

# Metamorphic Rocks

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## Introduction

The word **metamorphic** means “of changed form.” Metamorphic rocks are rocks that have been changed from one form, such as igneous or sedimentary, to another. This can occur when a given rock is exposed to intense heat, pressure, or hot fluids.

Recalling igneous rocks, the specific rock that forms from a given magma depends on the components of the magma, the temperature at which the magma cools, how quickly the magma cools and also the pressure at which the rock forms. As materials crystallize, the atoms form a structure that is most stable at the temperature and pressure of the environment.

Imagine a group of people filling a small room. If only a few people are in the room there is plenty of space for people to spread out and move around while they talk. However, as more and more people enter the room, those same people no longer have the same space and may have to adjust their bodies to become more comfortable.

Although, rocks differ significantly from people, pressure and temperature will have the same effect on the atoms that make up the rock. As pressure or temperature increases, the atoms that make up the original rock must rearrange themselves in order to form a more stable or “comfortable” structure, just as people in a room. However, since rocks are made of minerals and each mineral has a specific chemical structure and form, changing the structure and or form will then change the mineral.

The type of metamorphic rock that can form depends on the rock that is being metamorphosed as well as the amount of pressure and heat to which the rock is exposed. Since varied temperature and pressures will produce different minerals, the exact type of metamorphic rock produced depends on the *grade* (intensity) of metamorphism. The grade of metamorphism can most often be determined by the minerals present within the metamorphic rock and the type of rock formed. Some of the more common metamorphic minerals include quartz, feldspar, biotite, muscovite, chlorite, garnet, tourmaline, calcite, and amphibole. The rock that has undergone change is called the *parent rock*. Parent rocks can be any of the three types of rocks: igneous, sedimentary, or even metamorphic rocks which can be metamorphosed again.

## Metamorphic Processes

Metamorphism often occurs on two scales: contact and regional. **Contact metamorphism** occurs relatively locally, in areas adjacent to igneous intrusions or in areas that are in contact with hot water known as **hydrothermal fluids**.

Typically this kind of metamorphism is caused by moderate pressure and extreme heat that may last for a period of days to thousands of years. In cases of contact metamorphism, the most extreme metamorphism occurs at the contact point between the parent rock and the intrusive

magma or hydrothermal fluid. The degree of metamorphism then decreases rapidly as distance from the heat source increases. Depending on the source, zones of contact metamorphism may range from a few millimeters to tens of meters.

In contrast to contact metamorphism, **regional metamorphism** occurs over much larger areas. In areas such as rising mountain ranges, large igneous intrusions can form and warp overlying strata increasing the pressures above the intrusion. Also the extreme heat and pressures caused by tectonic forces or deep burial will cause widespread metamorphism.

In order to identify a metamorphic rock and understand the history of the rock, it is necessary to describe the mineralogical composition of the rock. Mineral composition of metamorphic rocks is often described in terms of relative abundance. The most abundant mineral will most often be used in naming the rock and, more importantly, will be helpful in determining the environment from which the rock formed.

### **Recrystallization, Neometamorphism, and Metasomatism**

The most common process in the formation of metamorphic rocks is recrystallization. In this process, small crystals of one mineral in contact with one another slowly come together to form fewer larger crystals. For example, the sedimentary rock, limestone. Limestone is composed of microscopic crystals of calcite that once formed the shells of marine creatures. When metamorphosed, those tiny crystals are slowly forced together under high pressure and begin to form larger, more visible crystals of calcite found in the metamorphic rock marble.

In other situations, mineral crystals may completely rearrange to form completely new minerals that are more stable under increased pressure and/or temperatures. This process is known as **neometamorphism**. This is most often observed with the sedimentary rock shale, which is composed of fine grained quartz, feldspars, and other clay minerals. When metamorphosed, these minerals grains will change to muscovite mica and garnet.

The process of **metasomatism** results in the loss or addition of chemicals. This can best be seen in the production of anthracite coal, which is almost pure carbon. The parent rock bituminous coal is produced from the aggregation of dead plant material, and anthracite is produced by the loss of the more volatile materials such as nitrogen, oxygen, and methane.





## **Classification of Metamorphic rocks**

### **Texture**

In order to identify any metamorphic rock, it is first necessary to determine its texture. The texture of a metamorphic rock is a description of its constituent minerals along with their arrangement and shape. Typically this will be initially described as foliated or non foliated. Non foliated textures have no obvious features and are classified mainly on the basis of crystal size.

**Foliation** is the existence or appearance of layers. Foliated textures result from a parallel arrangement of flat, platy minerals such as muscovite. This is usually a result of mineral

recrystallization in the presence of a directed pressure. Under this condition, the mineral grains will grow in an orientation that best distributes the force of the pressure. Typically, mineral grains will grow perpendicular to the force being enacted on them.

Foliated Textures	Examples
<p><b>Slaty Rock Cleavage</b></p> <ul style="list-style-type: none"> <li>▪ very flat foliation that resembles mineral cleavage.</li> <li>▪ develops in clay or mica rich rocks-</li> <li>▪ indicative of low grade metamorphism</li> </ul>	
<p><b>Phyllite</b></p> <ul style="list-style-type: none"> <li>▪ wavy wrinkled foliation made up of small platy minerals such as muscovite and chlorite.</li> <li>▪ usually gives rock a somewhat metallic look</li> <li>▪ indicative of an intermediate grade metamorphism</li> </ul>	
<p><b>Schistosity</b></p> <ul style="list-style-type: none"> <li>▪ a scaly layering of large (visible) crystals of platy minerals such as amphibole, micas, and chlorite</li> <li>▪ product of intermediate to high grade metamorphism</li> </ul>	
<p><b>Gneissic</b></p> <ul style="list-style-type: none"> <li>▪ Alternating layers of dark and light medium to coarse grained mineral crystals</li> <li>▪ Indicative of high grade metamorphism</li> </ul>	

Metamorphic rocks are classified based on their texture and mineralogical composition. This information will also be useful in determining the conditions under which the rock has formed, which can give valuable insight into the geologic past.

Using the following chart and the information supplied in this lab answer the questions and complete the table at the end of this lab using metamorphic rock samples supplied by your instructor.

Texture		Mineralogical composition	Name	Parent Rock	
<b>Foliated</b>	Fine Grained	Slaty Rock Cleavage	<b>Slate</b> Modify by describing color	Mudstone or Shale	
		More Wavy foliation than rock cleavage	<b>Phyllite</b> Modify by naming other minerals by order of abundance		
	Coarse Grained	Schistosity	<b>Schist</b> Modify by naming other minerals by order of abundance		
		Gneissic	<b>Gneiss</b> Modify by naming other minerals by order of abundance		
<b>Nonfoliated</b>	Fine grained	Glassy Texture	<b>Anthracite</b>	Peat, lignite, bituminous	
		Microcrystalline	<b>Hornfels</b>	Any type of rock	
		Microcrystalline-may have smooth cleavage surface	<b>Serpentinite</b>	Basalt, Gabbro, or ultramafic rock	
	Coarse grained	Sandy or crystalline texture	Quartz sand grains fused together	<b>Quartzite</b> Modify by naming quartz	Sandstone
			Calcite-reacts with acid	<b>Marble</b>	Limestone
		Conglomerate but breaks across grains	Stretched pebbles	<b>Meta-conglomerate</b>	Conglomerate



