

Metamorphic rocks

They are rocks formed to the alteration of other rocks due to **high temperatures** or **high pressures** or **chemically active fluids**, this will lead it to change so it can re-equilibriume with the environment, so any type of rock can turn into metamorphic rock

- **Marble** is a metamorphic rock originating from the sedimentary rock **limestone**, due to high temperatures in the 150 – 200 degrees celcius, **the calcium carbonate crystals** in limestone recrystallize into larger interlocking crystals forming marble.
- **Slate** is a metamorphic rock characterized by its **foliated** texture originating from the sedimentary rock **shale**, due to extreme pressure under earth's surface, the clay minerals in shale will crystallize and align into a parallel fashion
- **Garnet schist** is a metamorphic rock originating from the sedimentary rock shale, due to chemical reactions involving materials like **aluminum, iron, and silica**, during the chemical reaction, minerals inside shale like mica, feldspar and quartz will crystalize forming garnet

Metamorphism

Is when rocks whether they are **sedimentary, igneous, metamorphic** turn into metamorphic rocks due to heat, pressure, or chemical reactions, without melting entirely and turning into magma

These changes are because when we apply pressure, heat, chemical reactions to the environment of the mineral atoms

they need to adapt to the changes, this can happen by the rearrangement of atoms to make a new structure, or ions may move between atoms differently leading to a new chemical composition

Hornfels, a metamorphic rock known for bands of dark and light crystals

Metamorphism appears in a rock as

- The change from a mineral to a new mineral
- Change of the rock's texture so it becomes more crystallized
- The arrangement of its minerals in perpendicular directions to the direction of the effect applied by the pressure

Type of metamorphism

- **Regional metamorphism** is the change in **enormous quantities** of rock in a **wide area** caused by **extreme pressure** from overlaying rocks, compression by geologic processes, deep burial exposes to high temperatures
- **Contant metamorphism** is the change of rock **in contact with magma**, the change is because of the **extreme heat of magma**

Classification of Metamorphic rocks

Texture

Extreme pressure will lead to foliation in the metamorphic rocks as it's squeezed tightly by pressure, for foliation to happen, the pressure needs to be in 1 direction



Metamorphic rocks like Quartzite and marble are non-foliated

Compositionally specific names

Some rocks are named based on their dominant minerals, **Quartzite** for quartz, **Marble** for calcite

Protolith classification

Protolith is the original rock from which they formed, for example

Shale -> slate

Shale -> phyllite

Types of metamorphic rocks

Massive Metamorphic rocks

They are the product of changing rocks under the effect of **high temperature when in contact with magma or adjacent to it**, and the further you get away from the magma, the effect of the metamorphism gets weaker

They become massive, **because** the temperature results in an increase in the size of the crystals forming massive granular texture

- **Quartzite** is the result of **sandstone quartz** meeting with high temperature
- **Marble** is the result of **limestone** meeting high temperatures under the ground, where crystals of **calcite** are cemented and compacted together, it gets its attractive colors from the impurities it has, that is why it is used as an **ornamental stone**



Marble

Commented [SD2]: decorative

Foliation Metamorphic rocks

they are the product of changing rocks under the effect of **high temperatures & extreme pressure**, where the crystals expand because of the heat, but in definite directions in form of **sheets** of flakes **perpendicular to the direction of pressure**

- **Slate** is a foliated metamorphic rock that is produced from the metamorphism of **shale** under high pressure and **low heat relatively (less than 200C)** and it is used in construction purposes
- **Schist rocks** have many different types and the most important type is **mica schist**, due to its foliation properties because of the parallel arrangement of mica crystals in 1 direction
- **Gneiss** is a metamorphic rock originating from granite when exposed to heat and pressure, its mineral crystals are arranged in parallel rows and not connected and intermitted



Mica schist



Gneiss

Reasons and places for metamorphism?

Metamorphism takes place during **mountain building movement (Orogenic Movement)** or when rocks are in **direct contact** with magma or in the movement of two blocks of rocks leading to friction and heat.



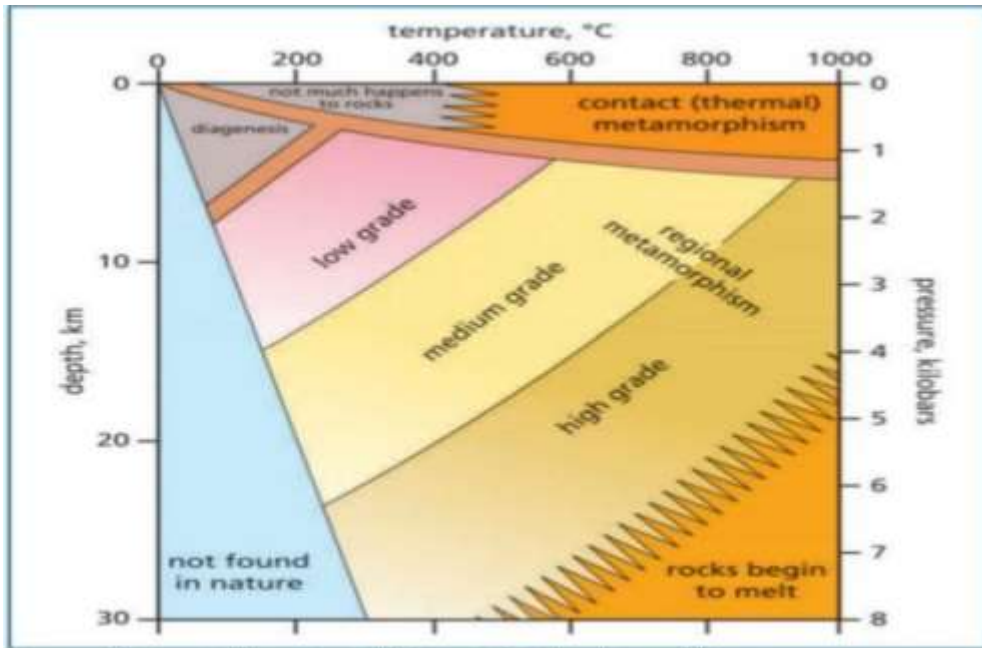


Figure 1 Diagram explaining regional metamorphism.

NEW STUFF

- **Diagenesis** is a type of metamorphism that includes chemical changes with the physical and lithification (the conversion of sediments into rock)., it doesn't need much heat or pressure, it involves processes like compaction, cementation, chemical alteration within the rock, and example is **sand -> sandstone**
- **Low grade regional metamorphism** is a type of regional metamorphism that occurs in low pressure and heat, the changes are relatively moderate, like how shale recrystallizes and turns into mica
- **Medium grade regional metamorphism** it represents a middle between low-grade and high-grade regional metamorphism, an example is like how the low grade regional metamorphic rock **slate -> phyllite**
- **High-grade regional metamorphism** is the most intense type of metamorphism occurring at very high temperatures, pressures, and depth, the rock will experience complete recrystallization and the loss of the original structure and textures, this is like how **granite -> gneiss** or how **shale -> schist**



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FACTS

- Some minerals like quartz and calcite retain their form doing metamorphism but they grow much larger
- Calcite in limestone will undergo complete erasing of the original features including fossils
- Geologists use specialized furnaces to replicate the extreme conditions of metamorphism
- The temperature for metamorphism can happen by two things
 - **Deep burial underground** by deposition of very thick layer of sediments on top of each other
 - **Friction** by colliding earth plates
 - **Passing or contacting** with magma
- If an intrusion with magma is small, a **thin layer** will be metamorphosed
- Transposition** is the movement of rock material from the original location to a new one caused by tectonic forces like folding, faulting or shearing.



Figure 2 When an igneous rock intrudes another rock, the intense heat of the intrusion can result in metamorphism of the surrounding rock. This is known as contact metamorphism.

Classification of Metamorphic Rocks			
Texture	Rock Name	Description	Rock Before Metamorphism
Strongly foliated: rocks in which platy minerals are arranged to be approximately parallel, causing the rock to split easily along parallel planes, or where mineral bands develop in which individual grains show common alignment.	Slate	Very fine grained, usually dark, splits easily along parallel planes.	Mudstone, claystone, shale
	Phyllite	Fine grained, usually dark, splits easily along parallel planes: often crinkled or folded; not as fine grained as slate.	Mudstone, claystone, shale
	Schist	Medium grained to coarse grained, with parallel alignment of platy mineral grains like micas.	Mudstone, claystone, shale, some volcanic rocks
	Gneiss	Medium grained to coarse grained, often with alternating layers of light and dark minerals.	Granite, rhyolite, some sandstones, some volcanic rocks
Weakly foliated or nonfoliated: rocks without abundant platy mineral; the rocks do not split easily along parallel planes.	Marble	Usually light colored, composed of calcite crystals.	Limestone
	Quartzite	Usually light colored, composed of quartz crystals.	Quartz sandstone
	Greenstone	Dark green, fine grained, made of various minerals rich in iron and magnesium.	Basalt
	Amphibolite	Dark colored, medium grained to coarse grained, with abundant amphibole minerals.	Basalt

Commented [SD3]: •Folding: Folding occurs when rock layers bend and warp due to compressive forces in the Earth's crust. These forces result from tectonic plate movements, and they cause the rocks to bend without breaking. Over time, this creates structures called folds, which can be categorized as anticlines (upward-arching folds) or synclines (downward-arching folds). Folds can vary in size, from small-scale bends in rock layers to large mountain ranges formed by extensive folding.

•Faulting: Faulting involves the fracturing and displacement of rock masses along fractures called faults. Tectonic stress within the Earth's crust causes rocks to break, creating faults where movement occurs. There are different types of faults, including:

○ **Normal faults:** These occur when tensional forces pull rocks apart, causing the hanging wall (above the fault) to move downward relative to the footwall (below the fault).

○ **Reverse faults:** These form from compressional forces, pushing rocks together and causing the hanging wall to move upward relative to the footwall.

•Strike-slip faults: These involve horizontal movement along a fault plane, where rocks move past each other laterally.

•Shearing: Shearing happens when rocks slide past each other horizontally along a fault plane due to lateral stress. Unlike faults where there is vertical displacement, shearing involves movement parallel to the fault plane without significant vertical movement. Shearing commonly occurs along transform plate boundaries, such as the San Andreas Fault in California.



Geo Words

- **metamorphic rock:** rock that has been changed (metamorphosed) into a different rock type, without actually melting, by an increase in temperature and/or pressure, and/or the action of chemical fluids.
- **fault:** a fracture or fracture zone in rock, along which rock masses have moved relative to one another parallel to the fracture.
- **regional metamorphism:** a general term for metamorphism affecting an extensive region.
- **transposition:** the process by which lines or planes within a material become more parallel when they are sheared.
- **foliation:** the tendency for a metamorphic rock to split along parallel planes
- **protolith:** the rock from which a metamorphic rock was formed.



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