
## Introduction

- Aggregate is defined as processed soil.
- 60-70% of Concrete Volume
- 80-90% of Asphalt Volume

## Soil

*** The term Soil has various meanings depending upon the general field in which it is being considered.**

***To a Pedologist (agricultural soil scientist)... Soil is the substance existing on the earth's surface, which grows and develops crops (plant life).**

***To a Geologist ..... Soil is the material like disintegrated rock in the thin surface zone on the earth crust, and all the rest of the earth's crust is termed ROCK irrespective of its hardness.**

## Soil

***To an Engineer ....**

Soil is the un-cemented deposits of mineral and/or organic particles or fragments covering large portion of the earth's crust.

Soil is also defined as "sedimentation and other accumulations of solid particles produced by mechanical and chemical disintegration of rocks" in USA.

In BS "Any naturally occurring loose or soft deposit resulting from weathering or breakdown of rock formation or from decay of vegetation".

## Soil Materials

- **Soil material is the product of ROCK**
- **The geological process that produces soil is called WEATHERING**
- **Variation in Particle size and shape depends on:**
  - ***Weathering & Transportation Process***

*** Transportation and Deposition**

**Four forces that cause the transportation and deposition of soils :**

**1- Water ------- Alluvial Soil**
**2- Ice ---------- Glacial Soils**
**3- Wind -------- Aeolin Soils**
**4- Gravity ----- Colluvial Soil**

## The Rock & Rock Cycle

- A ***rock*** is any solid mass of mineral or mineral-like matter that occurs naturally as part of our planet.
- Most rocks occur as solid mixtures of minerals.
  - Some rocks are composed of only one mineral.
- A characteristic of rock is that each component mineral retains their properties in the mixture.
  - Example: Granite
- Some rocks are composed of nonmineral matter.
  - Example: Coal (organic material)
- Volcanic rocks do not have a crystalline structure.
  - Examples: Obsidian and Pumice

## Rock Classification

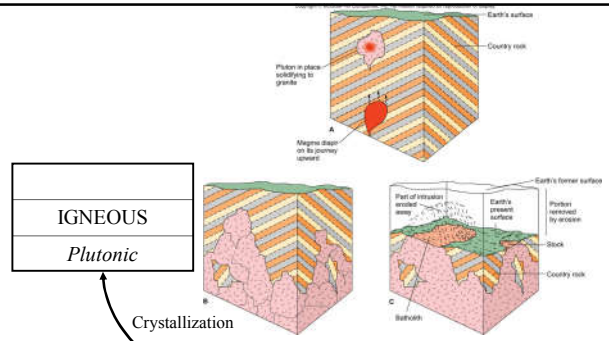
- Rocks are classified into three groups based on how they were formed.
- **Igneous**- form when magma or lava cools; can occur ***in or on*** the earth's crust
  - Magma-melted rock *in* the Earth's surface
  - Lava-melted rock that flows *on* the Earth's surface
- **Sedimentary**-the deposition of broken down minerals, rocks, or organic matter that is hardened, cemented or compressed into rock
  - Sediment-broken down minerals, rocks or organic material
- **Metamorphic**- rocks (igneous or sedimentary) that are changed by heat and/or pressure and/or chemical processes; rocks that are chemically different from their parent material

MAGMA

IGNEOUS

Crystallization

MAGMA

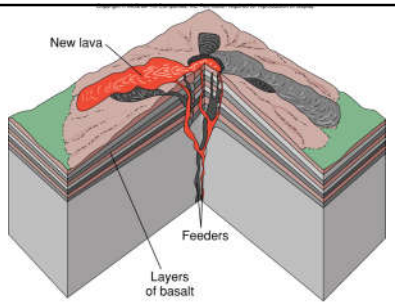



IGNEOUS

*Plutonic*

Crystallization

MAGMA




*Volcanic*

IGNEOUS

*Plutonic*

Crystallization

MAGMA

Weathering

*Volcanic*

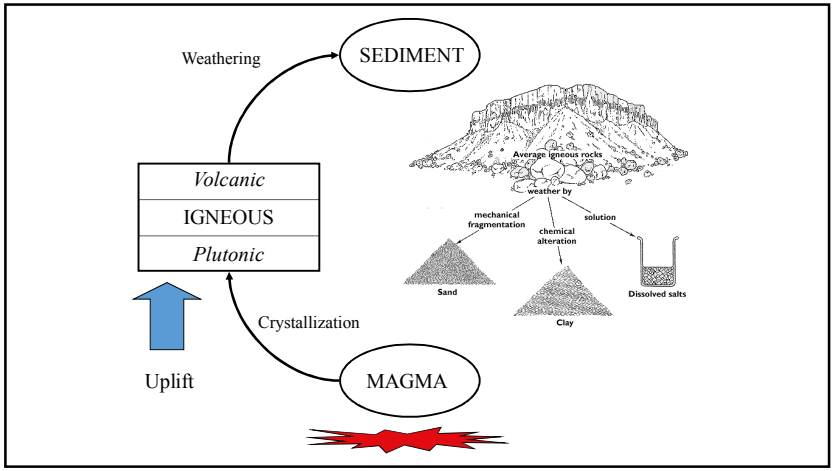
IGNEOUS

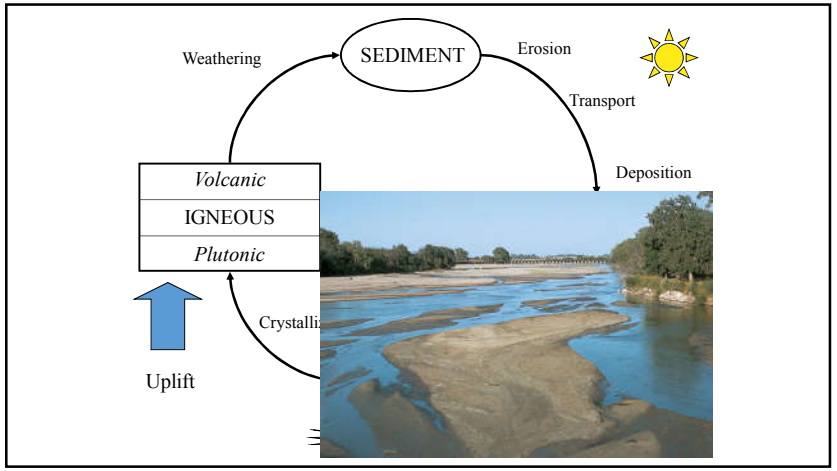
*Plutonic*

Uplift

Crystallization

MAGMA


Weathering
SEDIMENT
Volcanic
IGNEOUS
Plutonic
Average igneous rocks
weather by
mechanical fragmentation
chemical alteration
solution
Sand
Clay
Dissolved salts
Crystallization
Uplift
MAGMA


Weathering
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Erosion
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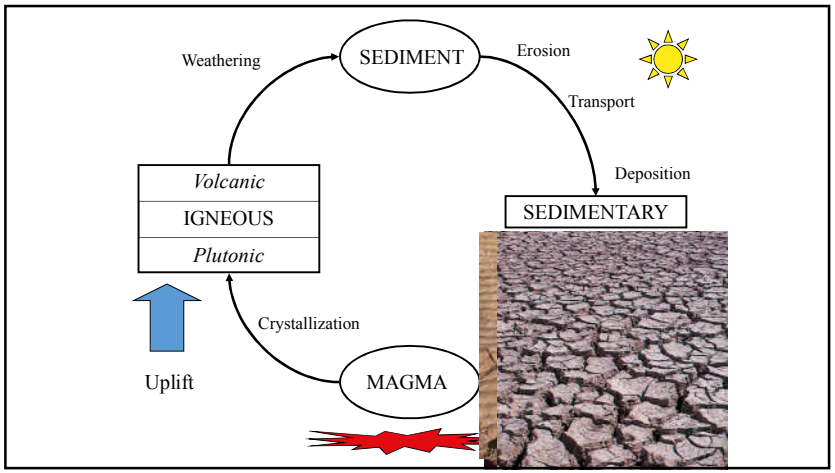
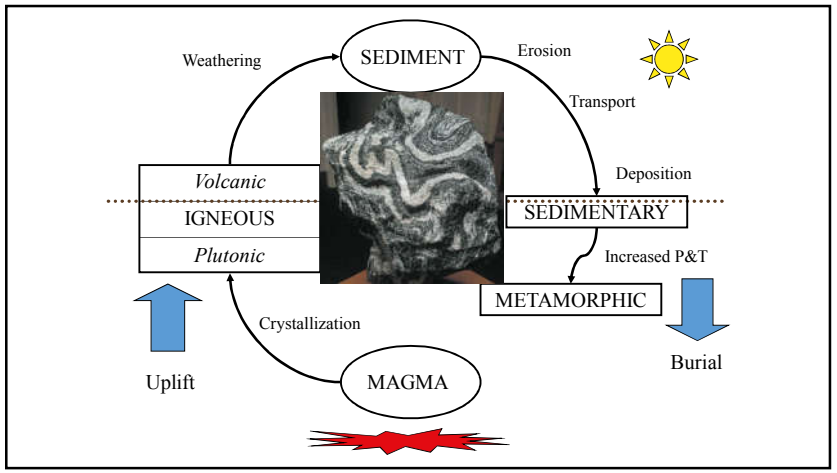

Weathering
SEDIMENT
Erosion
Transport
Deposition
Volcanic
IGNEOUS
Plutonic
SEDIMENTARY
Crystallization
Uplift
MAGMA


Weathering
SEDIMENT
Erosion
Transport
Deposition
Volcanic
IGNEOUS
Plutonic
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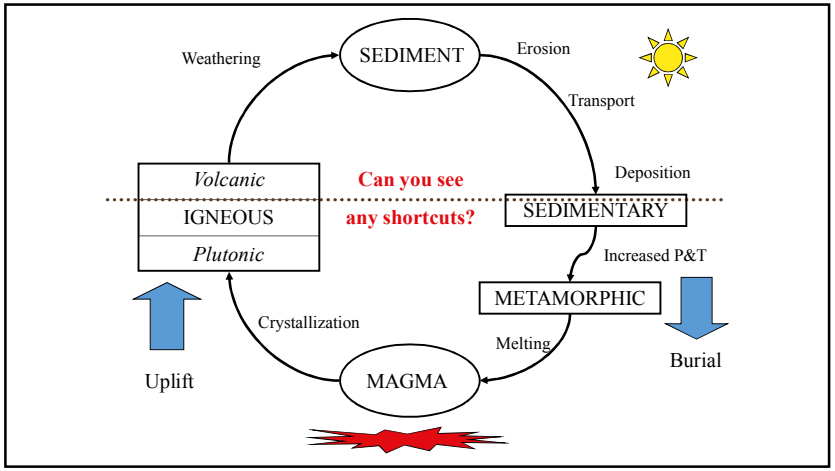
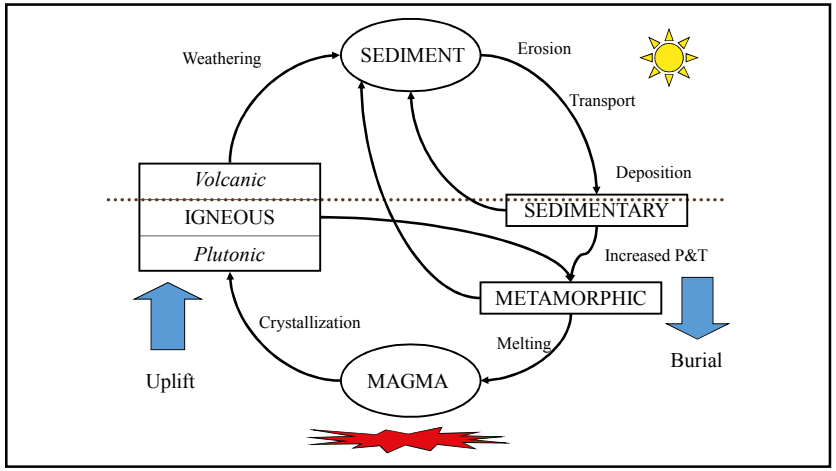
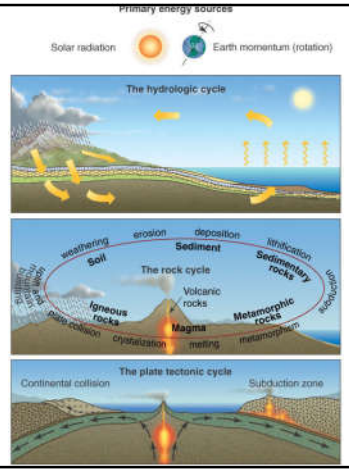
Increased P&T
METAMORPHIC
Burial
Crystallization
Uplift
MAGMA




*In Conclusion…*

- The rock cycle demonstrates the relationships among the three major rock groups
- It is powered by the interior heat of the Earth
- As well as earth's momentum and…
- The energy from the sun
- It involves processes on the Earth's surface as well as the Earth's interior
- It connects the "hydrologic cycle" with the "tectonic cycle".

## WEATHERING AND EROSION (Denudation)

- <u>Weathering</u>
  - All the processes that physically disrupt or chemically decompose a rock at or near the Earth's surface
- <u>Erosion</u>
  - Removal of weathered material from its place of origin
  - Agents are river , moving ice, wind and waves

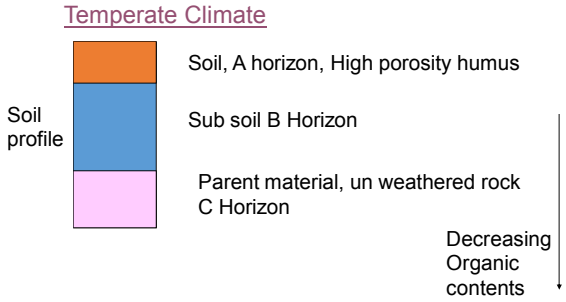
## Weathering

- Chemical Weathering
  - Decomposition of rocks and minerals via *chemical reactions* at the Earth's surface
  - Chemical agents: acids in rain air and rivers etc
  - More effect in soluble rocks
- Mechanical Weathering
  - disintegration/ disaggregation of rocks via *mechanical* processes
  - Temperature, abrasion in wind, rain drops
- Biological Weathering
  - Mechanical and chemical changes directly associated with animals and plants.
  - Plant roots, burrowing animals, root gases increasing acidity

## Chemical Weathering

- Some Processes
  - Solution. $CO_2$ in soil profile making carbonic acid $H_2CO_3$ with percolating rain water.
  - Oxidation. Oxygen with mineral forms oxides
  - Reduction. Oxygen leaves mineral
  - Hydration. Absorption of water, expands clays, hastens the above processes

Chemical Weathering



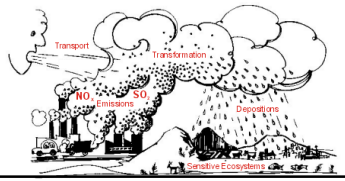
## Chemical Weathering

Features of Karst: Caves

Sinkholes

## Chemical Weathering

- Living Organisms
  - Lichens that grow on rocks produce weak acids that chemically weather rock
- Acid Rain
  - Compounds from burning coal, oil and gas react chemically with water forming acids.
  - Acid rain causes very rapid chemical weathering




## Chemical Weathering

## Mechanical Weathering

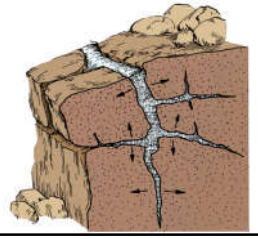
- Mechanical Unloading. Vertical expansion, erosion reduces load opening fractures
- Mechanical Loading. Impact and abrasion of wind borne particles in deserts and effect of intense rain drops
- Thermal Loading. Expansion of freezing water, high and low temperatures
- Wetting and drawing. Repeated loss & abrasion of water in certain clays
- Crystallization. Formation of crystals in fissures and pores, originally in solution
- Pneumatic Loading. Waves effect on trapped air in cliffs.

## Mechanical Weathering

- Unloading
  - Seen in granite intrusions
  - Joints parallel to ground open up forming ‘sheets’, 1m
  - Spallings, small platy fragments fall of
  - Many open up during quarrying with sound onces relieved of stresses


## Mechanical Weathering

- Frost Action
  - Freezing process increases volume in pores
  - Ice Wedging. Repeated freezing breaks of flakes & angular fragments (Screes)
  - Screes to Breccia deposits

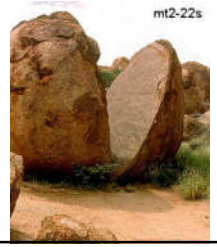



## Mechanical Weathering

- Frost Heaving
  - In areas including permafrost areas
  - Ice lenses formed at shallow depth. Up to 30 mm. Combined effect heaves up
  - Engineering problem, Water pipes above surface, higher plinth or air circulation to reduce heating effect

## Mechanical Weathering

- Insolation
  - Temperature variation in hot climate, flakes of outer layer of rocks split off
  - Process is exfoliation
  - Cracks may form, salts and water cause decomposition and increase weathering called insolation

## Biological Weathering

- Rock surface kept damp by plants, increase in solvent action.
- Vegetable Humus, aided by bacteria and fungi aerobic, organic acids are added
- Bacteria in aerobic mineral pore spaces, expanding byproducts
- Mechanical breakup of rocks hastened by wedging apart by roots.

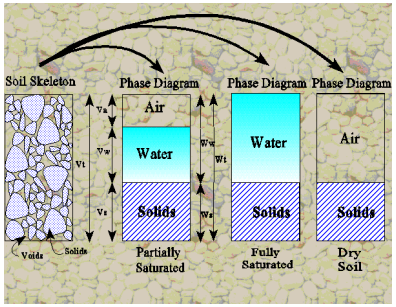
## Soil Component Types

- **- Boulders**
- **- Gravel**
- **- Sand**
- **- Silt**
- **- Clay**
- **-Organics**
  - Granular (coarse grained, over 5 mm sand and gravel), Fine grained (silt and clay) and organic.
  - Silts and clays differentiated – plasticity- shine- grittiness- dry strength – shaking of wet sample

## Soil Phases: Moisture Condition

- **Dry**
- **Saturated**
  - **Fully Saturated**
  - **Partially Saturated**
- **Submerged**

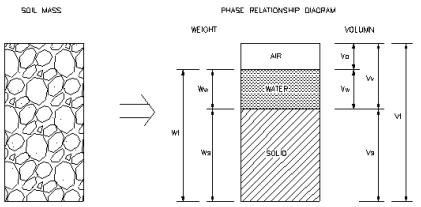
## Graphical Representation of Soil Phases:



- Soils are made of a combination of dissimilar materials – solids, liquid, gas
- Strength & behavior is a function of the interaction the components!
- How MUCH of each component matters.

## The Phase Diagram

- Solid
- Water
- Air




- If we determine the proportions of the components, we can calculate MANY other properties of the soil!

## Basic Relationships for Calculating Phase Diagram Components

- **Weight --Wt = Ww + Ws**
- **Volume --Vt = Vv + Vs = Va + Vw + Vs**
- **Unit Weight (Density)**

$$\gamma_{soil} = \frac{Total\ Weight}{Total\ Volume} = \frac{W_t}{V_t}$$

- **This is also known as (same thing by different names)**
  - **Bulk Density**
  - **Soil Density**
  - **Unit Weight**
  - **Wet Density**

## Properties We Can Calculate ONCE WE KNOW Volume & Mass of Components:

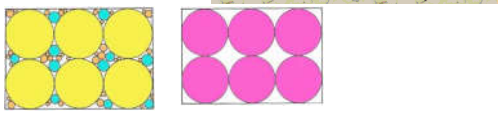
$$Degree\ of\ Saturation = S_r = \frac{Volume\ of\ Water}{Volume\ of\ Voids} = \frac{V_w}{V_v}$$

- The degree of saturation can range between zero for a completely dry soil, and 1 for a fully saturated soil.
- Degree of Saturation effects:
  - strength of soil
  - compressibility
  - flow & transport of fluids in soil

## Soil Porosity

- Amount of void space between soil particles.
- *Infiltration* (groundwater movement) and water storage occur in these void spaces.
- The porosity of soil is the ratio of the volume of pore space to the total volume of material.

$$Porosity = n = \frac{Volume\ of\ Voids}{Total\ Volume} = \frac{V_v}{V_t} \times 100\%$$



## Void Ratio

$$Void\ Ratio = e = \frac{Volume\ of\ Voids}{Volume\ of\ Solids} = \frac{V_v}{V_s}$$

•Represents denseness of the soil mass (ratio of voids vs. solids)

•Obviously, effects permeability & strength

## Other Weight-Volume Relationships For Solving Phase Diagrams

Total (moist) Unit Weight $\gamma_t = \frac{W_{total}}{V_{total}}$

Dry Unit Weight $\gamma_d = \frac{W_{solids}}{V_{total}}$

Solid Unit Weight $\gamma_s = \frac{W_{solids}}{V_{solids}}$

## Other Weight-Volume Relationships For Solving Phase Diagrams

Specific Gravity SG = $\gamma_{solids} / \gamma_{water}$
;where water = 62.4 lbs/ft$^3$

Moisture Content $w = \frac{W_{water}}{W_{solids}} \times 100\%$