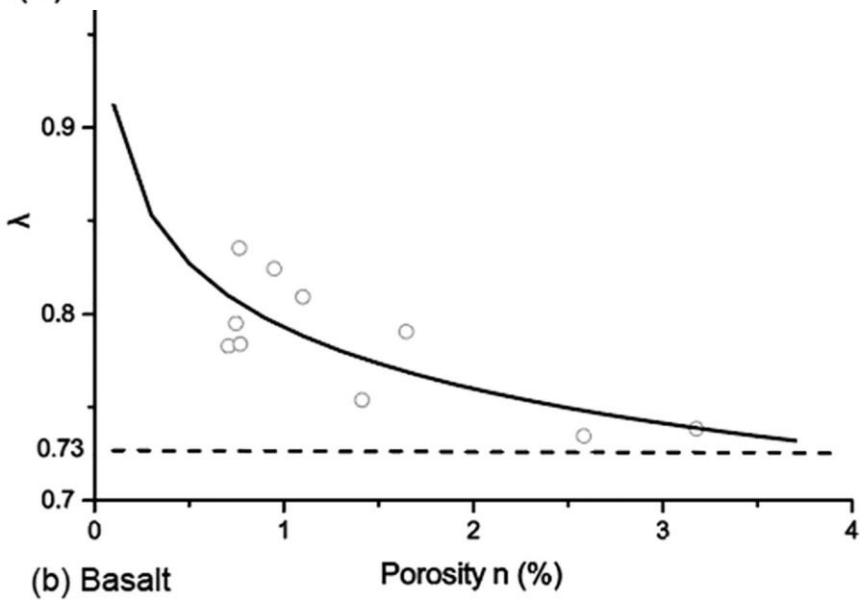
Rock Mass Parameters
tensile strength = -0.069 MPa
uniaxial compressive strength = 1.807 MPa
global strength = 5.230 MPa
deformation modulus = 3686.23 MPa



Rock strength and saturation

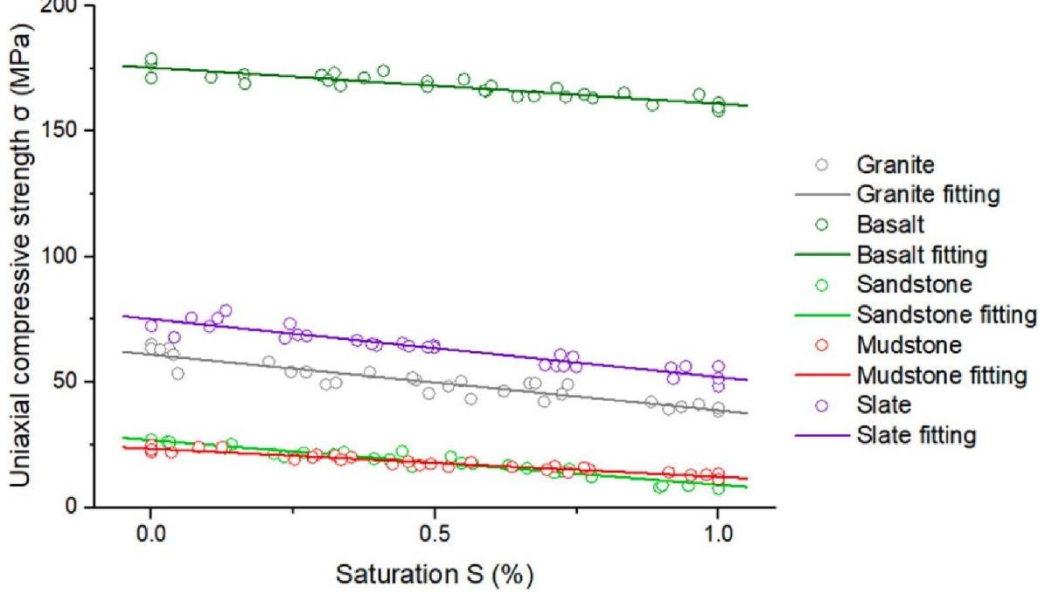


(a) Sandstone

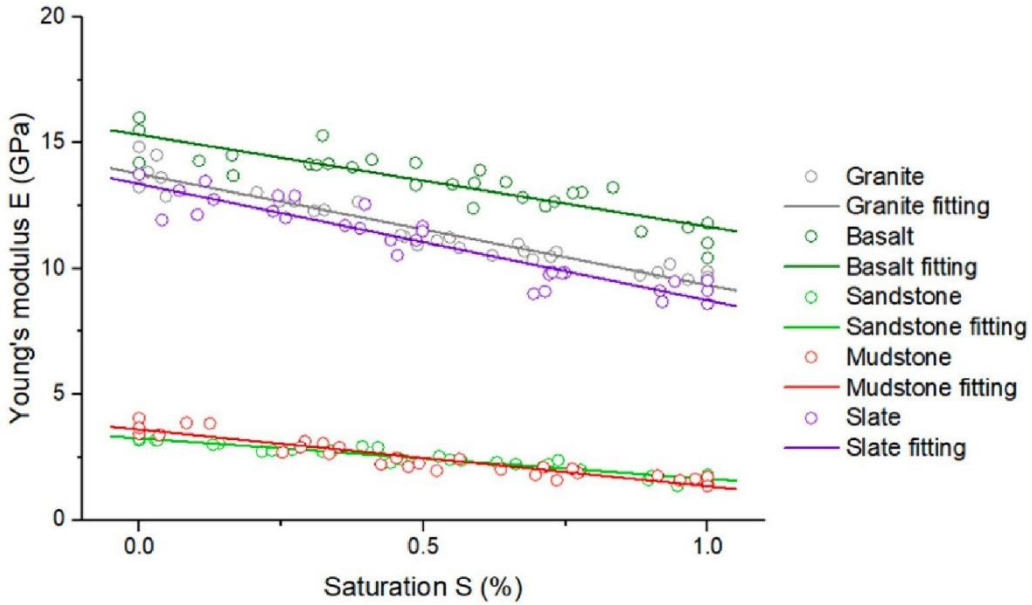


(b) Basalt

Pan et al.,
Computers and Geotechnics
Volume 128,
December 2020,
103806



(a) Uniaxial compressive strength



(b) Young's modulus

Thank you very much for your kind attention and time!

Question time