Dear students.Welcome to

the fifth module of

the paper GEC 105

Mineralogy. Today We're going to talk about the

mineralogical phase rule.

At the end of this lecture you will be able to

understand the mineralogical phase rule

and its implications.

Minerals, being chemical elements or components, their

formation must conform to the

chemical principles. They are produced by the combination of

elements from among those available and in such proportion

and structures as are stable in the given conditions.

Minerals are also associated with other minerals which were

formed in identical conditions.

The relationship of the minrals ,with the bulk composition and

environmental factors therefore follows the Gibbs Phase rule,

which states that number of phases plus the degrees of

freedom is equal to the number of components plus two. Now let

us see how we can apply this Gibbs Phase rule.

And modify it to get a mineralogical phase rule.

The Gibbs Phase rule.may be rewritten as the number of

Phases that is P is equal to C+ 2 -- F.

Now, this implies that the number of phases.

Or the number of minerals increases with the increase in

number of components. In other words, greater the chemical

complexity of the rock Larger the number of phases that are present in this

rock or greater, the number of chemical components.

Larger the number of minerals that will be

composing this rock.

But greater the degrees of freedom, lesser the number of

phases, because in this equation we are subtracting the

number of degrees of freedom to obtain the number of phases,

hence greater the number of components, greater the phases,

but greater the degrees of freedom you have lesser the

number of phases that can be present in a rock.

In any system that maximum number of phases will occur Thus when the degrees of freedom is zero, that is when P is equal to the number of components +2.

Now, since the degree of freedom is 0, the maximum number of

phases in a system can only be attained at a fixed and unique

pressure and temperature condition, because here there is

no variance, degrees of freedom is 0, right? Such a rock

assemblage but is extremely rare. It is extremely improbable that affixed pressure and temperature condition may be found in a geological

environment. We generally observe that any mineral that

is repeated in nature to form a rock usually exists over a

varying range of pressure and temperature conditions. Hence

the number of degrees of freedoms will always be greater

than zero. This results in 2 degrees of freedom. Hence, when

dealing with a rock, we may have a bivariant system.

2 degrees of freedom or variance. Substituting F is equal to two in the Gibbs phase

rule. Here you get the number of phases is equal to the number of

components in a bivariant system. Because you have F is

equal to two which is subtracted from plus 2 and, you get P is

equal to C.

Now, this was the conclusion that the famous geologists V. M. Goldschmidt arrived too and this is known as the mineralogical Phase rule. This mineralogical phase rule is derived from the

Gibbs phase rule.

And it states that in a system of C components at arbitrary

temperature and pressure, the maximum number of phases is

always equal to the number of components. It never exceeds the

number of components.

And this holds true for igneous and metamorphic rocks, which are

formed either by crystallization, igneous rocks and metamorphic rocks are formed by solid solid reactions.

Now let's look at the mineralogical Phase rule and apply it to a unary system. If You can re collect unary system is a system which can be defined by just one component. C is equal to 1.

Any individual element is a one component system. For example, sulfur. sulfur occurs in its native form in nature. Hence it's an individual element. Now this individual element of sulfur is a one component system. However, it can exist in two distinct phases. That is an orthorhombic form, and a monoclinic form. But each of these phases is stable over a particular range of temperature and pressure. Therefore, at any fixed pressure, the two phases can exist together in equilibrium only at a fixed temperature. That meanss here you have when the pressure is fixed, the temperature is also fixed for both the phases of sulfur to coexist in equilibrium. At atmospheric pressure, this temperature is 95 degrees Celsius. Hence at 95degrees Celsius you will have both orthorhombic and monoclinic sulfur coexisting. Therefore.

Generally we see only one of this form of sulfur that exists

in nature because the temperature is not necessarily

95 degrees Celsius all the time.Hence at one atmospheric

pressure you will just have one form of sulfur that is present

depending upon the temperature of the system.

Applying the mineralogical phase rule to a binary system. Now

here you have the number of components equal to two, hence

the number of phases should also be equal to two and it should

not exceed the number of components. Now let's look at a

system Nepheline silica. Nepheline $NaAlSi04$ and silica SiO_2.

Now this system at varying pressure, temperature conditions

or in the isobaric condition that is 1 atmosphere and varying

temperature can form four different phases that is. It

Can form quartz, nepheline, albite or jadeite. However, if you look

at the rocks that are found in the geological environment, you

see that in any given rock, just two of these four phases will be co-existing this is because according to the mineralogical Phase rule in a binary system which is defined by two

components, the number of phases is always equal to two. It

cannot exceed 2.

So let's look at the two possible associations that can

be found in igneous rocks.

Now you can have.

Undersaturated syenite, wherein you have nepheline and albite. Jadeite
Or quartz will not be present in this undersaturated

Syenite. Whereas in a normal syenite, You will have albite

And quartz. So you see that in a rock just two phases are

occurring. Same way in metamorphic rocks you may either

have the Association or the assemblage of albite plus

quartz, or there'll be another rock which has jadeite plus

albite. Or there will be another rock which has jadeite plus

quartz. There will never be a rock which has jadeite albite and

quarts in it together. Hence the mineralogical Phase rule plays a

very important role in the formation of minerals so also

in their stability.

And this phase rule the mineralogical phase rule, can

explain the limited mineralogy of the most common rocks that we

find in the geological setting.

For this lecture you may refer to the books

mineralogy by DexterPerkins or Manual of

Mineral Science by Klein,and Dutrow or igneous

and metamorphic rocks by winter. Thank you.