

In this particular module,
we will outline the factor of pressure
that is, the directed and load
pressure, that results in metamorphism.

By the end of this module,
we will be able to learn how pressure plays
a role in bringing about metamorphism.

And, to list the various effects the
pressure has on metamorphic rocks.

What is pressure?

Pressure or stress is defined
as force per unit area.

It is the applied force acting on a
rock over a particular cross sectional
area and strain is the response to
the rock due to the applied stress.

Trapped fluid phases such as
water and carbon dioxide,
may create pressures and such pressures are
referred to as Pfluid PH₂O or PCO₂.

Pressure increases with depth and this

is due to the weight of the overlying rocks and this is called as a lithostatic pressure or confining pressure.

Or it is denoted as P-load or P-lithostatic stresses.

P-Load in the crust increases about 0.1 gigapascals for every 3.3 kilometers of burial.

Pressure of metamorphic ranges from usually less than 0.1 gigapascals up to 10 gigapascals

present deep within the mantle and core.

However,

Petrologists are mainly concerned with pressures ranging from 0.1- 1.5 gigapascals,

which is approximately 15K bars.

In addition to pressure,

you also have directed or deviatoric stresses acting in a particular

direction an exceeding the mean

hydrostatic stresses,

commonly affecting rocks during metamorphism.

So let us take a look at first

the lithostatic pressure.

This is also called as a

hydrostatic pressure.

It is equal in all directions.

This is believed to be the case

of many metamorphic environments.

If the pressure in one direction

was significantly greater than

the other direction,

the rocks would yield, until the motion

offset the pressure difference.

Such deformation occurs when the

pressure differential exceeds the

material strength, which we can

expect to occur beneath a relatively

shallow zone or low pressure with

relatively cool and brittle rocks.

In rocks, having hydrostatic conditions,

regardless of the pressure.

That will not change the shape of the rock.

That is, they will not deform.

Pressure will cause the volume loss,

but it will be uniform in all directions.

This volume loss is facilitated

by the formation of low volume,

high density minerals,

which is why high pressure metamorphism

favors the production of dense minerals.

Deviatoric pressure is when

only when the pressure is unequal

in various directions,

will the rock be deformed.

Unequal pressures is called

as deviatoric stress.

This can be resolved into three mutually

perpendicular stress components.

Sigma one is where the maximum

principle stress, Sigma 2 is the

intermediate principle stress

and Sigma 3 is the minimum

principle stress.

This is seen mostly to occur at orogenic belts.

extending rifting margins and shear zones

that are generally at on your plate

tectonic boundaries.

The yielding of the rock that will

strain in form of deformation.

So this is your differential stresses.

As you can see,

you have three of them,

resolved into three components.

That is, you have Sigma one,

which is the maximum Sigma 2,

which is the intermediate and Sigma 3 which

is the minimum if they all were to be equal,

it would be a hydrostatic state.

But, since they are not of equal strength

they result in deviatoric stresses.

Divided stresses can therefore

be resolved into three types,

that is along the line in opposite

directions, away from a common point,

producing tension with Sigma

ϵ is negative and the resulting

strain is extension or pulling apart.

Along the line in direction

towards a common point,

producing compression.

Here one stress direction is a dominant one.

Also along opposite direction

along different lines,

building a force couple and

producing attendant compression

tension as well as shear.

We can see in this diagram you have a diag

which shows the force coming together,

producing compression.

Then B, extension when they have Sigma

ϵ is negative. And C shear causing

slip along parallel planes and rotation.

Let us take a look at what is tension?

Tension can occur only at shallow depths.

And the response is largely brittle,
faulting.

A common result is the development
of tensional fractures with generally
filled with fluids that precipitate
minerals in these extending fractures.

Let us take a look at compression.

Compression cause folding or a more homogeneous
deformation called flattening.

Existing minerals with platy or
elongated shape may be rotated
during either folding or flattening.

When we sample a rock that has
been deformed by compression,
we see parallel alignment of
minerals such as, that of mica,
which has a platy habit.

Also,

if new mineral mica grows during compression,
they will tend to grow perpendicular to
the maximum principle stress σ_1 .

This planar texture or structure is called as foliation as seen to give the rock as a cleavages or schistosity. that is developed in this way.

This type of metamorphic rocks.

If σ_1 is equal to σ_2 and both of them are greater than σ_3 , you will have elongated mineral such as amphiboles will either rotate or grow so that their maximum elongation is parallel to the longest axis of the deformed ellipsoid.

This will impart lineation to the rock.

However,

as σ_1 is greater than σ_2 and is greater than σ_3 , the Rock may exhibit both foliations and lineations simultaneously.

The next is Shear stresses.

The motion occurs along a set of planes at an angle to σ_1 .

The strain ellipsoid is similar to
that resulting from flattening
like in case of compression.

This flattening is referred to
as simple shear as opposed to pure
shear that is caused by compression.

In a you have compression that
causes flattening of folding.

This is what will result in formation
of cleavage and schistosity. You have
tension when σ_3 is negative,
producing fractures which is perpendicular
to the maximum principle stress,
and causing extension. third is shear
causing slip along parallel planes
and rotation.

Now, what are the effects of
pressure on metamorphic rocks?

Rocks under Lithostatic condition,
regardless of the pressure,
will not change shape,

that is, they will not deform.

They will only cause a volume reduction.

This volume reduction is facilitated by

the formation of their full low volume,

high density minerals. Therefore,

you have high pressure metamorphism

that favors dense mineral formation.

If you have differential stress or deviatoric

stress is present during metamorphism,

it will have a profound effect on the

texture of the fabric of the rock.

Stress affects the texture

and structures in the rock,

but not the equilibrium mineral assemblages.

In addition to some strain

energy in the form,

rocks may also provide the impetus

to overcome some kinetic barriers to

reaction that would otherwise occur

had not the barriers been effective.

Therefore,

the formation may have catalytic effect.

An element metastable mineral

association in favour of stable ones.

Rounded grains will become flat

in the direction of the

maximum compression stress.

Minerals that crystallize or grow

in differential stress may develop

a preferred orientation. Sheet

Silicates and minerals that have

elongated habit will grow with their

sheets or direction of maximum

elongation oriented perpendicular

to the direction of maximum stress.

This is because growth of such

minerals is much easier along

directions parallel to sheets or along

directions of elongation that will

grow along σ_3 or σ_2

that is perpendicular to σ_1 .

Since most phyllosilicates

are aluminous minerals,

elements,

Aluminous rocks such as shale generally develop

A foliation as a result of metamorphism

in a differential stress field.

For example,

when you have metamorphism of shale,

it will result in formation of slate

which will have cleavage schistosity.

As this,

rocks will align with your sheet silicates,

usually developing perpendicular

to the differential stresses.

This are your references.

Thank you.