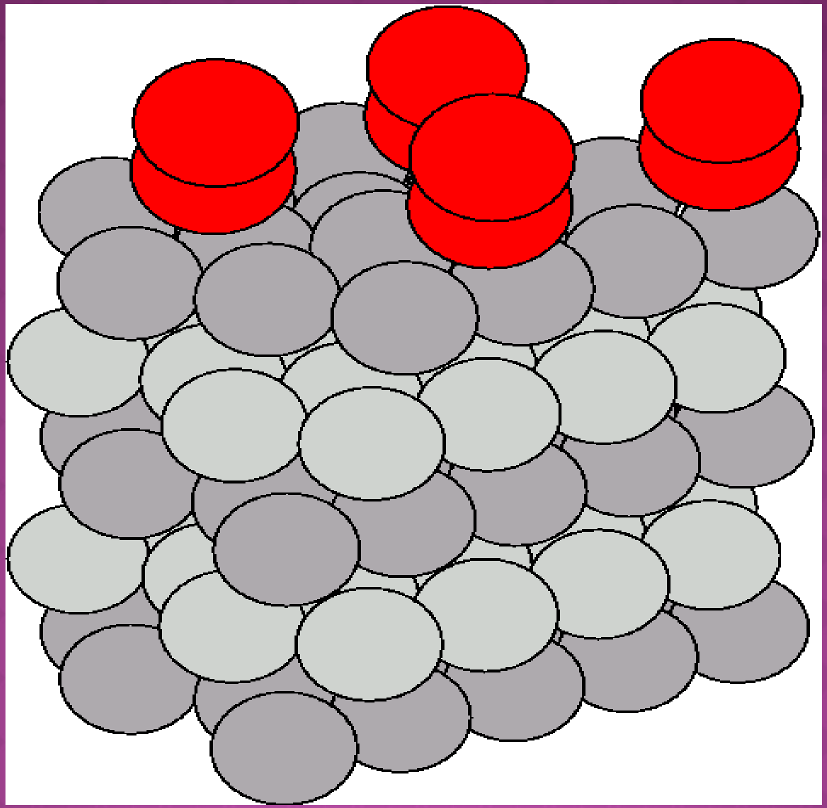
ADSORPTION & GROUNDWATER FLOW



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ADSORPTION

- *Adsorption* is the ability of a compound to "attach" itself to the soil. Its determined highly on the properties of the soil and the compound. Differences in solubilty and reaction with organic materials help make up a wide range of adsorption strengths.
- The substance thus adsorbed on surface is called Adsorbate and the substance on which it is adsorbed is called Adsorbent.
- Adsorption effects the transport of contaminants in the groundwater system.

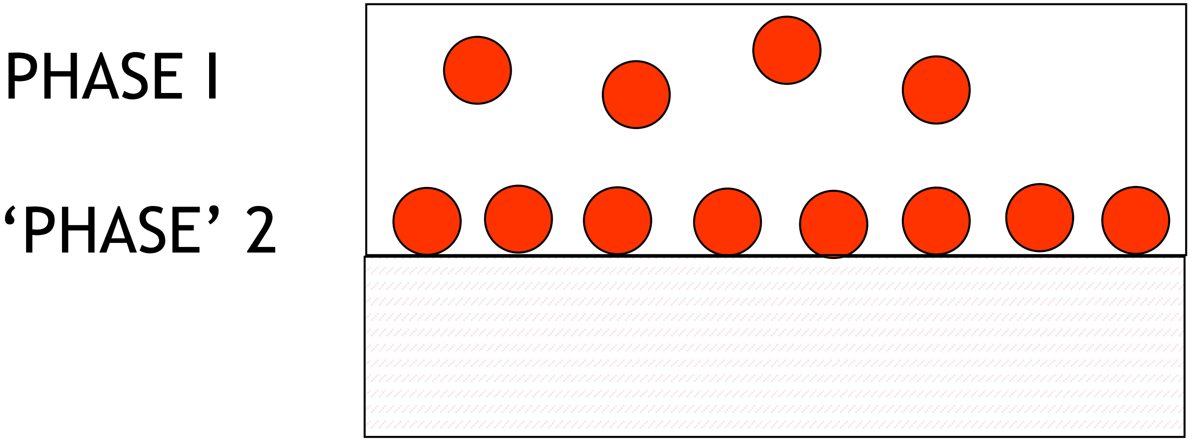
SORPTION

ADSORPTION
VS
ABSORPTION

- Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or, more rarely, a liquid (adsorbent), forming a molecular or atomic film (the adsorbate).

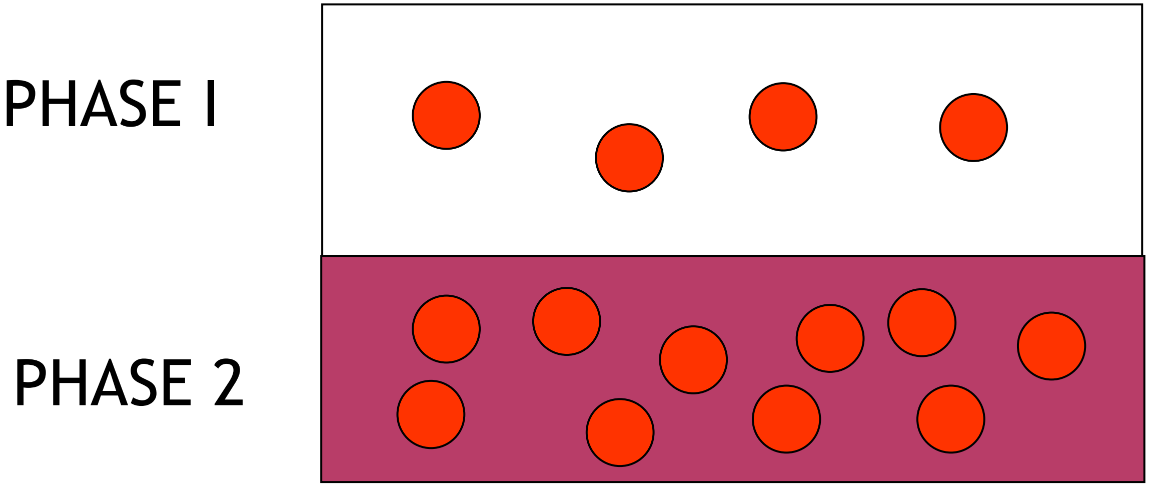
- Absorption is dissolution of molecules within a phase, e.g., within an organic phase in contact with an air or water phase

Adsorption


PHASE I

‘PHASE’ 2

Absorption
(“partitioning”)


PHASE I

PHASE 2

CAUSES OF ADSORPTION

- Adsorption arises at the surface of solids as a result of presence of unbalanced forces at the surface. These forces develop either during the crystallization of solids or by virtue of the presence of unpaired e- in d-orbital.
    - van der Waals forces: physical attraction
    - electrostatic forces (surface charge interaction)
    - chemical forces (e.g., π- and hydrogen bonding)
- Dislike of Water Phase – ‘ Hydrophobic bonding’
- Attraction to the Sorbent Surface

FACTORS ON WHICH ADSORPTION DEPEND

- 1. **Surface area of Adsorbent :**
- Greater the surface Area of Adsorbent, greater is the volume of gas adsorb
- 2. **Nature of gas being Adsorb :**
- Higher the critical temp. of gas, greater is the among of that gas adsorbed.
- 3. **Temperature :**
- Adsorption decreases with increase in temperature and vice - versa.
- 4. **Pressure :**
- Adsorption of a gas increase with increase of pressure because on applying pressure gas molecules comes close to each other.

- Two components of the soil matrix have the greatest effect on adsorption:
- organic matter
- clay minerals

In most groundwater aquifers, the organic fraction tends to control the adsorption of organic contaminants

TYPES OF ADSORPTION

- **1. Instantaneous or equilibrium adsorption**
- It is very often assumed that equilibrium conditions exist between the aqueous-phase and solid-phase concentrations and that the adsorption reaction is fast enough relative to groundwater velocity so that it can be treated as instantaneous .
- linear isotherm
- non-linear Freundlich isotherm
- non-linear Langmuir isotherm

2. KINETIC (SLOW, NON-EQUILIBRIUM) ADSORPTION

- In many cases it is not possible to assume that adsorption/desorption are instantaneous processes. This is the case especially in heterogenous aquifers when water and the dissolved contaminants move faster in more permeable layers and more slowly e.g. in clay lenses of the aquifer

ADSORPTION MODELS (ISOTHERMS)

- Adsorption is usually described through isotherms,a graph between the amount adsorbed by an adsorbent and the equilibrium pressure of the adsorbate at a constant temperature is called the Adsorption isotherm.
- The quantity adsorbed is nearly always normalized by the mass of the adsorbent to allow comparison of different materials.

- linear isotherm
- non-linear Freundlich isotherm
- non-linear Langmuir isotherm

LINEAR ISOTHERM

The simplest expression of equilibrium adsorption is the linear isotherm, which is valid for dissolved species that is present at concentrations less than one-half of its solubility

$$S = K_d C$$

- where S is the adsorbed concentration (mg/kg)
- K_d is the distribution coefficient
- C is the dissolved contaminant concentration (mg/l).

LANGMUIR ISOTHERM

- In the Langmuir model adsorption increases linearly with increasing solute concentration at low C values and approaches a constant value at high concentration

$$S = \frac{K_L bC}{1 + K_L C}$$

- where S is the adsorbed concentration (mg/kg)

- K_L is the equilibrium constant for the adsorption reaction
- b is the number of sorption sites (maximum amount of sorbed contaminant).

- most adsorption processes are best described by the Langmuir isotherm

FREUNDLICH ADSORPTION ISOTHERM

- If the number of adsorption sites is large relative to the number of contaminant molecules it is possible to use the Freundlich isotherm

$$S = K_d C^N$$

- where S is the adsorbed concentration (mg/kg)
- C is the dissolved contaminant concentration (mg/l)
- N is a chemical-specific coefficient (need to be determined experimentally).

- ....Thanks ☺