# Factor of Soil formation

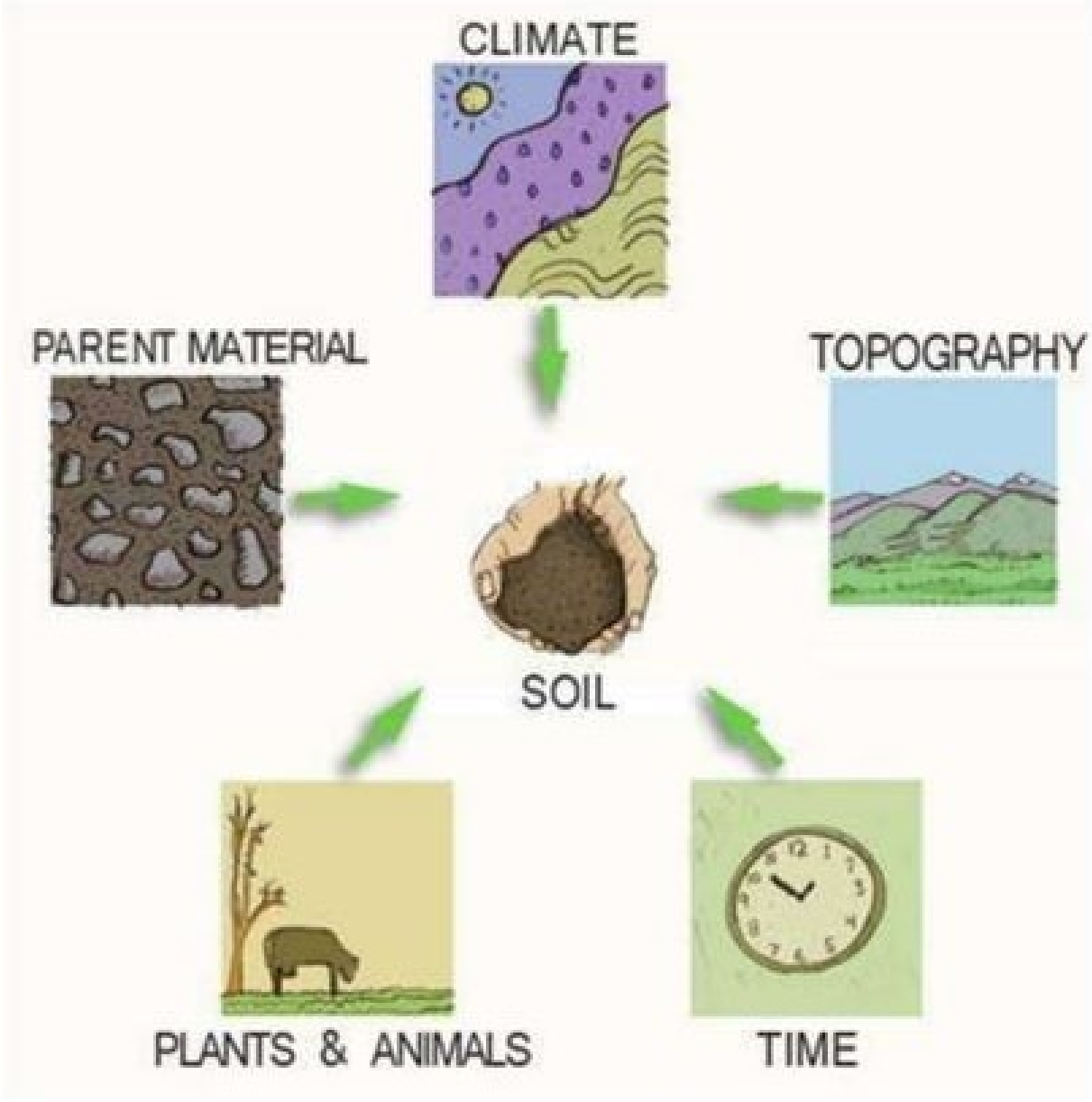
Presented by

BUDDHADEV SHIT

Department of Geography

Saltora Netaji centenary college

# Factors of soil formation



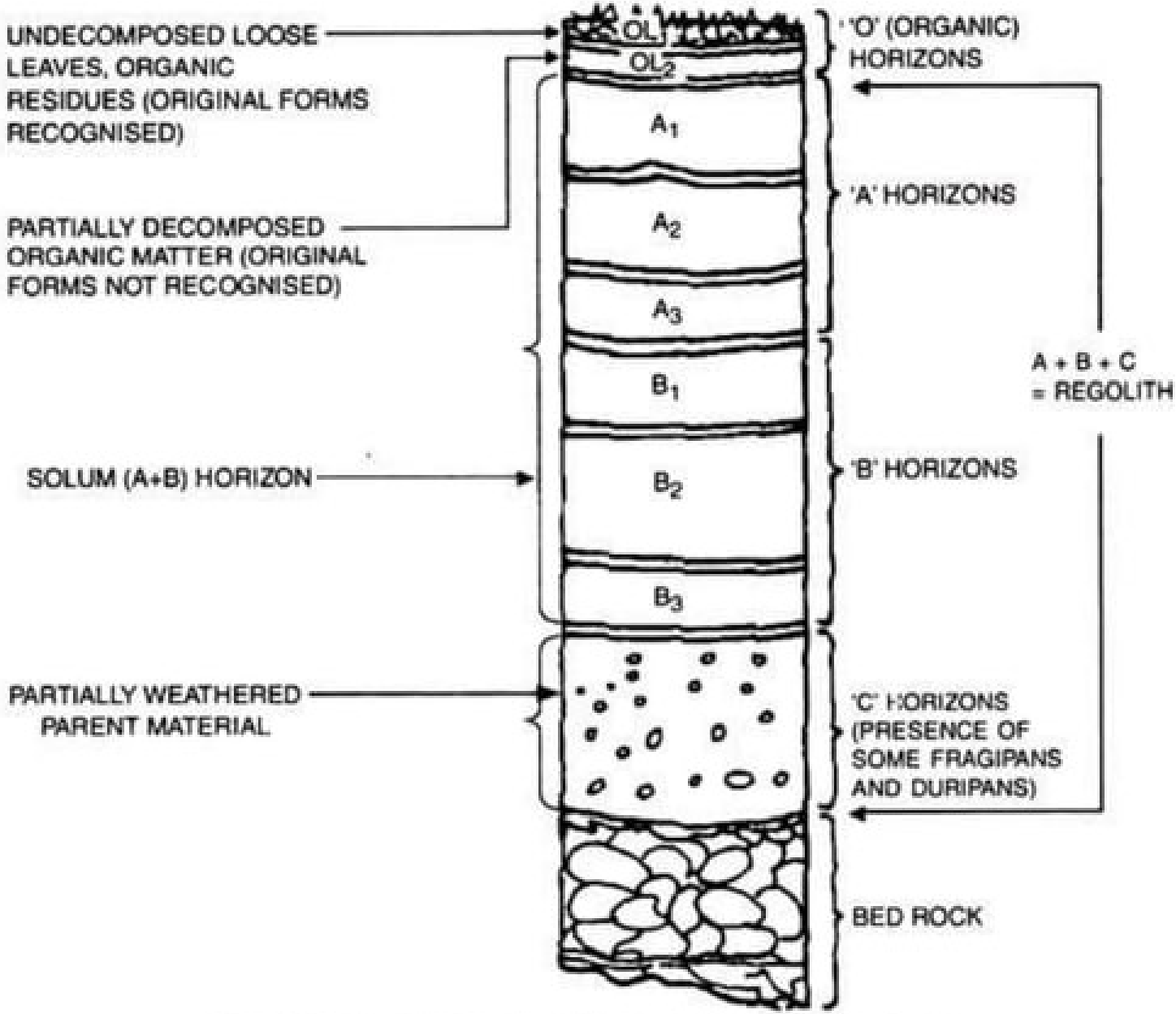



**Fig. 1.2.** Theoretical soil profile consisting of all horizons.

# Soil forming factors

- The evolution of true soil from the **regolith** (parent material) takes place by the combined action of **soil-forming factors and processes**.

- Dokuchaiev (1889), the father of soil science, was the first person to show that soils usually form a pattern in the landscape and established that they develop as a result of the interplay of soil-forming factors viz. parent material, climate and organisms and time which he put forward in the form of an equation:

  S = f (P, Cl. O)) formulated the following equation

- Jenny (1941) formulated the following equation.

  S=f (cl, o, r, p, t.....)

# Classifications of soil forming factors

## Active factors

1. Climate
2. Vegetation and organisms (biosphere)

## Passive factors

1. Parents material
2. Relief of topography
3. Time

# Climate

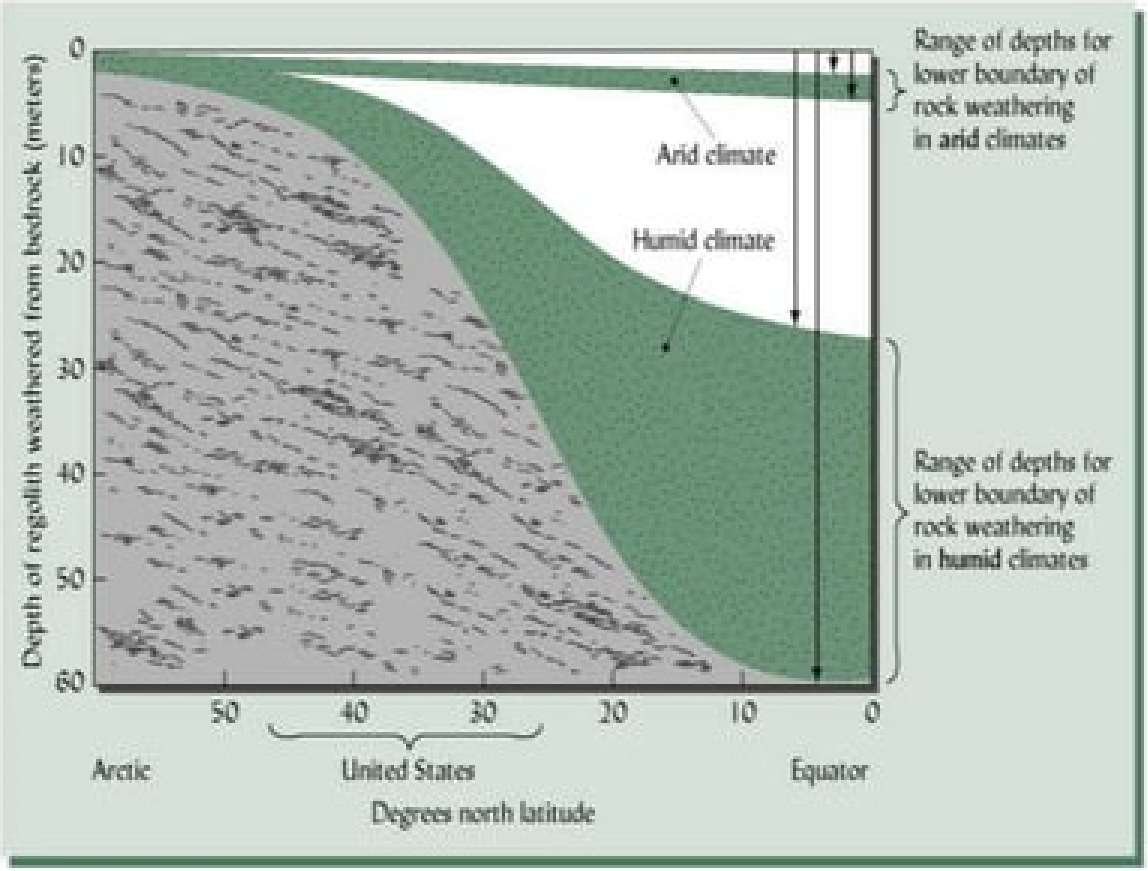
- Amongst all the soil forming factors, climate is perhaps the most influential in soil development.

- **Precipitation and temperature** are the two major climate elements which contribute most to soil formation. These elements are most significant in determining the **water-balance**. This approach is based on precipitation (water-supply) and evapotranspiration (water-need).

- When precipitation exceeds water-need, there is **surplus of water** for storage and leaching. On the other hand, when water-need exceeds water supply, there is a **deficit of water**. This will demand withdrawal of water from the store to meet the deficiency.

# Climatic regions based on precipitation

- ***Arid climate***: The precipitation here is far less than the water-need. Hence the soils remain dry for most of the time in a year.
- ***Humid climate***: The precipitation here is much more than the water-need. The excess water results in leaching of salts and bases, followed by translocation of clay colloids.
- ***Oceanic climate***: Moderate seasonal variation of rainfall and temperature
- ***Mediterranean climate***: The moderate precipitation, here is in winters and summers are dry and hot.
- ***Temperate climate***: Cold, humid conditions with warm summers.
- ***Tropical and Subtropical climate***: Warm to hot, humid with isothermal conditions in the tropical zone.




**Leaching and percolation** of water through the soil are the two outstanding processes in soil formation. The percolating waters translocate ions and micro-size particles from a place to another

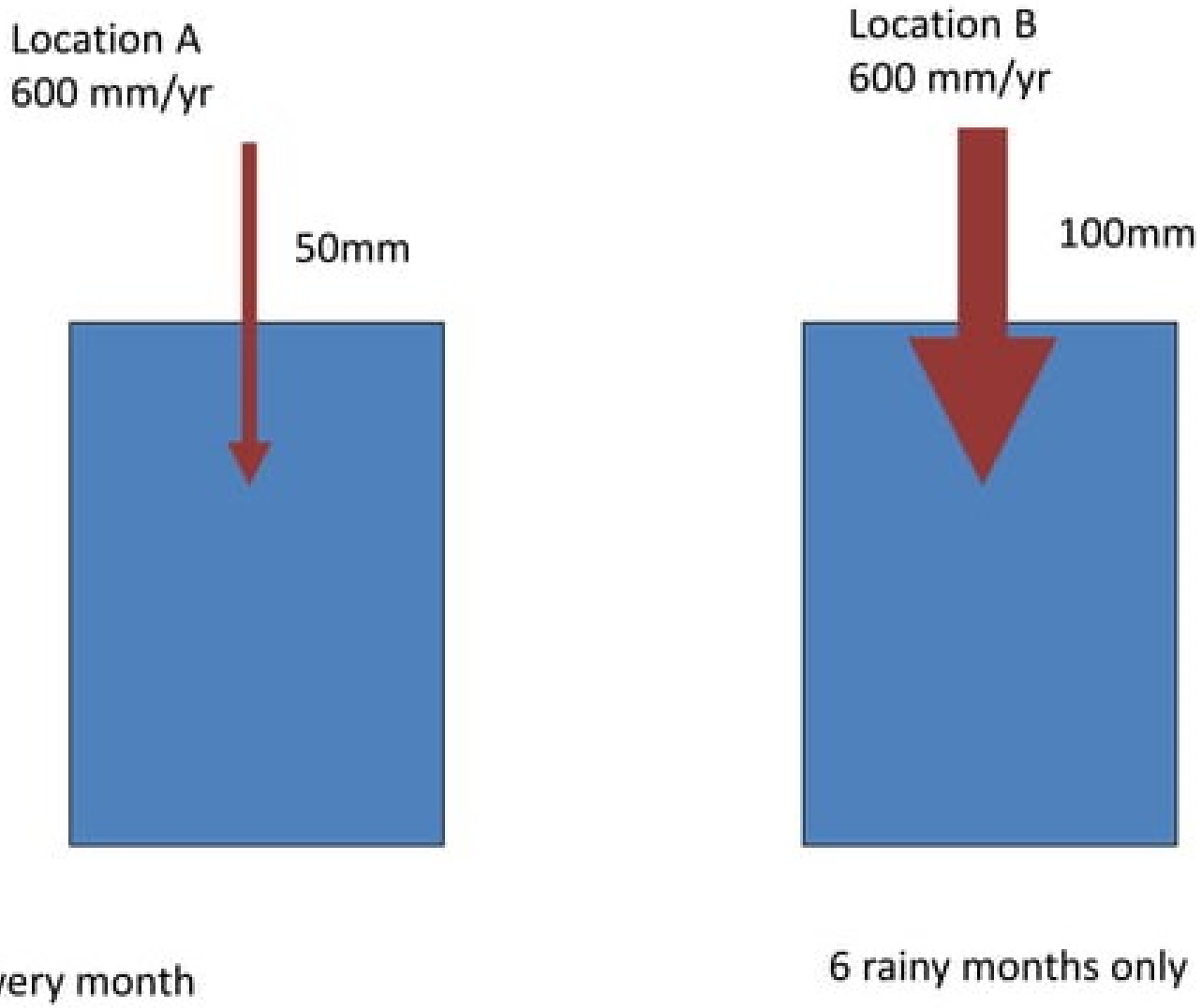
# *Effective* precipitation

a) Seasonal distribution
b) temperature, evaporation
c) topography
d) permeability

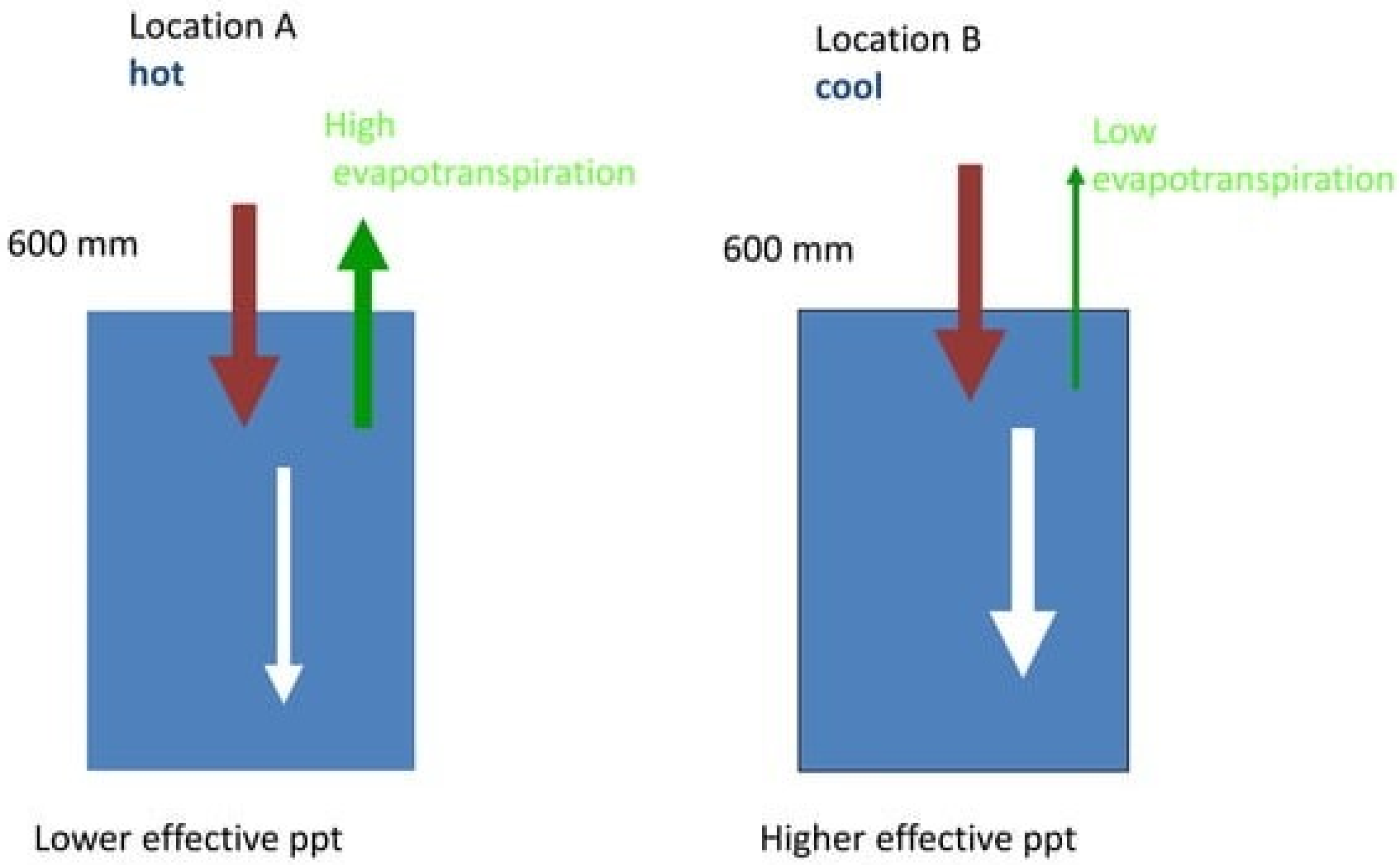
It is generally accepted that only **15-50 per cent of precipitation is available for percolation and rest is lost by way of surface runoff and evaporation**. The **percolation** is depends upon intensity of rain, texture of the mineral material, slope of land, temperature and vegetation. On steep slopes, precipitation affect profile development by causing erosion and prevent soil development, thus producing thin soil cover.

With increasing precipitation, there is more percolation and consequently more soil development and distinct horizonation with the development of gypsic and/or calcic horizon.

a) Seasonal distribution of precipitation:



b) Temperature and evaporation:



Topography:

level

slope

concave or
bottom of slope
(receiving)

# Temperature

- Temperature is the second important element of climate which influences soil formation. It is **high in the equatorial region and gradually declines towards the poles**. The amount of electromagnetic radiation reaching the surface of the earth is controlled by the number of factors such as cloudiness, dust particles, water vapours present in the atmosphere. Vegetation has a buffering effect on soil temperature and the snow cover reducing the loss of heat from the soil and on other hand reflects almost 90 per cent of the incoming radiations.

- It is estimated that only **about 0.1 per cent of the total energy reaching the earth's surface** is absorbed by plants and fixed in photosynthetic processes.

- The amount of radiation reaching the surface and soil temperature are determined largely by **daily (diurnal) and seasonal fluctuations**. The diurnal variation is more significant. During day, the heat moves downwards to the soil due to warming by incoming radiation and upwards during the night as the surface cools at night. These diurnal changes are maximum in desert areas and are mostly observed upto a limited depth of 30 cm.

- ***Aspect* and *latitude*** also influence soil temperature. The land surfaces receiving direct sun rays (at equator) are warmest and as the distance from the equator increases, the amount of radiation reaching the earth's surface decreases. As the latitude increases, the temperature decreases at the rate of about 1°C for each 175 m. The effect of temperature on soil formation rate can be related by Vant Hoff's (1884) law which states that "**for every 10°C rise in temperature the speed of chemical reactions increases by a factor of two or three**".

# Soil properties affected by soil temperature

- ***Depth of weathering***: In warm humid climate of the tropical regions, the rocks weather to much greater depth (30 or 40 cm) than in the cold temperate zone where the depth of solum may vary form a few cm to a metre or so.
- ***Nitrogen and organic matter contents***: Within uniform conditions and comparable vegetation, the amount of nitrogen and organic matter in the soil decreases as the annual temperature increases.

- ***Clay content***: They clay content of soils increases as the annual temperature and rainfall rise.
- ***Silica-sequioxide ratio***: At constant high moisture content, the $SiO_2$:$R_2O_3$ ratio decreases as the temperature increases.
- ***Soil colour***: In young soils, the colour is influenced by the parent material. With increasing stage of soil development, following increased temperature and rainfall, the soil tend to become more brownish/reddish rather than grayish / yellowish in colour.

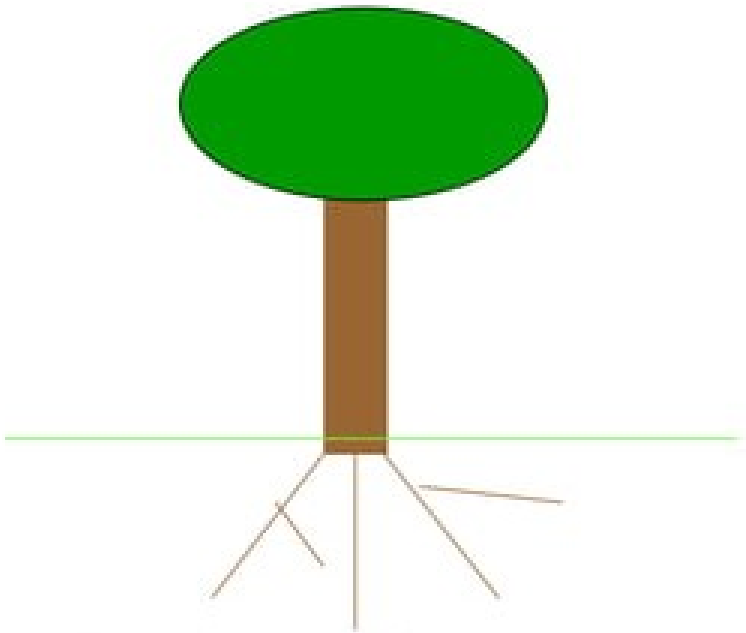
# Organisms - Vegetation

1. **Production and addition of organic matter**:. Different types of plant species produce varying amounts of organic matter and subsequently different type of leachates. The amounts of underground and above ground organic matter which is added to soils, is variable and is largely dependent on the **plant species and the environments**. The grasses with their fibrous root system decompose readily and favour the accumulation of organic matter up to 15 per cent in the rooting zone. The forest vegetation with woody tap roots, on the other hand, provide little organic matter at depth.

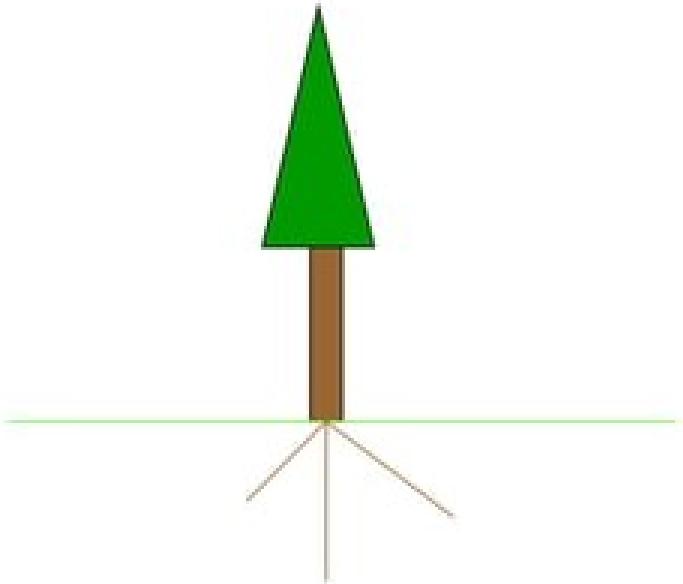
2. **Translocation and accumulation of mineral substances** is influenced by the type of vegetation and the prevailing environments. It is more under forests than under grassland vegetation because of the differing root system and environments. Since the coniferous trees are poor feeders of bases (Ca, Mg and K) these cations tend to leach down by the percolating water, rendering the soils acidic. Under such conditions, the rate of decomposition of organic matter do not thrive in acid environments, encouraging further tendency towards acidity. On the other hand, grassland vegetation, dominantly observed under comparatively low rainfall and neutral soil conditions, returns **high amounts of bases to the surfaces** and checks soils from becoming acidic.

# Base pumping

**Deciduous trees** are more effective base pumpers than **conifers**



-deciduous litter is easy to break down
-cations (bases) are released so surface soils are not acidic



-needles are hard to break down
-basic cations leach away: soil is acidic

3. **Plant composition and profile development**: Chemical composition of various plants exerts a profound influence on the type and speed of soil-forming processes. The pine-forst litter, having low bases and low ash content and whose leachates are acidic, tends to make the soils acidic. On the other hand, the organic matter of grass vegetation, rich in bases and ash content, and whose leachates are neutral, tends to develop neutral soils.

4. **Macro-organisms and Soil formation**: The macro-organisms which inhabit the soils are rodents, moles, millipeds, centipeds, snails, earthworms, termites etc. Owing to their burrowing habits, they burrow deep into the soil, causing considerable mixing of the materials of the lower layers with the upper layers, and even bring subsoil to the surface. Thus they interrupt the soil development and tend to retard horizon differentiation.

5. **Micro-organisms and Soil formation**: The various micro-organisms that inhabit the soil are

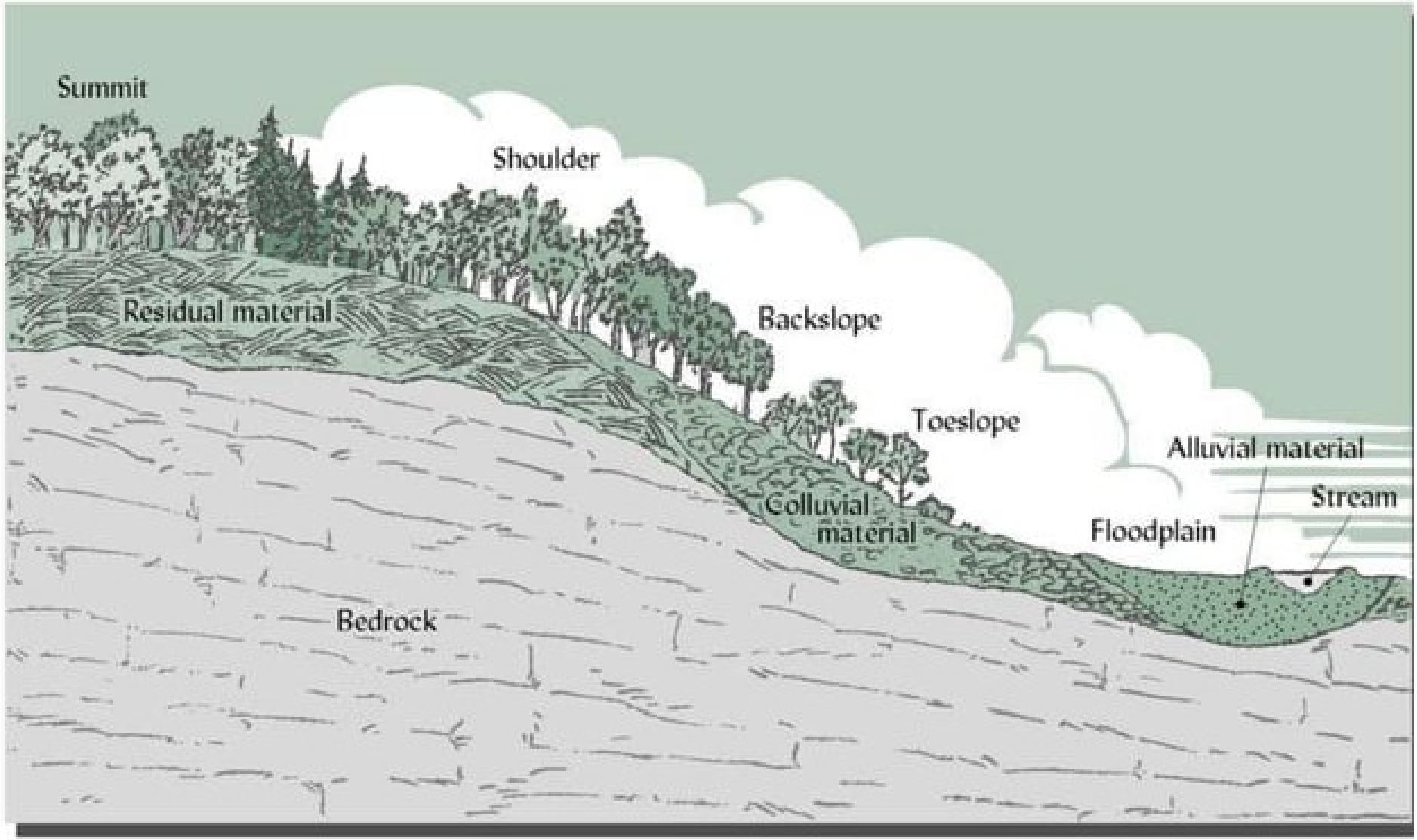
- Microflora : Bacteria, actinomycetes, fungi and algae
- Microfauna: Protozoa and nematodes
- Besides microfauna, the soil harbours a large number of worms and insects of different kinds and sizes.

6. **Man and soil formation**: Man is a destructive factor in soil formation. Man through exploitive land use, converts the areas under natural vegetation to agricultural land which, with time and under unprotective agriculture, get eroded. The agricultural practices, such as cultivation, puddling of fields, cropping systems, use of manures, fertilizers, amendments, drainage, irrigation and reclamation, alter the general characters of soil profile. The unjudicious use of irrigation water by man has rendered many fertile lands to unproductive saline lands.

# Topography / Relief

- They denote the configuration of the land surface. Relief may be described in terms of relative relief, drainage spacing, slope angle. The topography refers to the differences in elevation of the land surface on a broad scale. A relief or topography of a land may hasten or delay the action of climatic forces depending upon its features. The prominent types of topography designations, as given in FAO Guidelines (1990) are:

| Land surface | With slope of |
|---|---|
| Flat to almost flat | 0-2 % |
| Gently undulating | 2-5 % |
| Undulating | 5-10 % |
| Rolling | 10-15 % |
| Hilly | 15-30 % |
| Steeply dissected | 30 % with moderate range of elevation (< 300 m) |
| Mountainous | > 30 % with great range of elevation (> 300 m) |


Summit
Shoulder
Residual material
Backslope
Toeslope
Alluvial material
Stream
Colluvial material
Floodplain
Bedrock

| Slope classes | Symbol | % slope |
|---|---|---|
| Level to nearly level | A | 0-1 |
| Very gentle sloping | B | 1-3 |
| Gentle sloping | C | 3-8 |
| Moderately sloping | D | 8-15 |
| Moderately-steep sloping | E | 15-30 |
| Steeply sloping | F | 30-50 |
| Very steeply sloping | G | > 50 |

- The soils on steep slopes are generally shallow stony and have weakly-developed profiles with less distinct horizonation. It is due to:

- **accelerated erosion which removes surface material before it has the time to develop.**
- **Reduced percolation of water through soil because of surface runoff, and**
- **Lack of water for the growth of plants which are responsible for checking of erosion and promote soil formation.**

# Time

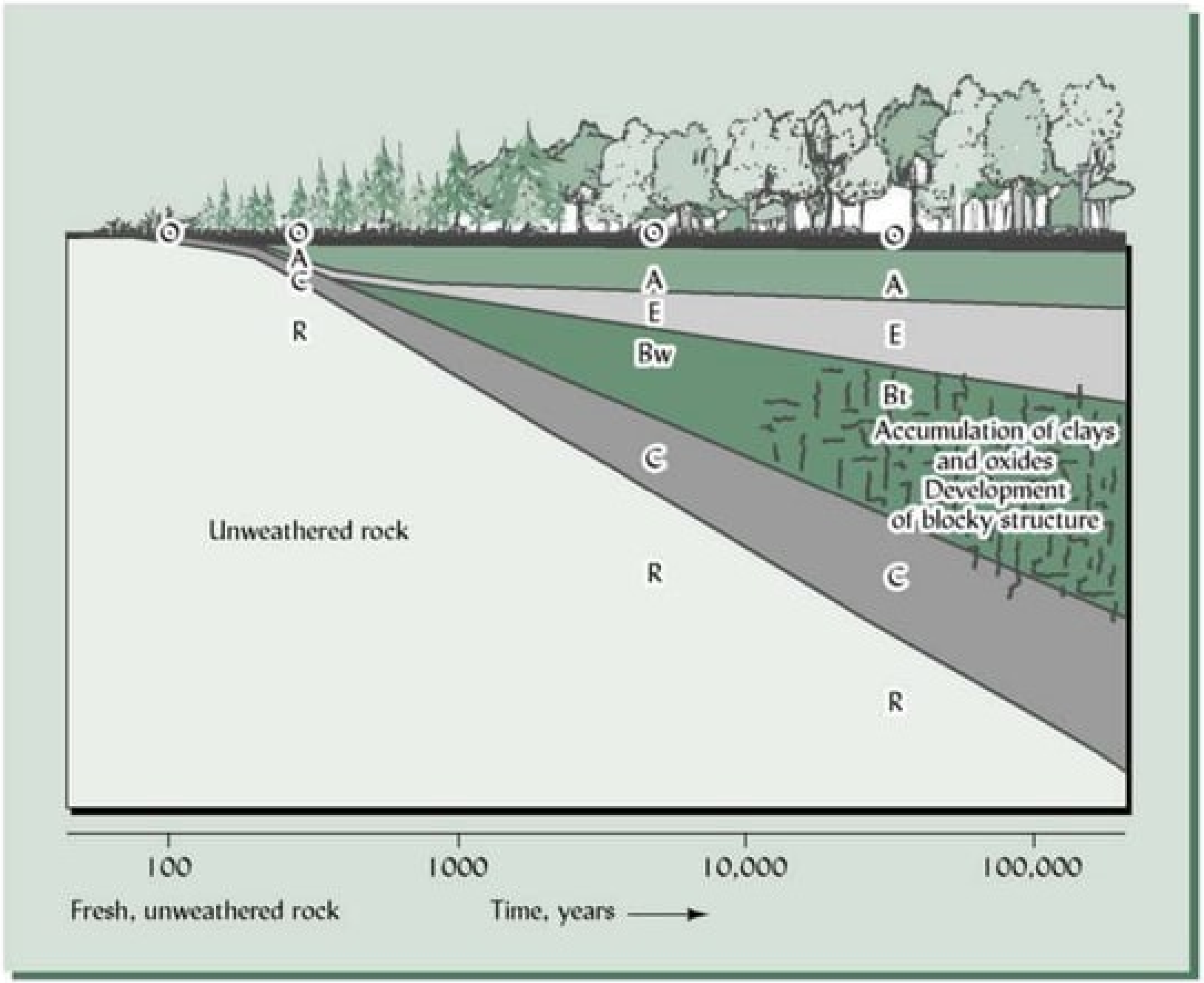
- Soil formation is a very slow process requiring thousands of years to develop a mature pedon. The time that nature devotes to the formation soils is termed as ***Pedologic Time***.

| Stage | Characteristic |
|---|---|
| Initial | Unweathered parent material |
| Juvenile | Weathering started; but much of the original material still unweathered |
| Virile | Easily weatherable minerals fairly decomposed; clay content increased; slowly weatherable minerals still sppreciable |
| Senile | Decomposition reaches at a final stage; only most resistant minerals survive |
| Final | Soil development completed under prevailing environments |

**The soil properties also change with time, for instance**

- **Nitrogen and organic matter** contents increase with time provided the soil temperature is not high (thermal, hyperthermal or megathermal)
- **$CaCO_3$** content may decrease or is even lost with time provided the climatic conditions are not arid.
- In humid regions, the $H^+$ concentration increases with time because of chemical weathering.
- The horizonation develops with time.
- Soil mature with time.

Time and degree of maturity are the factors used in many systems of soil classification, for instance classification of soils into Zonal, intrazonal and Azonal soils.


A
C
R
A
E
Bw
C
R
A
E
Bt
Accumulation of clays and oxides
Development of blocky structure
C
R
Unweathered rock
100
1000
10,000
100,000
Fresh, unweathered rock
Time, years

# Reference

Prof. A. Blasubramnian, Chemical properties of soil

www.slideshare.net

# THANKS