Soils Composition

Soils: Formed by **weathering** of rocks.

Rock: Defined as naturally occurring consolidated aggregates of geological material, called minerals.

Physical Properties of Soils: Primarily dictated by the minerals that constitute the soil particles.

Rock Cycle & Origin of Soils

Soils:

- Mineral grains that form from the solid phase of a soil aggregate are the **product** of the rock weathering.
- **Size** of the individual mineral grains varies over a wide range.
- Many of the physical properties are determined by the **size, shape and chemical composition** of the mineral grains.

Types of Rocks

On the basis of the **mode of origin**:

- **Igneous Rocks-** by cooling magma/lava.
- **Sedimentary Rock-** by lithification of sediments
- **Metamorphic Rock- by metamorphism**

Weathering

Process of breaking down of the rocks by mechanical and chemical process into smaller pieces.

- **Mechanical Weathering (disintegration)**: Caused by the expansion and contraction of rocks from the continuous gain and loss of heat, which result in ultimate disintegration. Mechanical erosion due to ocean wave and wind at Yehliu, Taiwan.

- **Chemical weathering (decomposition)**: Original rock minerals are transformed into new minerals by chemical reaction. Honey comb structure



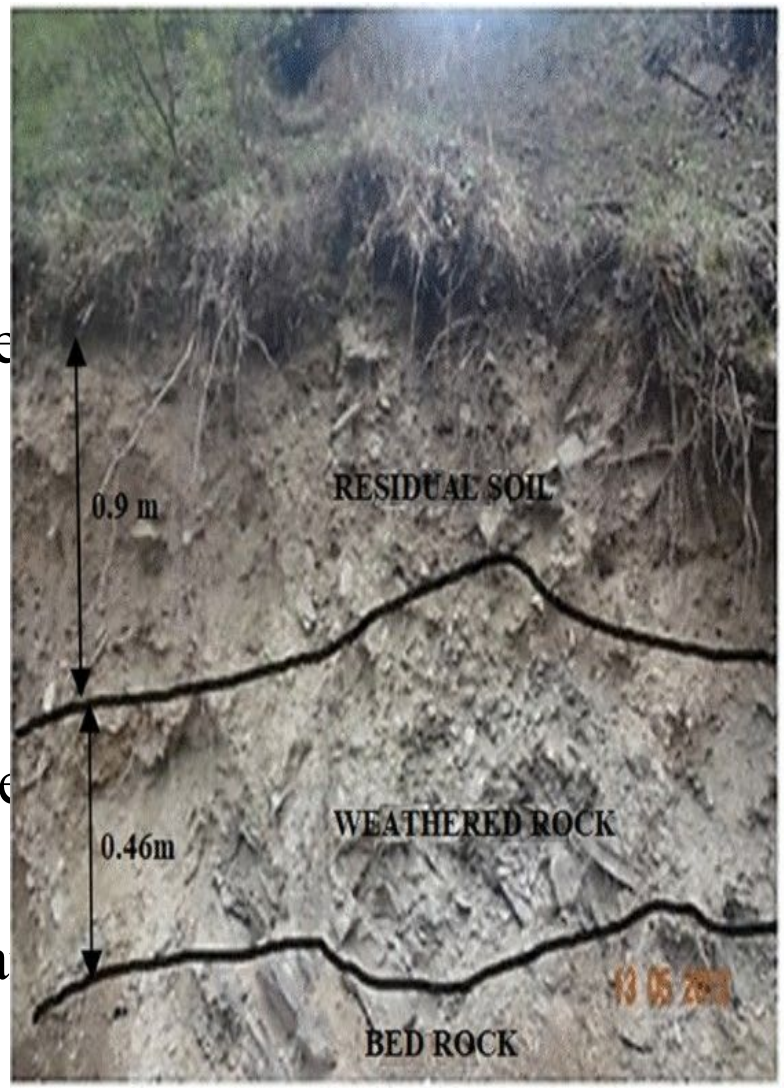


Transportation of Weathering Product

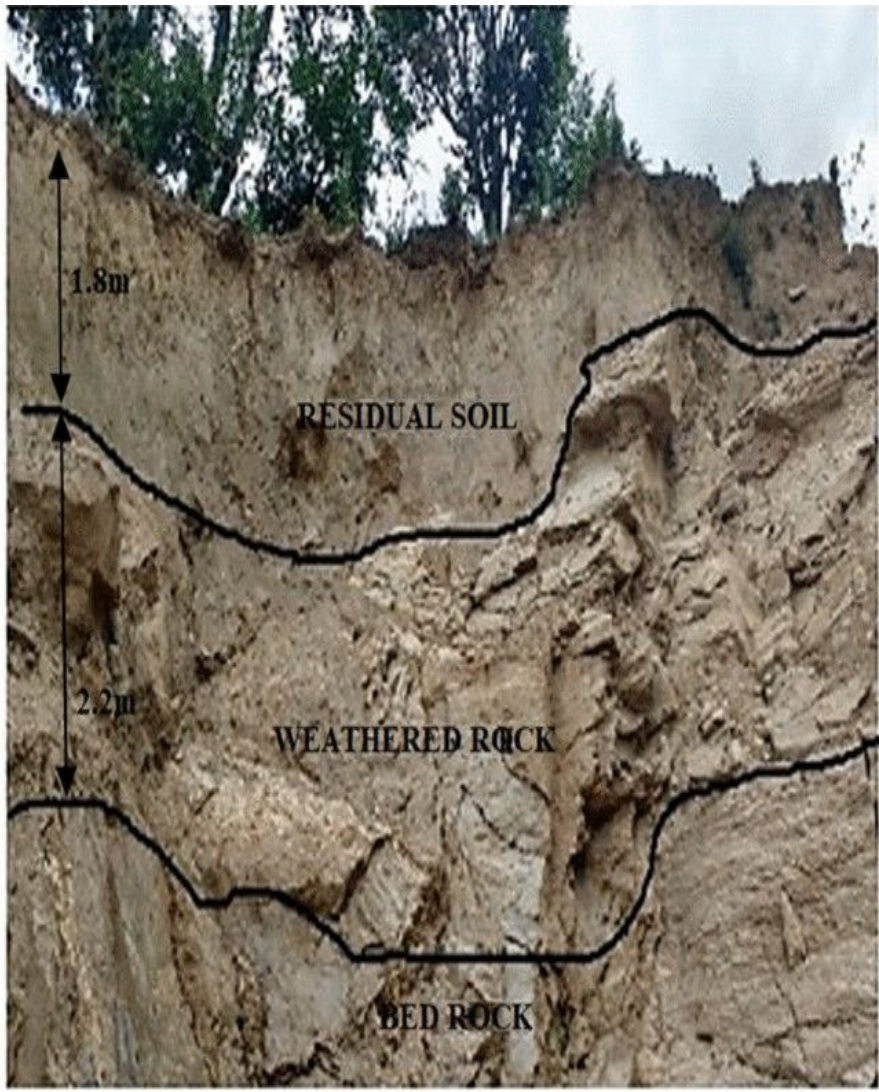
Products of weathering **may stay** in the **same place or may be moved** to other place by ice, wind and gravity.

At Place of Origin:

- Soils formed by the weathered product at place of origin are calle **residual soils**.
- An important characteristics of of residual soils is the **gradation** of particle size.
- Fine grained soils is found at the surface, grain size increases with depth and at greater depth, angula fragments may also be found.



(a)



(b)

Classification of Transported Soils

Depending on mode of transportation and deposition, transported soils may be classified into several groups:

- **Glacier soils** – by glaciers
- **Alluvial soils** – by streams
- **Lacustrine soils** – by lakes
- **Marine soils** – by seas
- **Aeolian soils** – by wind
- **Colluvial soils** – by gravity



Sedimentary Rock

Mechanical Sedimentary Rocks:

- Deposits of gravel, sand, silts and clay formed by weathering may become **compacted** by overburden pressure and **cemented** by agents like iron oxide, calcite, dolomite and quartz.
- Cementing agents are generally **carried** in solution by ground water.
- Such solutions **fill spaces** between particles and form sedimentary rocks known as detrial rocks.
- **Example**: Conglomerate, Sandstone, mudstone, shale.



Chemical Sedimentary Rocks

- Formed by the chemical process.
- **Examples**: Limestone, halite, dolomite and gypsum



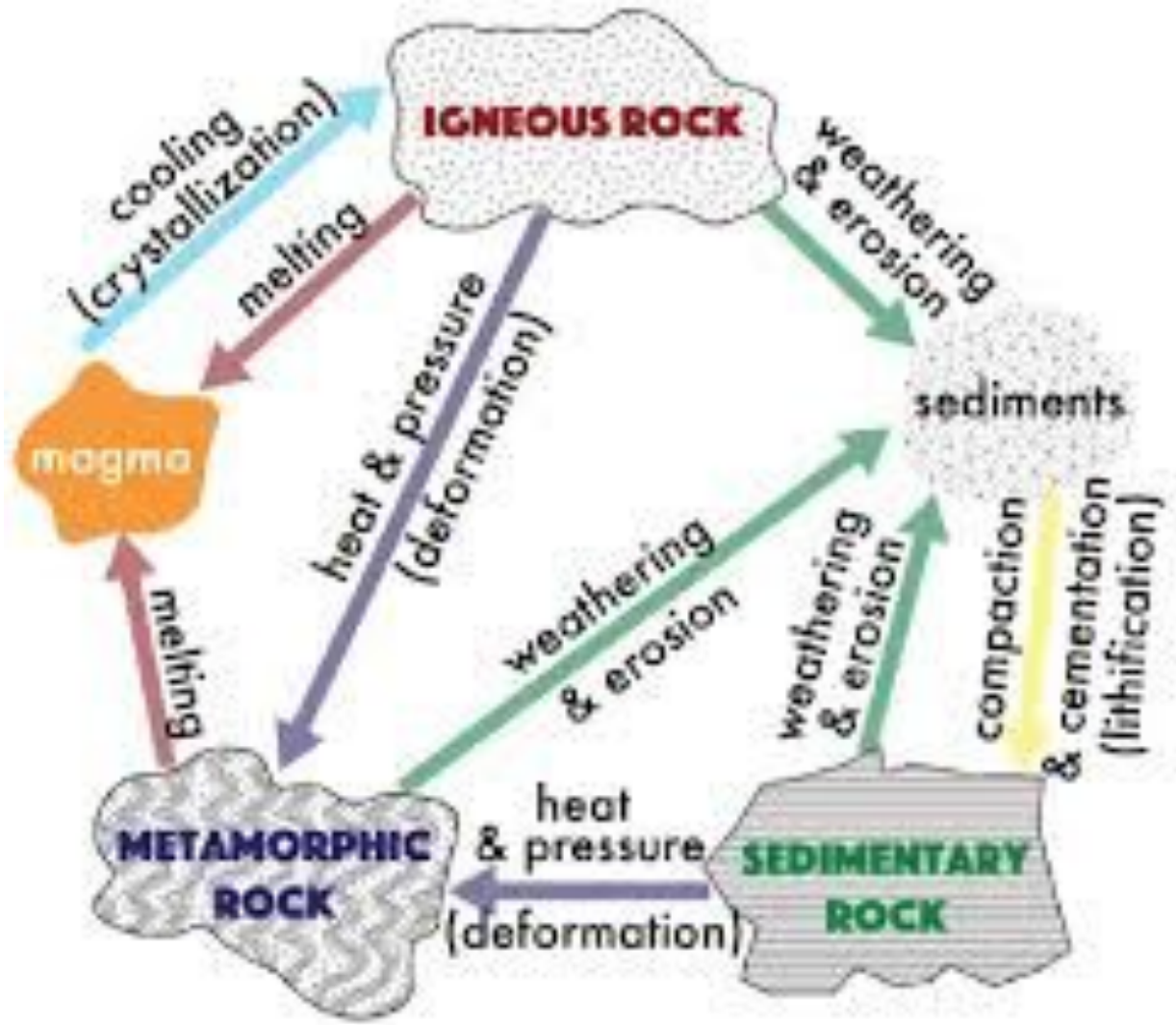



Metamorphic Rocks

- Process of changing the composition and the texture of rock by heat and pressure (without melting).
- Process known as metamorphism.
- Examples: Gneiss, Phylite, Schist.



Rock Cycle

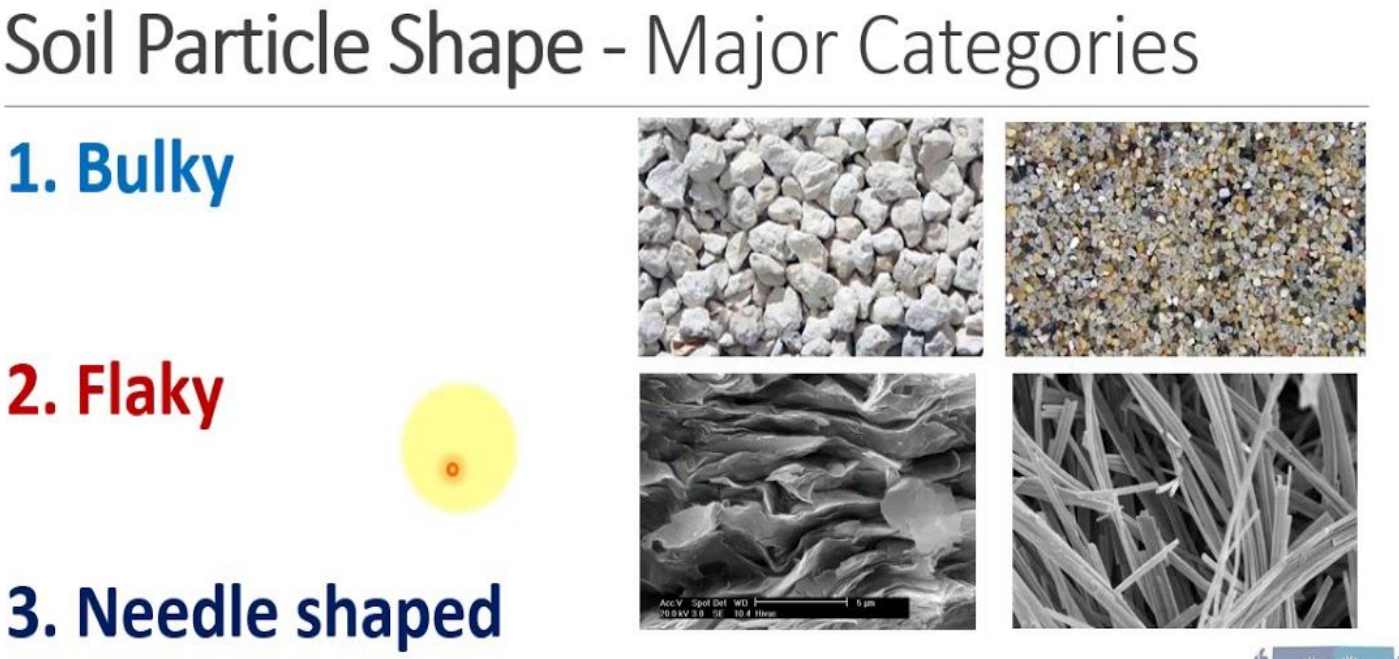

IGNEOUS ROCK
cooling (crystallization)
melting
weathering & erosion
magma
heat & pressure (deformation)
sediments
melting
weathering & erosion
weathering & erosion
compaction & cementation (lithification)
METAMORPHIC ROCK
heat & pressure (deformation)
SEDIMENTARY ROCK

Soil Particle Shape

Shape of particles is equally important as particle size distribution, because it has significant influence on the physical properties of a given soil.

Divided into 3 major categories:

- Bulky
- Flaky
- Needle shaped.



Bulky

- Formed mostly by mechanical weathering of rock and minerals.
- Shapes of the bulky particles are termed as:

  Angular

  Sub-angular

  Sub-rounded

  Rounded

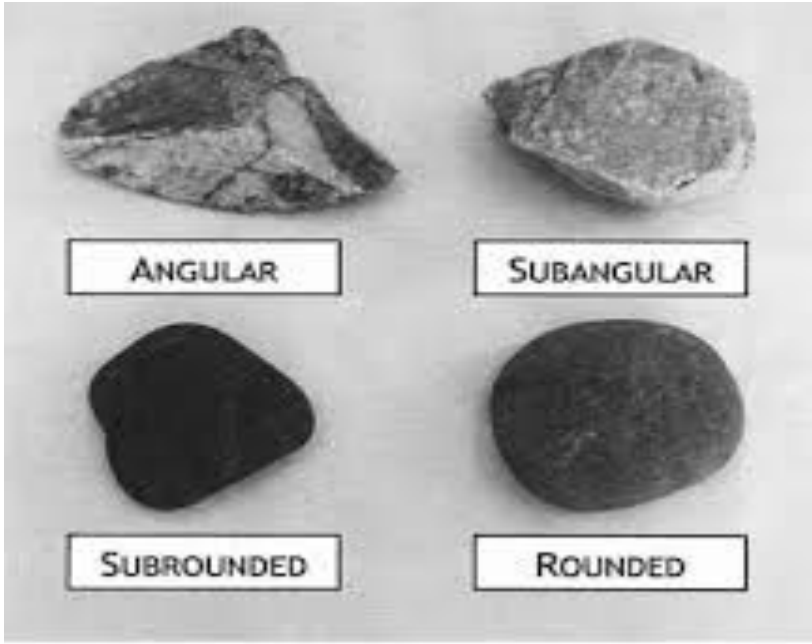


Figure 2.22 Shape of bulky particles (Courtesy of Braja M

- Small sand particles located close to their origin are generally **very angular**.
- Sand particles carried by wind and water for a long distance can be **sub-angular to rounded shape**.
- Shape of angular particles in a soil mass has a **great influence on the physical properties** of the soil, such as

  maximum and minimum void ratio

  shear strength parameters,

  compressibility etc.

Flaky Particles

- When the particle thickness is small when compared with the width and length of that particles.
- Particles are predominantly clay minerals.

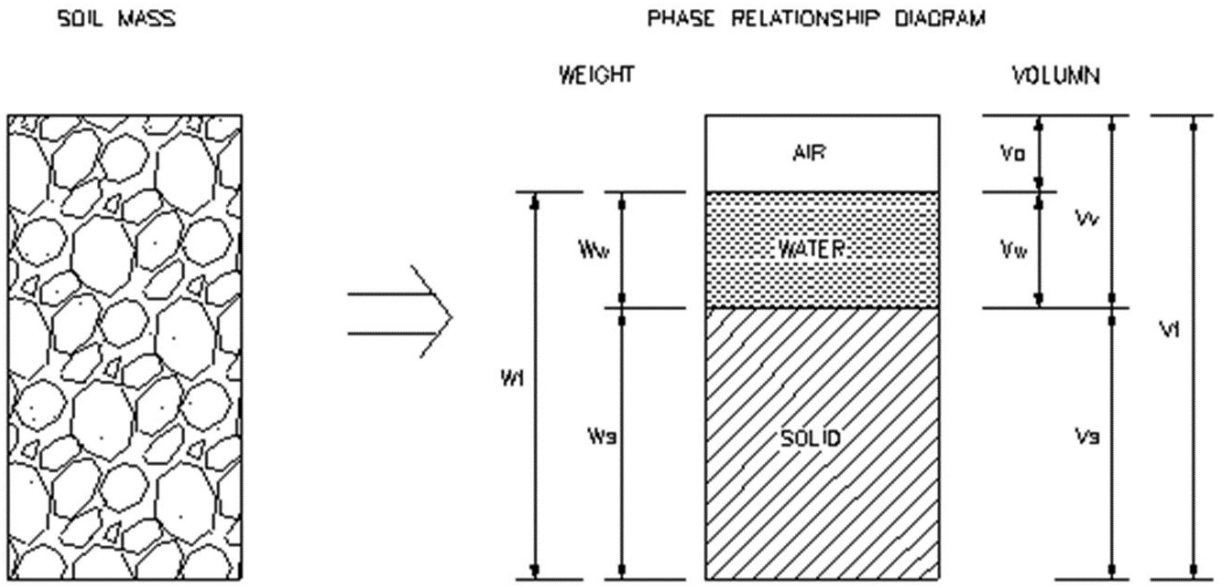


Elongated Particles:

A particle having a length to width ratio greater than 3.

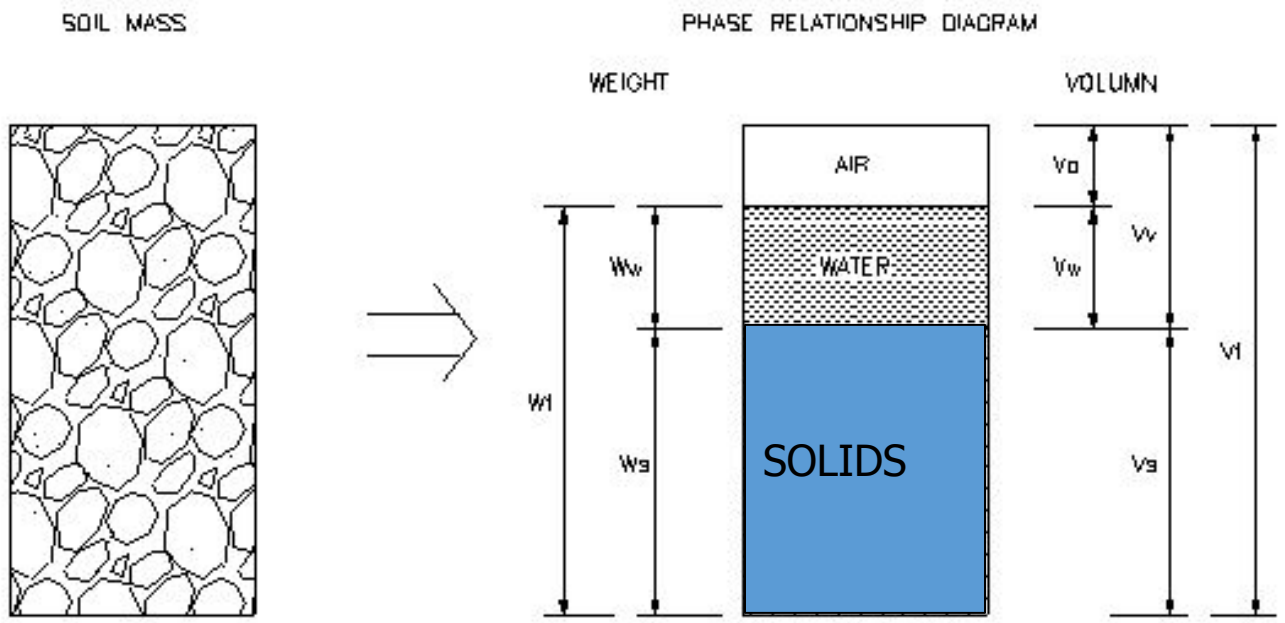
Three Phase System

- **Soils are different** from most of the civil engineering materials that it can contain **solid, liquid and gas phases.**
- **Liquid and gas phases** are contained in **voids or pores** between solid particles.
- **Three phases are often interact** and **these interactions have significant effects on soils behavior**.

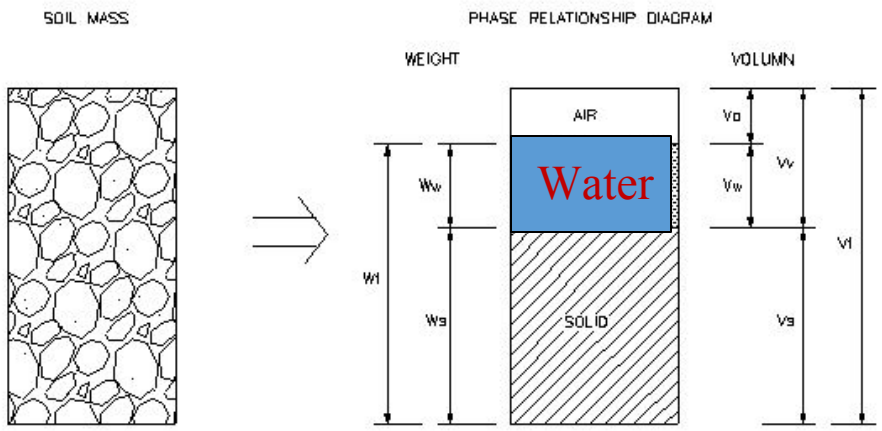


Solid Phase

- **Always present** in soils.
- **Consists of particles** derived from the weathering of rocks.
- Can **include organic materials**.



Liquid Phase



- **Usually present**, most often consists **of water**.

Can include other materials also:

- **Gasoline or other chemicals**

  -have **leaked out** of underground tanks or pipelines

  -or **infiltrated** from the ground surface.

clean up of such contaminants can be a significant problem.

- **Leachate**

  -Liquid that has escaped from the **sanitary landfill**.

Can **contaminate GW** and make it unfit for drinking.

- **Sea Water**

  -sea water moving inland through soil.

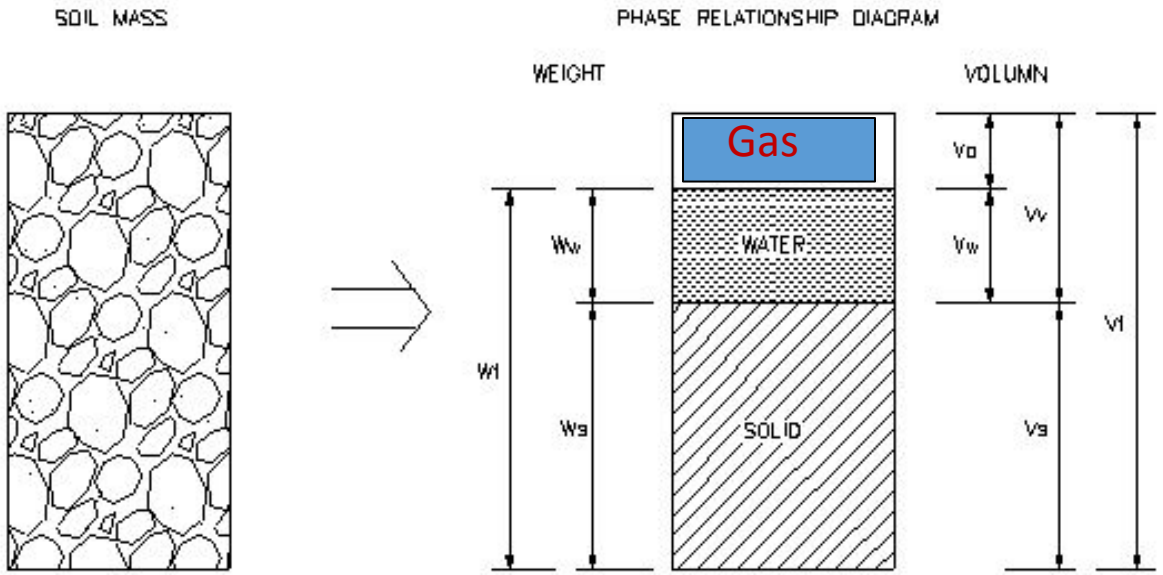
  -when wells are installed near ocean to pump out fresh water, get salt water.

- **Natural Petroleum Seeps**

Importance: Although these constituents usually present a **small fraction** of the liquid in a soil, they can be **very important,** specially if **the GW is to be pumped out and used** for domestic purposes, but becomes contaminated.

Gas Phase

Gas Phase



If the **liquid phase does not completely fill** the voids, the remaining, the remaining phase is occupied by the gas.

- **Usually air**, can include **other gases** also.

- **Methane and Carbon dioxide:**

  -Form from the **decomposition of organic materials**

  -often found from **the sanitary land fills**, and **near highly organic natural soils.**

- **Petroleum Vapor**: from the **contaminated soils**.

- **Hydrogen Sulfide**:

  -from the **decomposition of sulfide bearing materials.**

  -sometimes found **near sanitary landfills**, **sewerage facilities** and **coal deposits**.

Hazardous Effects of Gas in soils.

Gases other than air can be important because they sometimes **pose safety hazard to the workers** in **utility vaults**, **small excavation**, **mines** and **underground areas**.

Toxic and Inflammable:

- **Carbon dioxide**: form from the **decomposition of organic materials** and **toxic.**
- **Hydrogen Sulphide: poisonous**
- **Methane:** Also **form from decomposition of organic materials** and **inflammable**. If trapped, and accidentally ignited, create explosion.

- **Gases neither toxic nor inflammable**, can be dangerous because they displaced Oxygen, thus **suffocating workers**.

- This problems has **caused injury and death**, but can be avoided by using special detection equipment and adequate ventilation.

- Components other than air are very important, but air generally represent **a small portion of the soil weight and volume.**

- Simply refer to the liquid and gas phases as '**Pore water**' and '**Pore air**'.

Soils as Particulate materials

Most of the engineering materials consists of:

- **Continuous mass** held together with **molecular bond**, and

  -**Mechanical properties** of such materials depend on their **chemical make up** and the **nature of these bond.**

Example: Steel

-Shear strength of steel depend on the strength of their molecular bond,

-their shear failure requires breaking them off.

- Soil is a **particulate material that consists of individual particles assembled together**. Its engineering properties depend on:

  -**primarily** on **interaction** between these particles.

  -**only secondarily** on their **internal properties**.

Example: Gravel, sand, silts

When soil **fails in shear**, they do:

-because of the particles began to **roll and slide past** each others.

-**not because of the particles beak**, breakage of individual particles is typically minimal.

- **Shear strength of soil** depend on the following factors:
  - **coefficient of friction** between particles and
  - **tightness** of the of packing ie compaction.

- **Clays also have particulate structure** but the nature of the particles is quite different.
  - **much more interaction between the particles** and the pore water.
  - **behavior is more complex** than that of other.

Thanks