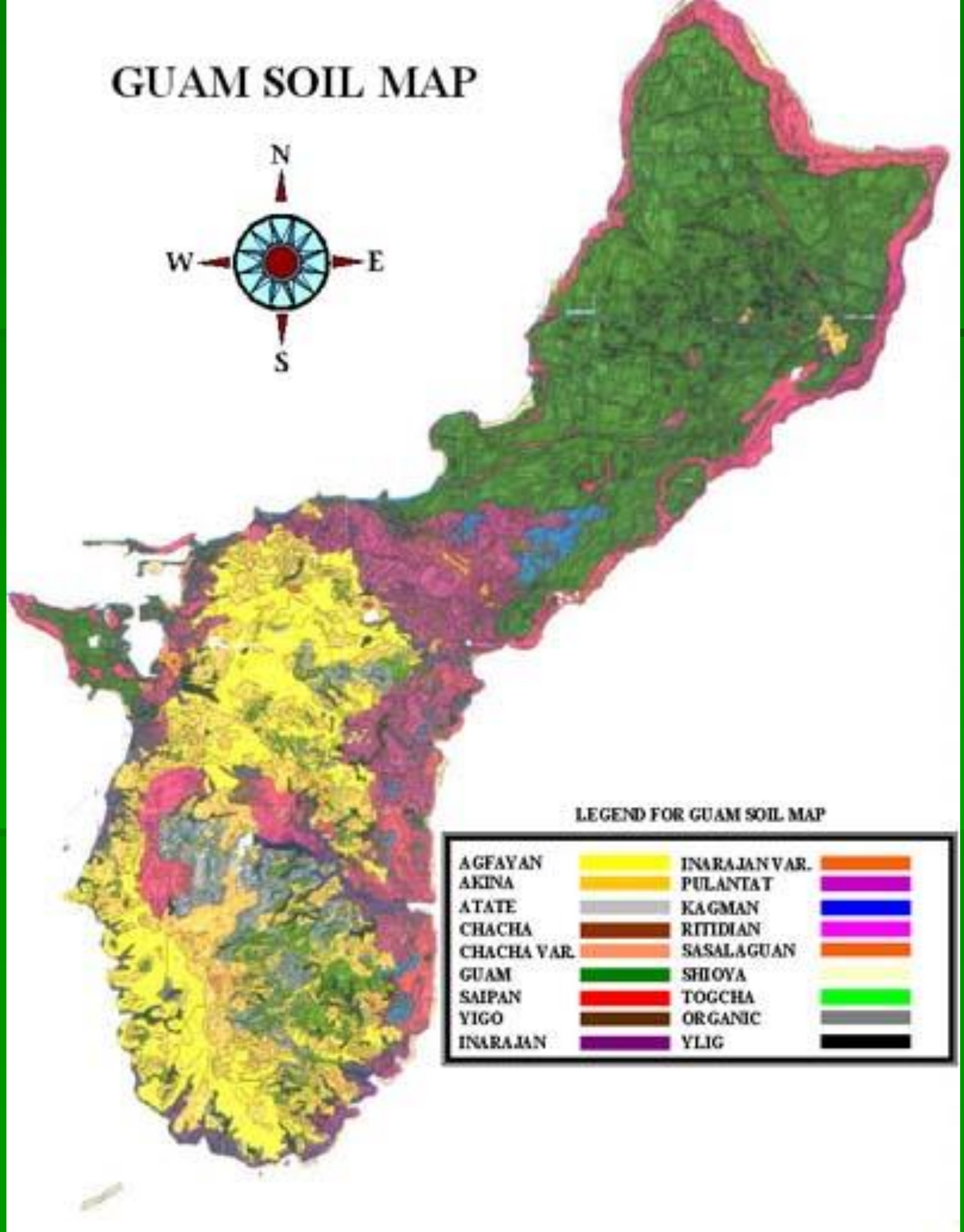
Soils of Guam

BI201 Natural History of Guam

Class Presentation 15

- What is soil?
  - Soil is a layer of weathered, unconsolidated material on top of bed rock
- Guam soils
  - Nineteen different soil series have been mapped in Guam [see *Soil Survey of the Territory of Guam*, U.S.D.A. 1988]


GUAM SOIL MAP
N
W
E
S
LEGEND FOR GUAM SOIL MAP
AGFAYAN
AKINA
ATATE
CHACHA
CHACHA VAR.
GUAM
SAIPAN
YIGO
INARAJAN
INARAJAN VAR.
PULANTAT
KAGMAN
RITIDIAN
SASALAGUAN
SHIOYA
TOGCHA
ORGANIC
YLIG

- These 19 soils can be grouped into three primary categories
  - soils over limestone (pure or argillaceous)
  - soils over volcanic uplands
  - soils on bottomlands and coastal margins

- **Soil formation**
  - There are five major factors that influence soil formation:
    1. Parent material
       - The type of bedrock (e.g., flow basalts vs tuffaceous rock vs limestone) contributes to the chemical composition of the soil
       - Soil chemistry and texture influence the type of vegetation that can grow in a given area
         - For example, silica bodies form ‘teeth’ on swordgrass
         - Therefore, swordgrass is distributed only on volcanic soils

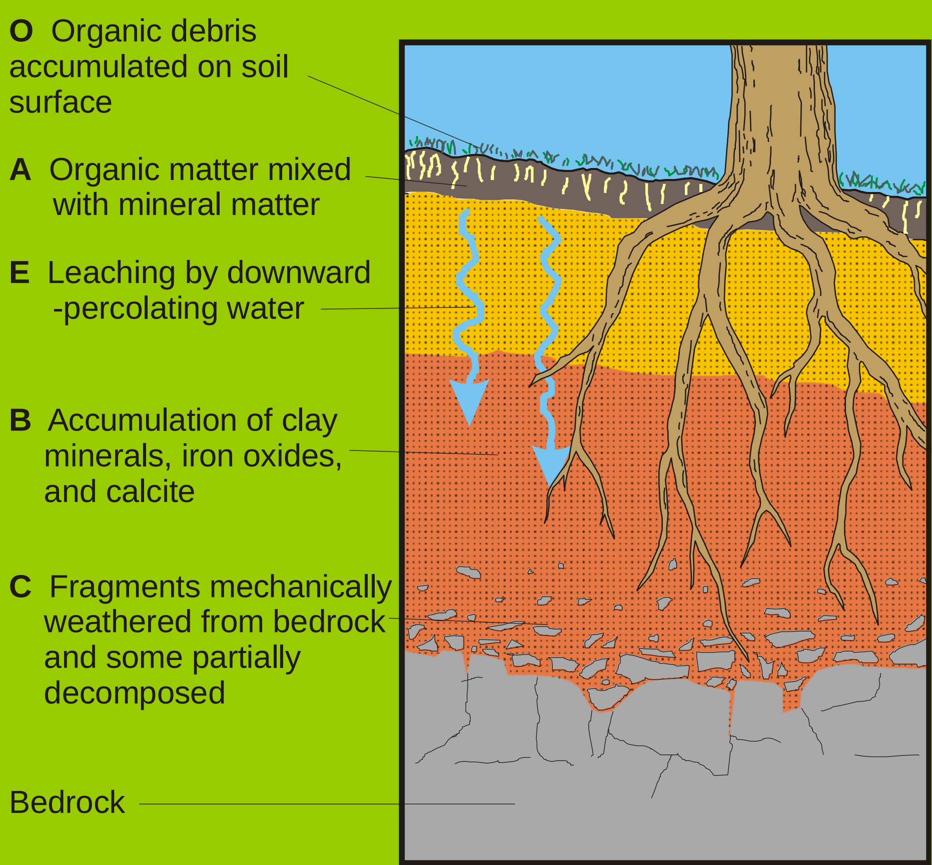
2. **Age**
   - The thickness and character of a soil change over time
3. **Climate**
   - Long-term averages of rainfall and temp affect the rate weathering of rock and the end products of weathering
4. **Topography**
   - The degree of inclination affects erosion on slopes and accumulation of sediments in depositional basins
     - Soils tend to be thicker on flat land and thinner on steep slopes, where gravity pulls soil particles downhill
   - Topography also affects water retention and drainage
5. **Vegetation**
   - Plant litter affects the organic content and pH of soil

- **Soil horizons**
  - As soils mature, distinct layering may become apparent
  - Layers of soil distinguishable by characteristic physical or chemical properties are called **soil horizons**

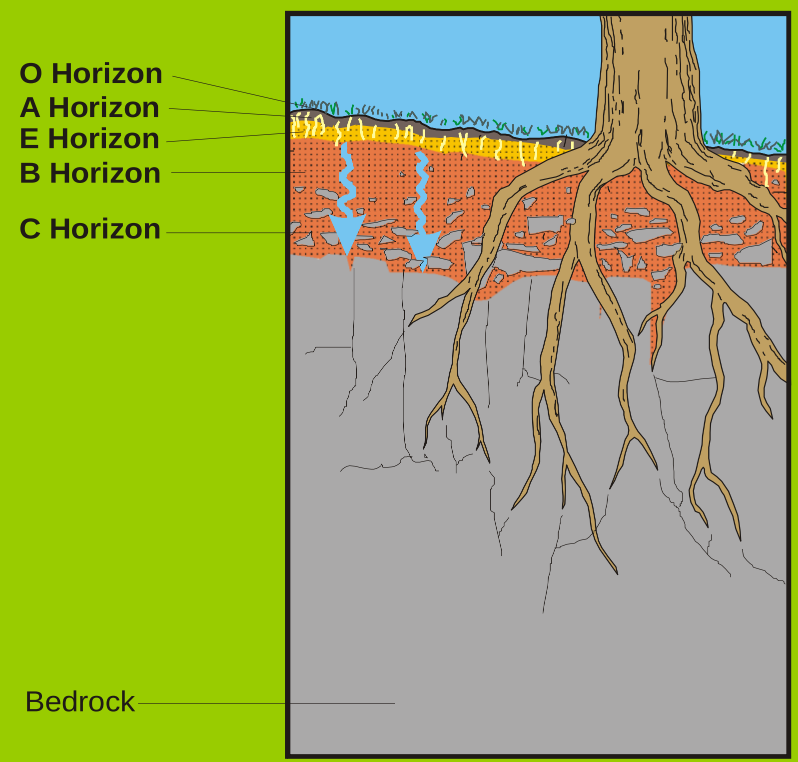
- **O horizon**
  - The O horizon refers to the accumulation of organic detritus on the surface of soil
- **A horizon**, or **zone of leaching**
  - The A horizon is the top layer of soil, and it is frequently referred to as topsoil
  - The A horizon is characterized by the downward movement (i.e., percolation) of water
  - Percolating water causes **leaching** [i.e., dissolution and transportation of soluble and insoluble minerals downward in soil]

- **B horizon**, or **zone of accumulation**
  - The B horizon is a soil layer characterized by the accumulation of material leached downward from overlying A horizon
  - This layer is often clayey in texture
- **C horizon**
  - The C horizon consists of loose, unconsolidated rock lying above bedrock
  - Therefore, the C horizon is a layer of incompletely weathered parent material lying between the B horizon and the parent rock

- **Bedrock**
  - Bedrock is the parent material of the overlying soil horizons
  - Bedrock is subjected to mechanical and chemical weathering from roots, plant acids, groundwater, etc.



Soil horizons (A, B, & C) that form in a humid, temperate climate.



Soil horizons (A, B, & C) that form in a humid, tropical climate.

- Boundaries between soil horizons are usually transitional rather than sharp
- Occasionally, an E horizon can be found below the A horizon
  - The E horizon is notable for its low organic matter, clay, and iron
- In tropical zones like Guam, soil horizons are not well developed
  - When present, soil horizons on Guam tend to be compressed upward
  - The A horizon is poorly developed if it occurs at all
  - The B horizon is a zone of hydrated aluminum and iron oxides forming clays in Guam

- **Classification of soils**
  - Soil scientists have developed a universal classification of soils in which soils are sorted into various soil orders
  - This field of study is called **soil taxonomy**
  - All soils, therefore, can be classified into one of twelve orders based on their chemical and physical properties [http://soils.usda.gov/technical/soil_orders/]

- **Soil orders**
  - **vertisol** [from L. *verto* = under turn]
    - When wet, vertisol swells; when dry, it cracks
    - By definition, a vertisol contains >30% swelling soils by weight
    - In alternating wet and dry seasons, swelling and shrinking churns the vertisol because the surface material falls into cracks during the dry season
    - Hence, the name comes from self-in<u>vert</u>ing nature of this soil

- **oxisol**
  - An oxisol is an oxide soil
  - Oxisols are well aged and have good structure
    - They do not shrink and swell
  - An oxisol is characterized by high clay content and relatively low fertility
- **andisol** [from Japanese *ando*, common black soil from Mt. Fuji in Japan]
  - The parent material of anisols is tephra

- **mollisol** [from L. *mollis* = soft]
  - Mollisols are prairie soils
  - Mollisols comprise the greatest agricultural soils in world
    - They are characterized by high fertility, and they must contain at least 1% organic matter by weight
  - Mollisols are well developed in Iowa, Indiana, Nebraska, and Argentina, the so-called ‘breadbasket’ areas of the world

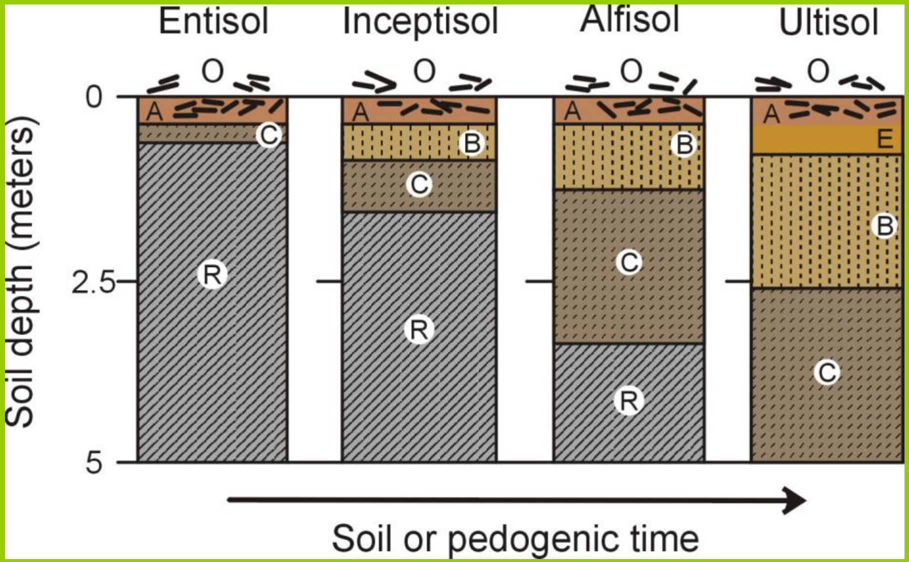
- **aridisol** [from L. *aridus* = dry]
  - Arisols are found in arid environments
  - An arisol has very little organic matter
- **entisol** [from rec<u>ent</u>]
  - Entisols are alluvial soils of river floodplains, deltas, or bases of steep slopes
  - Entisols are embryonic soils that have no horizons

- **spodosol** [from Gr. *spodos* = ashy, gray]
  - Spodosol is found primarily in pine forests of Germany
- **histosol** [from Gr. *histos* = tissue]
  - Histosols are found in swampy areas
  - They usually required anoxic conditions for organic accumulation
  - Therefore, these are mostly organic soils

- **ultisol** [from L. *ultra* = on the other side, beyond]
  - Ultisols are best known for their clayey B Horizons, which are acidic and low in fertility
  - They are red in color from FeO_x compounds
  - Ultisols are one of the most common soils of the tropics
  - They are the world's most highly weathered soils

- **inceptisol** [from L. *incipere* = begin]
  - Inceptisols are soils having one or more soil horizons in which mineral materials have been weathered or removed
  - Therefore, these are soils in early stages of forming visible horizons
- **alfisol**
  - An alfisol is a soil having clay-enriched or argillaceous B horizon
  - Alfisols are usually alkaline to neutral in pH
  - Alfisols are normally derived from alkaline parent minerals

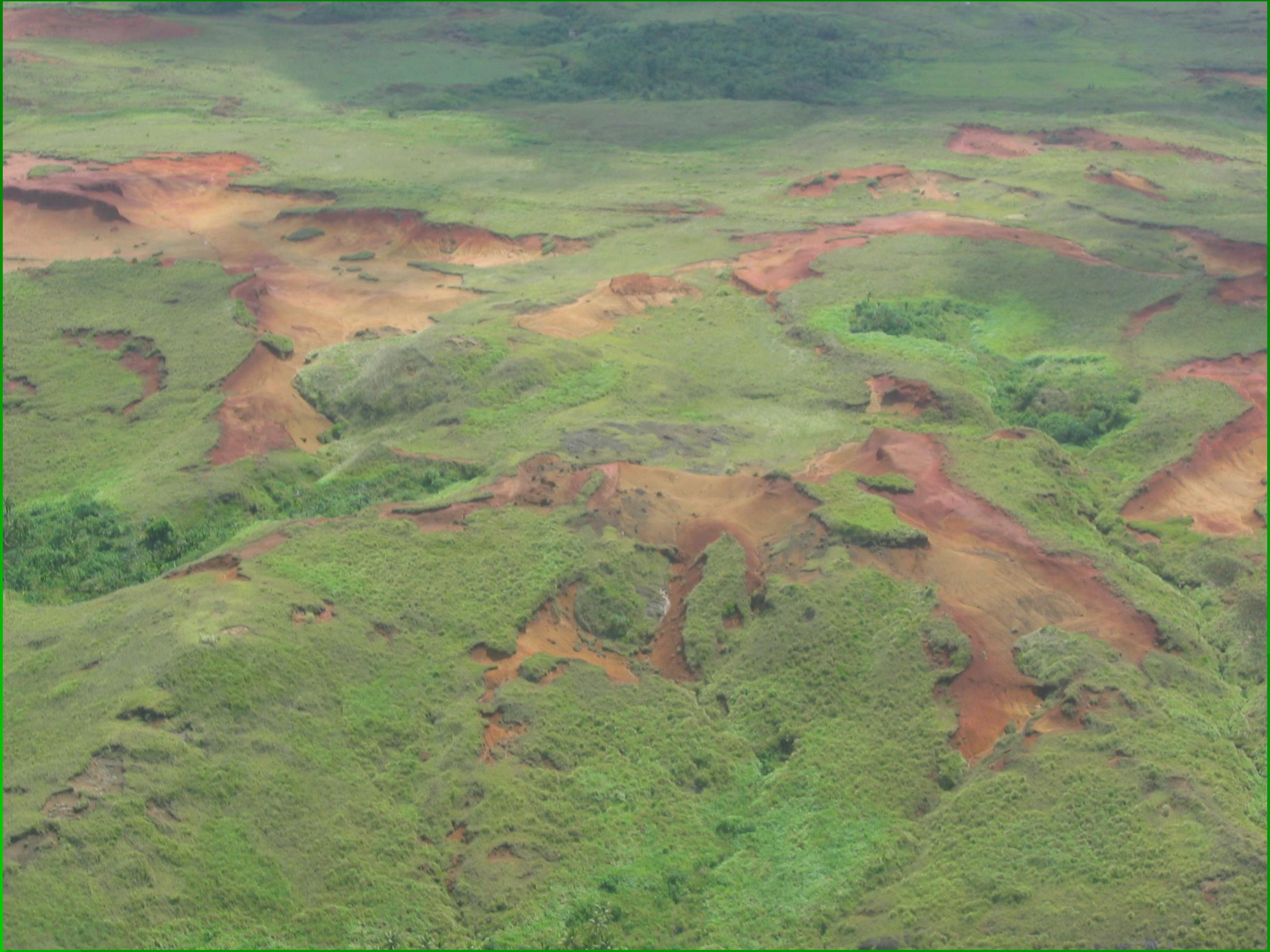
- These soils may undergo changes from one soil order to another during their developmental sequence as a result of aging or changes in their environmental conditions



Some common soil orders and soil horizons that result from the ecosystem process called soil genesis. The illustrated soils from left to right constitute a general age sequence of soil development. Soil horizons such as the O, A, E, B, and C horizons and the underlying unweathered rock (R) are shown. The soil development sequence illustrates the gradual formation of the B and C horizons and the deepening of the soil profile through time. When organic matter initially accumulates in O and A horizons, an Entisol is formed, and soil formation is initiated. Entisols exhibit a simple soil profile with A and C horizons. Once a B horizon develops, the soil is classified as an Inceptisol. Both Entisols and Inceptisols are often youthful soils, not strongly weathered. Alfisols form following more intensive weathering and as clays accumulate within the B horizons. Generally, Alfisols are not strongly acidified and are often nutrient-rich. The products of Alfisol acdificiation are often Ultisols. Like Alfisols, Ultisols have high clay contents in the B horizons, but in Ultisols these clayey B horizons are strongly acidic and are highly weathered. (Adapted from Richter and Markewitz, 1995. BioScience 45(9):600-609).

- **Laterites**
  - Guam lies in the global belt of tropical soils, where primary soil-forming processes are **lateritic**
  - Lateritic soil forming processes:
    - high humidity
    - high rainfall
    - high temperature
  - *laterite* [from Lat. for ‘brick red’ soil] = highly leached tropical soil, usually red in color and composed almost entirely of hydrated oxides of iron and aluminum, which are the least soluble products of rock weathering in tropical climates

- If a soil is rich in hematite, it can be mined as iron ore
  - However, tropical rainfall usually hydrates the hematite to limonite, which is seldom rich enough to mine
- Therefore, laterites are relatively non-productive soils
  - It may seem strange in consideration of the lush jungle growth that exists on lateritic soils in many tropical areas
  - However, the jungle growth is supported by tightly closed mineral cycling in the layer of humus on top of the soil
  - If the jungle and humus layer are removed, the laterite quickly becomes incapable of sustaining plant growth (e.g., south of Agat)
  - Laterite exposed to the sun tends to bake into a permanent, brick-like layer



- **Some soils of Guam**
  - Complete descriptions of Guam soils can be found at http://www.uog.edu/cals/site/users/soil/soil/index.html

  - **Guam clay**
    - Guam clay is soil developed on pure limestone
      - It is very thin soil, usually < 12“ deep, stony, and highly permeable

- Guam clay is usually dark red in color, and low in silica
- It is somewhat sticky when wet, and rather granular when dry (i.e, friable)
- Its pH is alkaline, i.e, > 7.0, so its called ‘sweet’ soil by farmers
- Guam clay is generally best developed in flat terrain

- **Chacha clay**
  - Chacha clay is soil developed on argillaceous limestone
  - This limestone soil has better development of soil horizons than Guam clay
  - Its color is yellowish brown, and its texture is firm to plastic
  - Its thickness ranges from several feet to >50 ft, and its permeability is slow where thickly developed
  - The pH of chacha clay is variable, from slightly acidic to slightly alkaline

- **Agfayan clay**
  - Agfayan clay is soil developed on tuffaceous rock
  - It usually develops on steep-sloping volcanic rock
  - The color of Agfayan clay varies from gray to brown to olive green to mottled
  - The thickness of Agfayan
  - clay ranges from 0–50 ft
  - Its pH is moderately acidic

- **Atate clay**
  - Atate clay is a soil developed on tuffaceous rock
  - It usually develops on gently-sloping ridge tops and swales
  - Its color is deep red, and its texture is granular
  - The pH of Atate clay is acidic, down to 4.0
  - Its thickness ranges from 0 – 100 ft, depending on the amount of erosion