

Unit 4: The Rock Cycle

Objective:

E 3.1c Explain how the size and shape of grains in a sedimentary rock indicate the environment of formation (including climate) and deposition.

E 3.1d Explain how the crystal sizes of igneous rocks indicate the rate of cooling and whether the rock is extrusive or intrusive.

E 3.1e Explain how the texture (foliated, nonfoliated) of metamorphic rock can indicate whether it has experienced regional or contact metamorphism.

Expectation 1

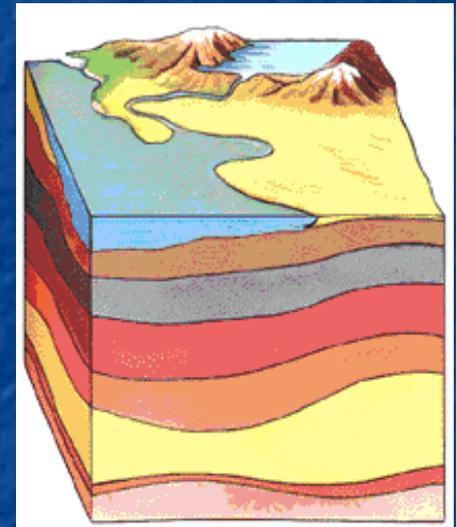
- E3.1c - Explain how the size and shape of grains in a sedimentary rock indicate the environment of formation (including climate) and deposition.

Sedimentary Rocks

Although Earth's crust consists primarily of igneous rock, most of the crust's surface is covered by sedimentary rock.

Sedimentary rock forms through the compacting and cementing of layers of sediment (also known as lithification).

Sedimentary rocks are classified by three basic formation processes (clastic, chemical, and organic).



Clastic Rocks*

Clastic sedimentary rocks are formed from fragments of other rock. The fragments come from the weathering of igneous, metamorphic, and sedimentary rocks.

Fragments may be the size of pebbles, gravel, grains of sand, tiny particles of silt, or microscopic flakes of clay.





Wentworth Scale

smaller

Particle Name

Diameter

- Clay less than 0.004 mm
- Silt 0.004 mm to 0.0625 mm
- Fine sand 0.0625 mm to 0.2 mm
- Medium sand 0.2 mm to 0.6 mm
- Coarse sand 0.6 mm to 1 mm
- Very coarse sand 1 mm to 2 mm
- Pebble (or gravel) 2 mm to 64 mm
- Cobble 64 mm to 256 mm
- Boulder more than 256 mm

larger

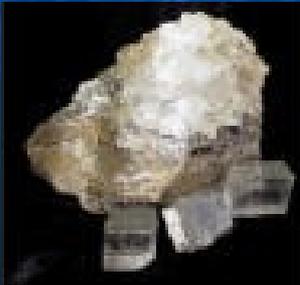
Clastic Rocks

- Conglomerates are the coarsest clastic rocks. These contain a cemented mix of rounded fragments (typically pebbles and sand grains). Breccia is an example.
- Sandstones are rough, gritty, and durable (if they are well cemented). Sandstones are typically both porous and permeable.
- Shales are smooth, soft, and easily broken. They are made of tiny flakes of clay minerals.



Chemical Rocks*

- Chemical sediments form when minerals precipitate (or fall out) of solution in waters found in seas, lakes, swamps, and underground.
- Precipitation occurs through evaporation or through chemical action (dissolved ions combining to form new minerals).
- Common examples are rock salt, gypsum, and some limestones.



Organic Rocks*

- Organic sedimentary rocks form from sediments consisting of the remains of plants and animals.
- Common organic sedimentary rocks are limestone and coal.
- Coal is formed from the fossilized remains of plants.



Environment of Formation



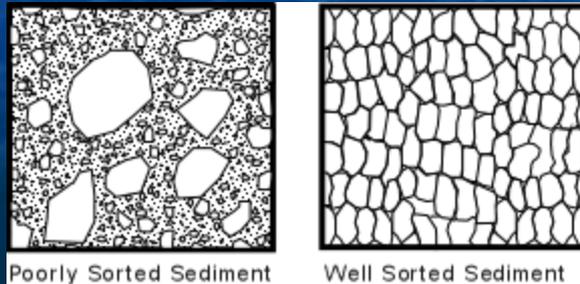
The physical characteristics of sediments are determined mainly by the way sediments were transported to the place where they are deposited. Sediments are transported by four main agents:



- * Water
- * Ice
- * Wind
- * The effects of gravity

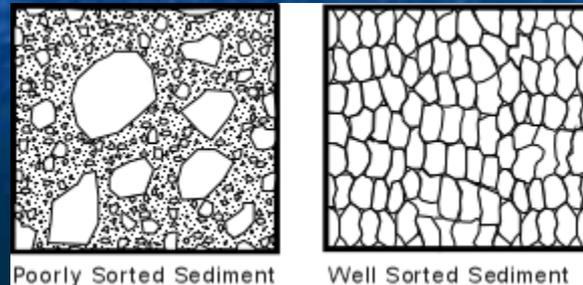
Environment of Formation

The tendency for currents of air or water to separate sediments according to size is called *sorting*. Sediments can be well sorted, poorly sorted, or somewhere in between. In well sorted sediments, all of the grains are roughly the same size and shape. In poorly sorted sediments, grains are of many different sizes and shapes.



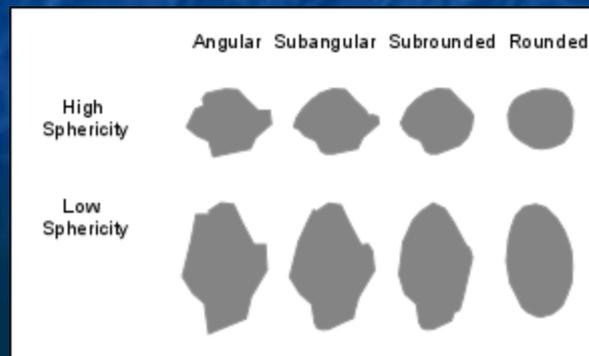
Environment of Formation

Deposition of sediments by sliding down a slope or by the melting of a glacier usually results in chaotic mixture of sediment sizes and shapes. Beach deposits and wind blown deposits tend to be well sorted because of the consistent energy of the waves and wind. The speed of a river determines how sediments are deposited, large grains are usually deposited first, while fine grains can be carried for much longer distances.



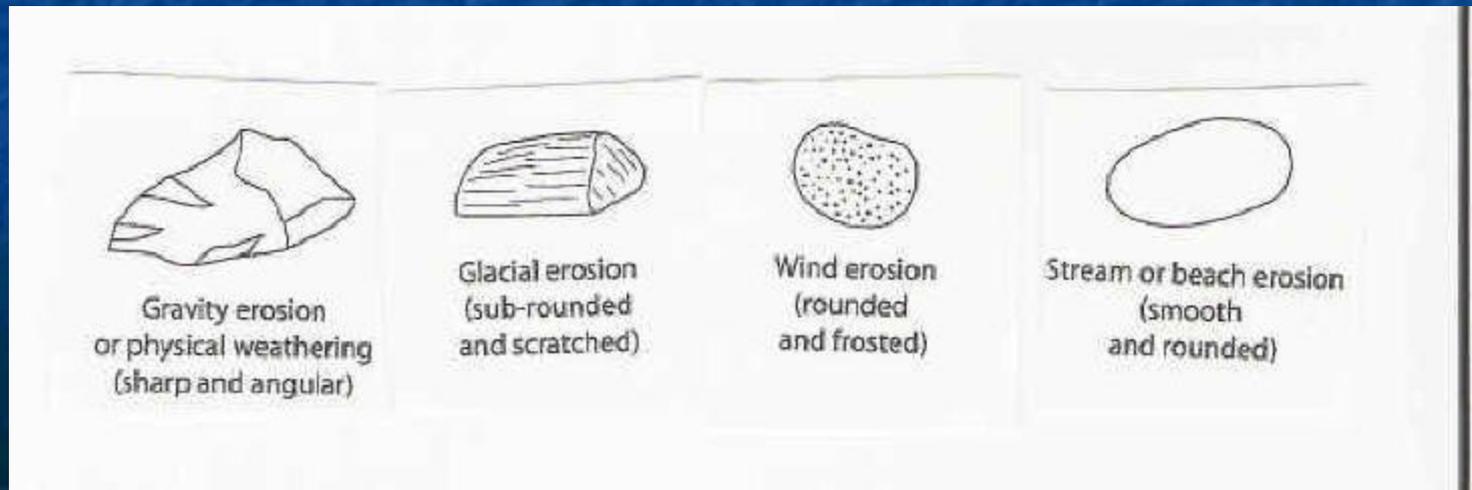
Environment of Formation

As sediments are transported, they may be reduced in size due to abrasion. The rounding of the grains (changing shape) gives us a clue about how long the sediments have been transported.



Environment of Formation

Gravity transported sediments tend to be more sharp edged or angular. Sediments moved by glaciers often have scratch marks on them (called striations). Sediments deposited by wind are often round and frosted (impact marks left by small particles striking the sediment). Sediments moved by water are often smooth and rounded (from numerous impacts).



Environment of Formation



Stratification (or layering) of sedimentary rock occurs when the conditions of sediment deposition change. The conditions may vary when there is a change in the sediment type or of depositional environment.

Environment of Formation



Some sedimentary rocks are characterized by slanting layers called cross-beds. Cross-beds generally form in sand dunes or river beds.

Zion National Park

Environment of Formation



Some sedimentary rocks clearly display ripple marks (top picture). These are caused by the action of wind or water on sand. When found, scientists know these sediments were once part of a beach or river bed.



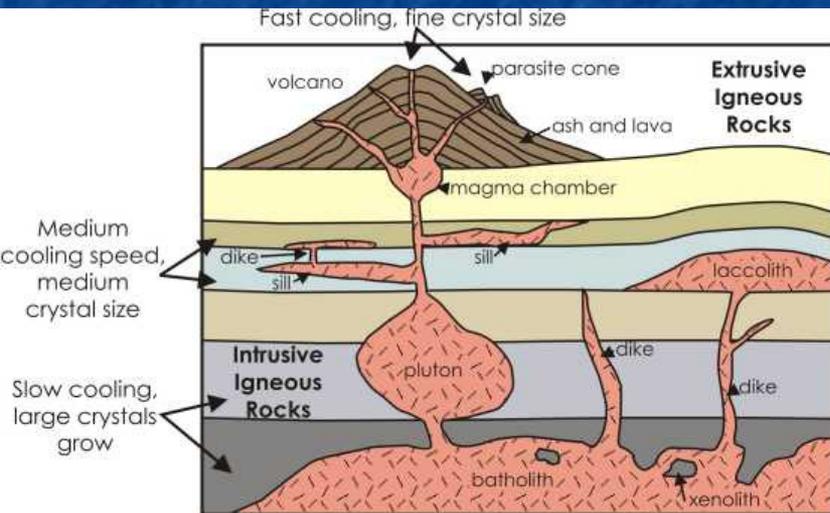
Mud cracks (bottom) form when muddy deposits dry and shrink. The shrinking causes the drying mud to crack. These usually show a river's flood plain or a dry lake bed.

Expectation 2

- E3.1d - Explain how the crystal sizes of igneous rocks indicate the rate of cooling and whether the rock is extrusive or intrusive.

Igneous Rock Formation

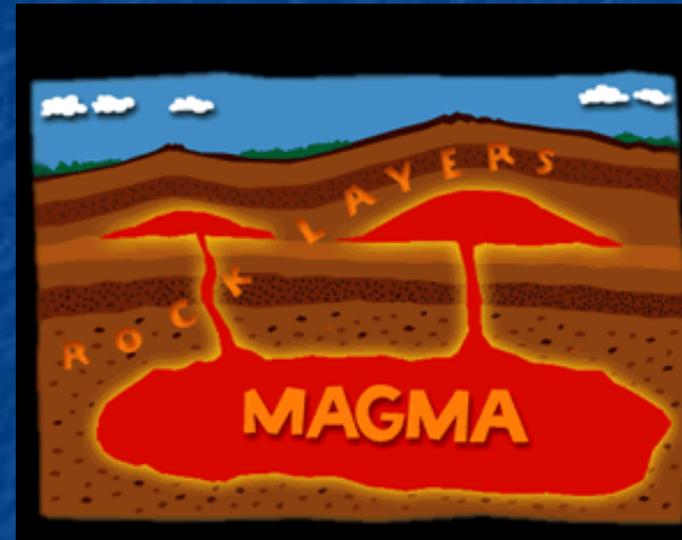
Igneous rocks are classified by their mineral composition and texture. Some igneous rocks form from volcanic ash. Most form directly from magma.



The location of the magma determines the rate at which it cools, which determines the texture of the resulting rocks. Igneous rocks formed from underground magma are called intrusive igneous rocks. Those formed at Earth's surface are called extrusive igneous rocks.

Intrusive Igneous Rocks*

- Magma trapped deep in Earth's crust hardens very slowly.
- Massive bodies of magma may take thousands of years to cool underground.
- Intrusive rocks appear at the surface when they are uplifted and the overlying rock is worn away.



Intrusive Igneous Rocks

- Have a granular, or coarse-grained, texture because the magma cooled very slowly.
- The longer the magma stays liquid, the larger the crystals will become.



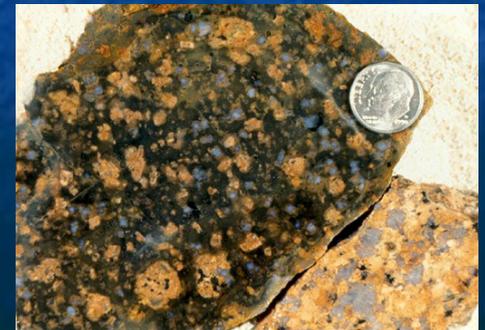
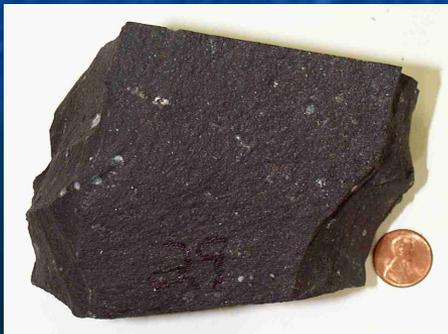
Extrusive Igneous Rocks*

- Magma pours onto Earth's surface during a volcanic eruption and is called lava.
- Magma (lava) will harden sometimes within a few hours or days.
- However, large lava flows may take years to cool and harden completely.



Extrusive Igneous Rocks

- Extrusive rocks with tiny crystals have a fine-grained texture (cooled rapidly). Basalt
- Extrusive rocks without crystals have a glassy texture (cooled very rapidly). Obsidian
- The shorter the time that the magma (lava) stays liquid, the smaller the crystals will be.
- *Porphyry* is an igneous rock in which large crystals (started cooling slowly) are surrounded by a fine-grained mass of rock (finished cooling quickly).

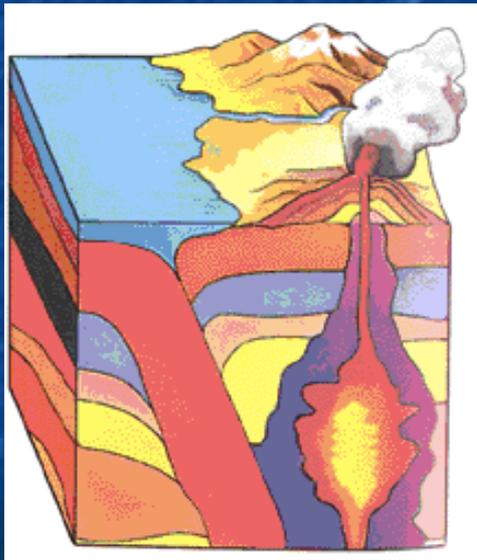


Expectation 3

- E3.1e - Explain how the texture (foliated, nonfoliated) of metamorphic rock can indicate whether it has experienced regional or contact metamorphism.

Metamorphic Rocks

Metamorphic rocks are formed from preexisting rocks called parent rocks.

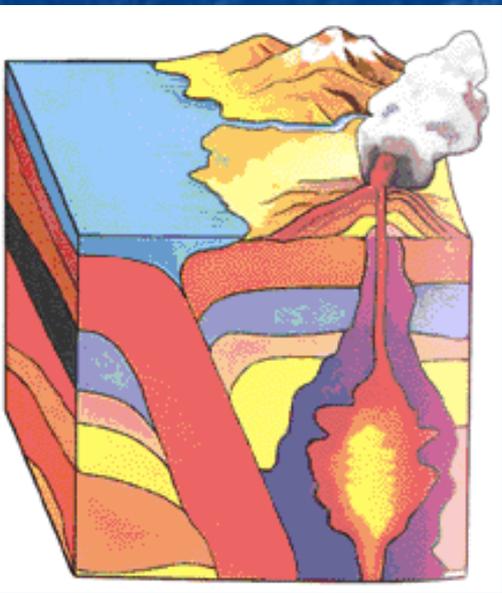


Metamorphic rocks often resembles its parent rock. Any differences between the two are a result of the metamorphic process the parent rock undergoes.

The process by which a rock's structure is changed by pressure, heat, and moisture is metamorphism.

Metamorphic Rocks

Pressure and heat can originate from Earth's internal heat, the weight of overlying rock, and the deformation of rock as mountains build.



A rock that has undergone metamorphism may have a chemical composition, texture, or internal structure that differs from the parent rock.

Minerals may be enlarged or re-formed, or new minerals may appear.

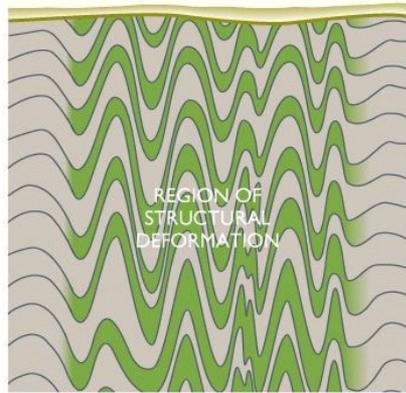
Pressure may force grains closer together, making the rock more dense and less porous.

Metamorphic Rocks*

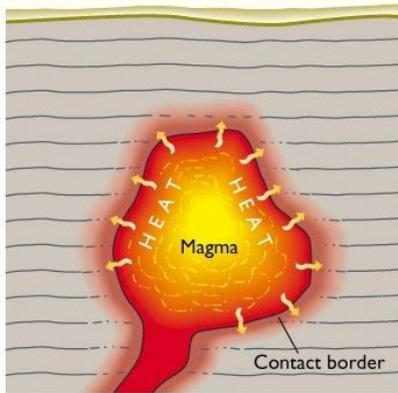
There are two basic types of metamorphism: regional and local (contact).

Where does Metamorphism occur?

Regional Metamorphism



Contact Metamorphism



(b) Contact metamorphism

(Local /
contact)

Regional metamorphism forms most of the metamorphic rock of Earth's crust; it occurs over very large areas.

Local (contact) metamorphism occurs in much smaller, more distinct areas.

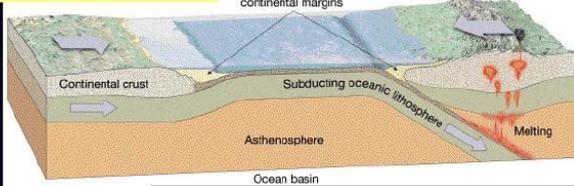
Regional Metamorphism

- Can occur during mountain-building movements of the crust, when large areas of rock change form (deformation) after exposure to intense heat and pressure.
- As mountains form, deeply buried rocks are subjected to high heat and pressure.
- The degree of regional metamorphism is influenced by the amount of heat, pressure, and fluids or gases to which the rock is exposed.
- Metamorphism occurs slowly when the parent rock is dry.

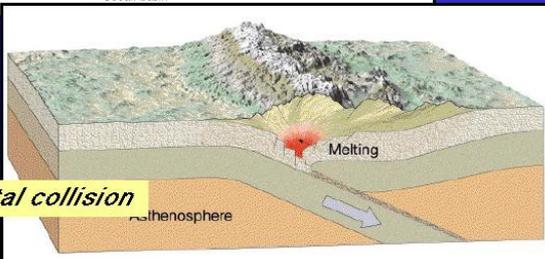
Metamorphic "styles": Regional Metamorphism

Subduction zones

Sediments deposited on continental margins

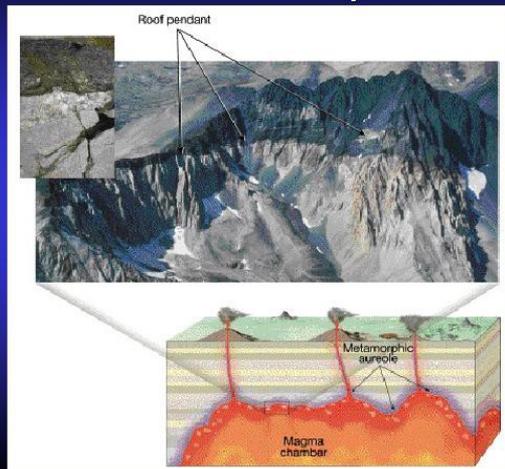


Continental collision



Local Metamorphism

Metamorphic “styles”: Contact Metamorphism



Contact metamorphism occurs when hot magma moves into rock, heating and changing it. The area affected is rarely wider than 100 meters.

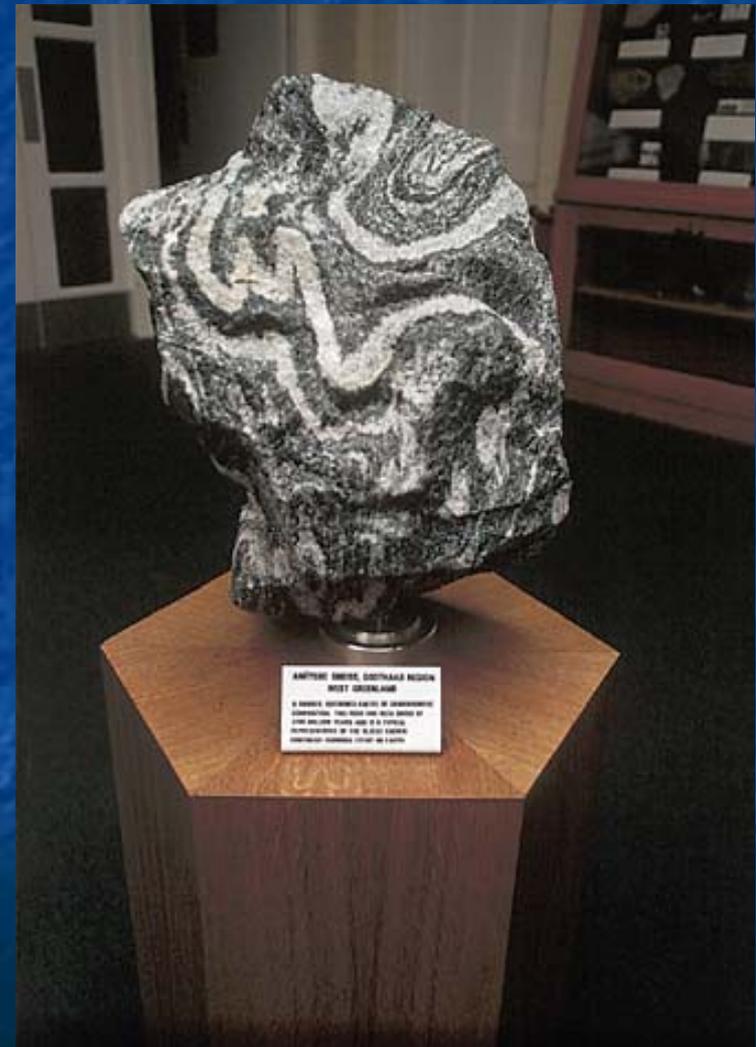
Metamorphic Rocks*

- Descriptions and identifications of metamorphic rocks are often based on the parent rock, mineral content, and texture.
- Foliation – the tendency of a rock to form bands of minerals or split along parallel layers (also used to identify and classify metamorphic rocks). Example: gneiss
- Nonfoliated rocks do not display bands of minerals. Example: marble



Foliation

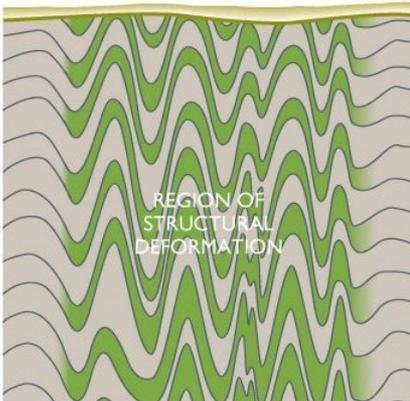
This foliated metamorphic rock is very old; at an age of 3.8 billion years, it is probably among the oldest rocks on the surface of the earth.



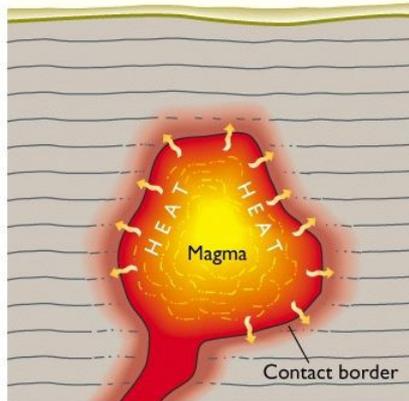
Foliation / Metamorphism

Where does Metamorphism occur?

Regional Metamorphism



Contact Metamorphism



(b) Contact metamorphism

Regional metamorphism is usually accompanied by deformation (stress), resulting in the creation of metamorphic rocks that display foliation.

Local (contact) metamorphism does not usually occur near high pressure areas, resulting in the creation of metamorphic rocks that do not display foliation.