

Isomorphism

Minerals that have similar crystal structure and system but different chemical composition are said to be isomorphous, and the phenomenon is known as isomorphism.

In isomorphous minerals, the relative sizes of the cations and anions are similar and have the same coordination number; therefore, they crystallize in the same crystal system. Examples are shown below:

Calcite group (carbonate) - trigonal system:

Calcite (CaCO_3), siderite (FeCO_3), magnesite (MgCO_3), rhodochrosite (MnCO_3), and smithsonite (ZnCO_3). All crystallize in the trigonal system.

Polymorphism

Minerals that have the same chemical composition but different crystal structures are said to be polymorphs, and the phenomenon is called polymorphism. If a crystal is subjected to different pressures and temperatures, the arrangement of atoms depends on the sizes of the atoms, and the sizes change with temperature and pressure.

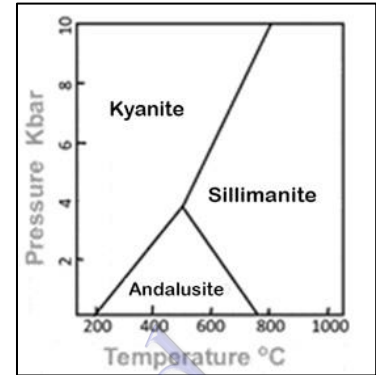
In general, as pressure increases, the volume of a crystal will decrease and a point may be reached where a more compact crystal structure is more stable. The crystal structure will then change to that of the more stable structure, and a different mineral will be in existence.

Similarly, if the temperature is increased, the atoms on the crystal structure will tend to vibrate more and increase their size. In this case, a point may be reached where a less compact crystal structure is more stable. When the crystal structure changes to the more stable structure, a different mineral will form.

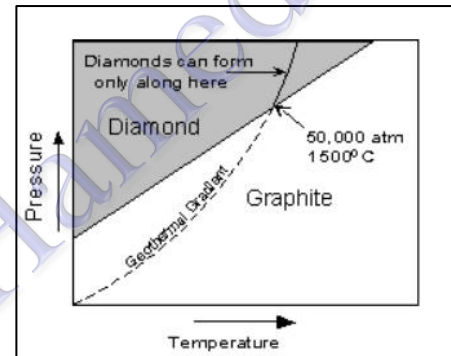
Important Polymorphs

Many common minerals show polymorphism. We here look at some of the more common ones:

1) Al_2SiO_5 : It has three polymorphs. The high pressure form is kyanite (triclinic), the high temperature form is sillimanite (orthorhombic), and the low temperature and pressure form is andalusite (orthorhombic).

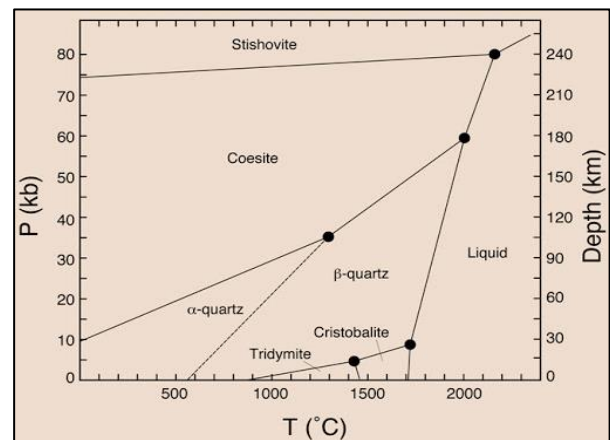


2) Carbon: It has two polymorphs. At high pressure, carbon has an isometric crystal structure that is called **diamond**. As temperature and/or pressure are decreased, diamond should undergo transformation to the hexagonal structure of **graphite**. Because this transformation involves rearrangement of atoms in the crystal structure.



3) Pyrite and Marcasite: The composition FeS_2 occurs most commonly as pyrite with an isometric structure and marcasite with an orthorhombic structure.

4) SiO_2 : It has 6 polymorphs. With decreasing temperature at low pressure, cristobalite (isometric) transforms to tridymite (hexagonal). Further lowering of temperature, tridymite transforms to high quartz or β -quartz (also hexagonal). With further lowering of temperature, high quartz transforms to low quartz or α -quartz (trigonal).



With increasing pressure, α -quartz transforms to coesite (monoclinic), and coesite transforms to stishovite (tetragonal) at even higher pressures.

5) KAlSi_3O_8 : It has three polymorphs (sanidine, orthoclase, and microcline) that undergo a transformation with lowering of temperature.

At high temperature the stable form is sanidine (monoclinic), it is usually only found in volcanic rocks that have cooled rapidly.

At lower temperature, the structure of sanidine changes to orthoclase (also monoclinic), i.e., with slower cooling, sanidine eventually undergoes a transformation to orthoclase.

At even lower temperature, orthoclase eventually transforms to microcline (triclinic) with further slow cooling.

6) CaCO_3 : Has two polymorphs. The high-pressure form is aragonite (orthorhombic) and the low-pressure form is calcite (trigonal).

Pseudomorphism

A mineral can be replaced by another mineral without any change in the external form. Such replacement is known as pseudomorphism.

There are two types of pseudomorphism:

1- Substitution pseudomorphs: No change in the chemical compound but change in structure. Example is calcite after aragonite.

2- Alteration pseudomorphs: Addition or losing of some elements or compounds, example gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) after anhydrite (CaSO_4); Kaolinite ($\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$) after orthoclase (KAlSi_3O_8).
