Mineralogy

Course of Mineralogy G102
Second Semester (February-June, 2014)
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Lecture 2

Goldschmidt's Classification of the Elements

- An empirical (observation of relationships) geochemical classification of the elements was made by V. M. Goldschmidt in the early part of twentieth century. This classification has led to many ideas about the geochemical distribution of elements in the Earth and in the universe.
- Goldschmidt classified the elemets into:
- 1- Lithophile elements
- 2- Chalcophile elements
- 3- Siderophile elements
- 4- Atmophile elements

Lithophile elements

- Lithophile elements are that elements who combine readily with oxygen.
  - Ex: Si combine readily with oxygen.
  - Al formn Corundum (Al_2O_3), Ca form Lime (CaO), Mg form Periclase (MgO), Ti form Rutile (TiO_2), U form Uraninte (UO_2).
  - Note// lithophile elements also combine with silicate to form silicate minerals which are the most common rock-forming minerals.
  - Lithophile elements who have large ionic radii (LIL), tend to enriched in late-stage fluids of crystallizing basaltic magmas, which tend to migrate upward into the upper part of the continental crust forming.
  - Ex: granite plutons, rhyolitic volcanics.

Chalcophile elements

- Chalcophile elements are that elenents who combine readily with sulfur and forming covalent bonded minerals.

- Ex: Chalcocite (Cu_2S), Galena (PbS).

  - Note// the common mineral Pyrite (FeS2) is an indication of the partly chalcophile character of ion.

Siderophile elements

- Siderophile elements are that elements wo combine readily with iron.

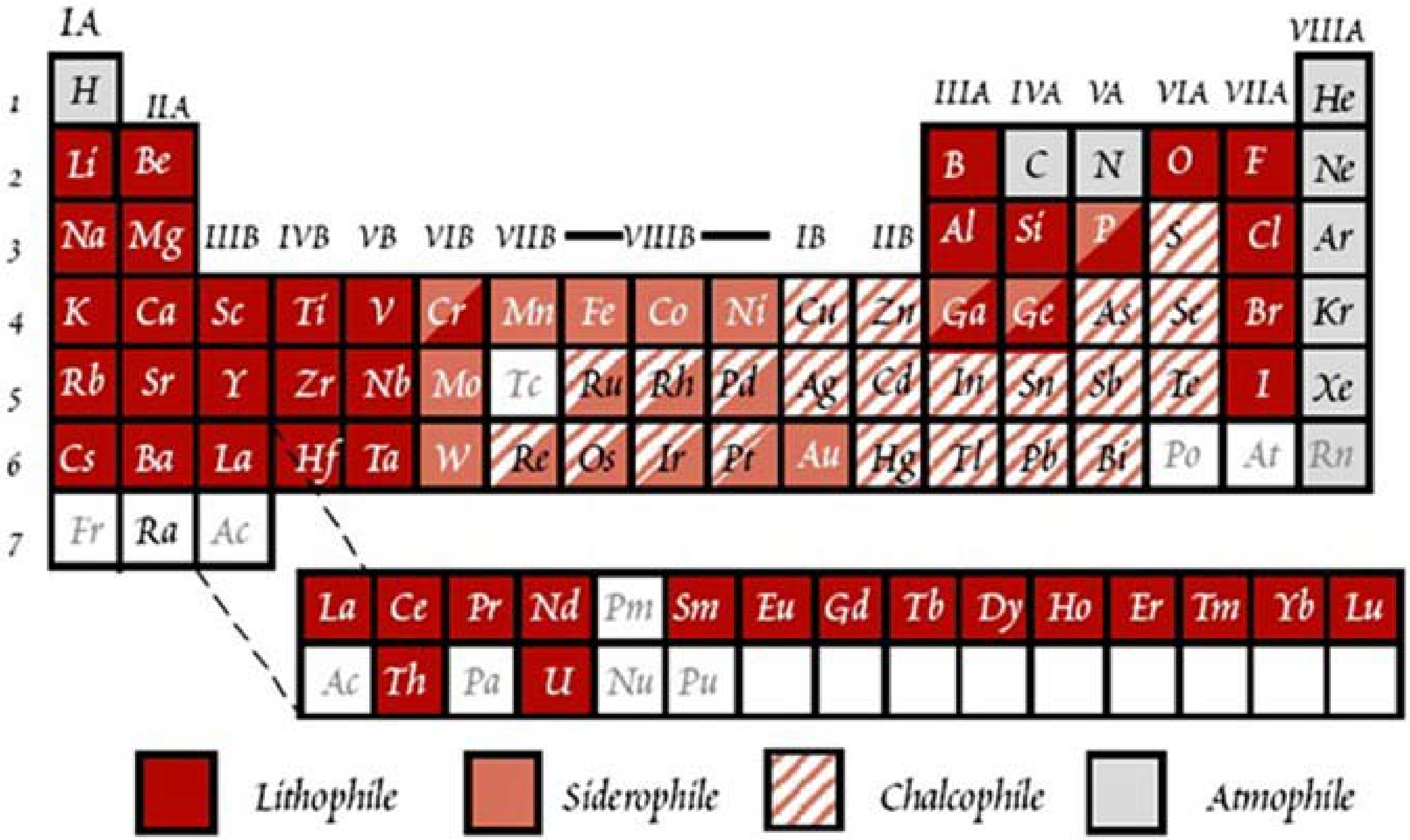
- Note// Ex: Iron-nickel core of the earth’s, and nickle associated with iron in the iron meterorites.
  - native iron is rarein the earth’s crust, not associated with lithophile or chalcophile elements.

Atmophile elements

Atmophile elements are inert gases. Such as: Ar, He, Ne, Ra, Xe, N and in part H and O.

Note// C (in CO2) and O in the atmosphere are considered partly atmophile.

Goldschmidt's Classification of the Elements



Formation of Minerals

Chemical Compounds

Nonstoichiometry

(violate the law of conversation of mass)

Ex: amorphous solids (mineral-like)

Stoichiometry

(related to the law of conversation of mass)

Ex: minerals

Law of conversation of mass

- *“the total mass of all substances present after a chemical reaction is the same as the total mass before the reaction”*.
  - Ex:
  - $2Cu^{+}+O^{2-}= Cu_2O$ (Cuprite mineral) …. *(Stiochiometrically correct)*

Formation of Chemical Compounds

- Chemical reaction reflects the fixed composition of elements in minerals and is governed by the *stoichiometry* of the participating chemical phase.

Chemical Reaction in Aqueous Solutions

- Chemical reaction includes:
  - 1- change in physical state, such as melting of ice or freezing of water.
  - 2- change in composition, such as the hydration of anhydrite to form gypsum.
  - 3- some combination of physical and compositional change. Such as crystallization of halite in a brine solution.

  - *Note// brine solution is a chemical system.*

Chemical system

- **Fluid phase:** like water and brine.
- **Solid phase:** designate as specific *minerals phase.*
- **Chemical components:** are the chemical building substances of minerals phases.

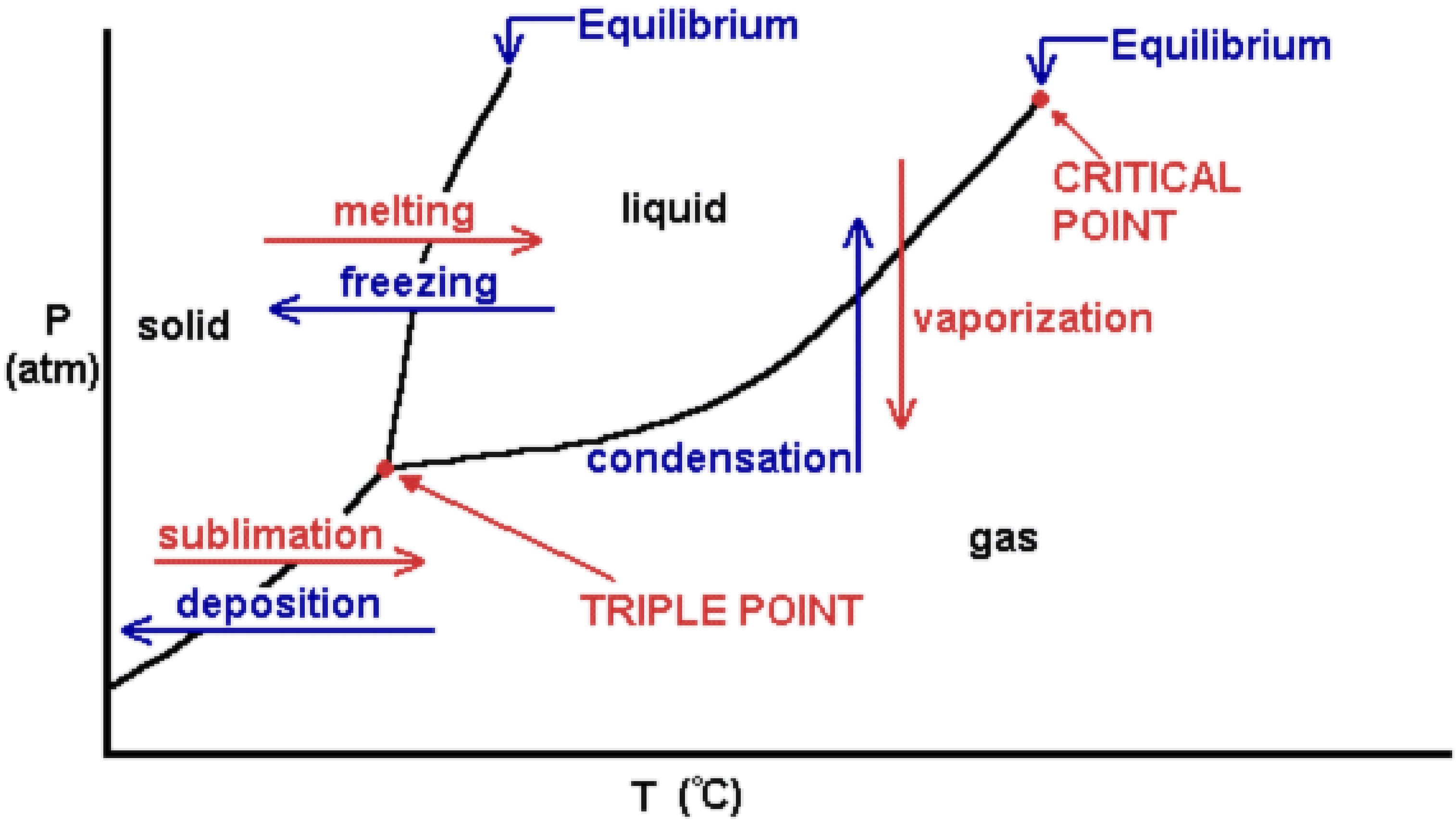
Ex: For anhydrite, gypsum, and halite components consist of Ca^{2+}, $SO4^{2-}$, H_2O, and Cl^-

Phase rule

- **Phase rule**: is used to predict the number of phases to be expected from a given set of components, and the type of equilibrium.

- Phase rule formula: **f=c+2-p**.

- Where:
- *F*= is the number of degree of freedom in terms of pressure and temperature.
- *C*= is the number of components.
- *P*= is the number of phases.



From www.kentchemistry.com

Types of equilibrium

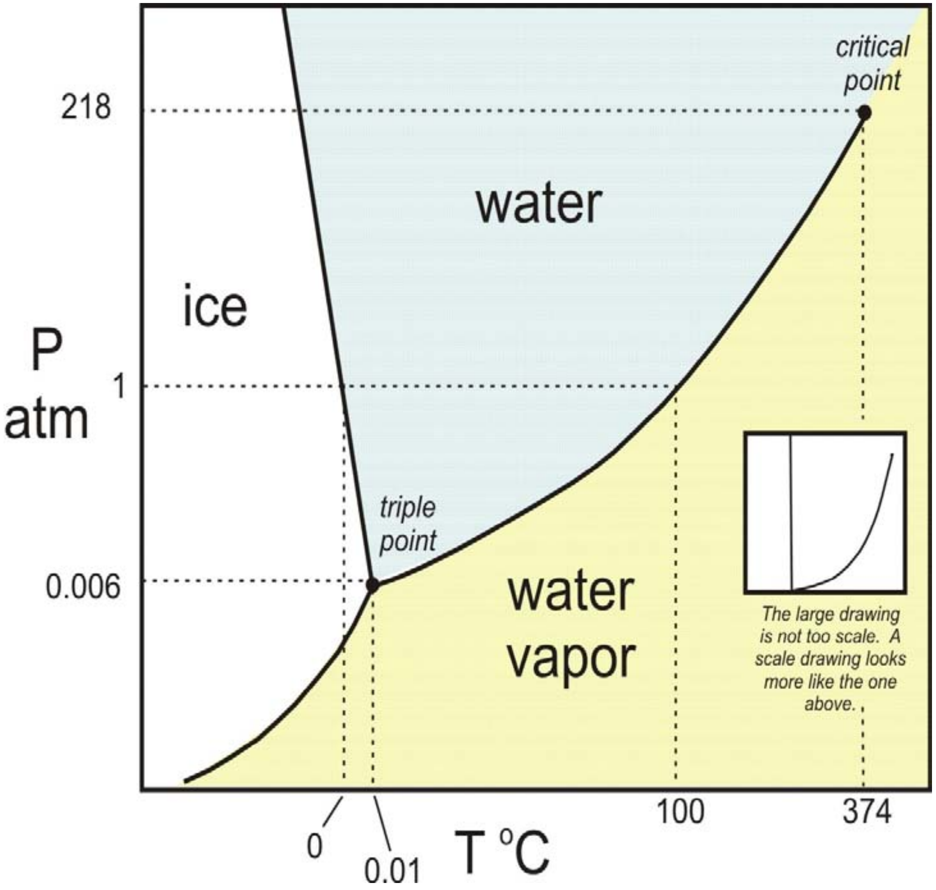
- **Invariant equilibrium:** means that the phases coexist only if pressure and temperature are not varied (no degrees of freedoms).
- **Univariant equilibuium:** means that if pressure or temperature is varied, there must be corresponding change in pressure or temperature (1 degree of freedom).
- **Divariant equilibrium:** means that a phase remains stable even though both pressure and temperature are varied independently of each other (2 degree of freedom).

Ex: H_2O System

For the H_2O system, below the critical point, the equilibrium ice=water, water-gas, and ice=water are all univarient equilibria, plotting as curves on the P-T diagram, because f=1+2-2=1.

At the invariant triple point, f=1+2-3=0.

For a point somewhere out in the field of ice, water, and water vapor, f=1+2-2=2, indicating divariant equilibria.



P-T Phase diagram of water: the triple point for water is about at the same temperature as the melting point of water, but at a pressure which is only 0.006 atm. Its critical point is at about 374°C and at a pressure of 218 atm, all far above the practical use of water.
From: http://cft.fis.uc.pt/eef/FisicaI01/fluids/thermo20.htm