

Metamorphic Textures (Part 1)

Metamorphism - to “*change form*.”

The degree of metamorphism is reflected in the rocks texture and mineralogy.

METAMORPHISM CHANGES TEXTURE

Two textures are formed as a result of metamorphism:

- 1) Foliated Texture
- 2) Non-Foliated Texture

Reference:

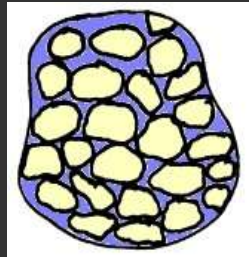
Tarbuck and Lutgens
Pages 193-196, 199
CD 426-436

Metamorphic Textures Depend On:

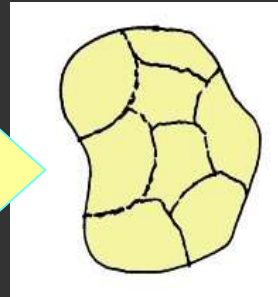
1) Recrystallization of minerals.

- Pressure causes minerals to recrystallize. This forms larger, more dense crystals.
- This process causes some metamorphic rocks to display visible crystals with no evidence of the original mineral grains. Ex: quartz sandstone changes to form quartzite.

Quartz
Sandstone



Recrystallizes

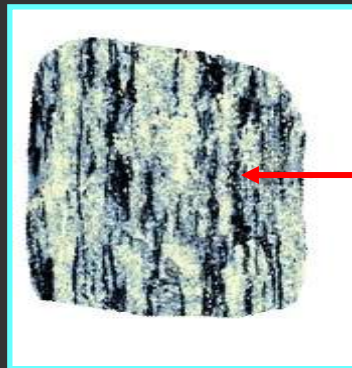


Quartzite

- Common during low-grade metamorphism. Produces a **non-foliated texture**.

2) Alignment of minerals.

- Directional stress makes minerals align when recrystallizing. The orientation is usually perpendicular to the compressional forces.
- This makes the metamorphic rock look layered.
- Common during high-grade metamorphism. Produces a **foliated texture**. Ex: Gneiss.



← Gneiss

Metamorphic Textures

Two textures form as a result of metamorphism

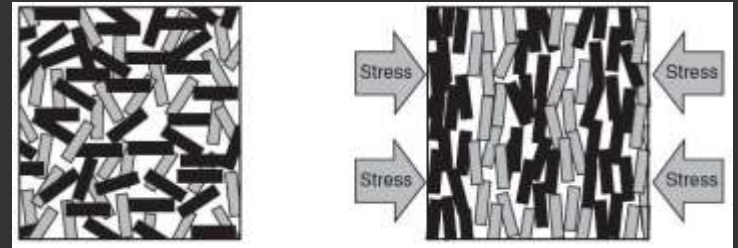
1) Foliated Texture

- When the minerals of a rock are brought into parallel alignment during recrystallization. Produces a banded or layered look.

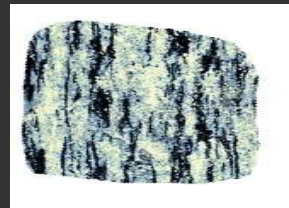
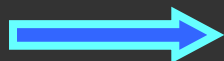
Before
Metamorphism



After
Metamorphism



- Remember Granite to Gneiss.



2) Non - Foliated Texture

- Results when the minerals of a rock are recrystallized creating uniform sized crystals with no visible foliation.
- Occurs when limestone (pure calcite) undergoes metamorphism and the smaller calcite crystals combine to form larger interlocking crystals. This forms **Marble**.



Marble

Sample Problem

Using examples, distinguish between foliated and non-foliated metamorphic rocks.

Answer:

Foliated: show layering or banding of different minerals created by the alignment of minerals during directional stress and recrystallization (Ex: schist, gneiss)

Non foliated: a mass or network of interlocking crystals consisting of one mineral with no visible layering or banding (Ex: marble, quartzite)

Agents of Metamorphism (Part 2)

- Three things cause rocks to change:
 - 1) increased heat
 - 2) increased pressure
 - 3) chemically active fluids
- During metamorphism, all three agents often occur at the same time.

Reference:

Tarbuck and Lutgens
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CD 426-436

1) Heat:

- **Most important agent of metamorphism. Provides the energy to drive the chemical reactions that recrystallize minerals.**
- Rocks are heated by burial under surface (30 C/km) and by intrusions of molten material rising from below.
- Minerals, like clay, can be buried only a few kms down, recrystallize and become stable, but, others like igneous minerals are stable at higher temperatures and pressures and must be buried deeper (20 km or more) before metamorphism will occur.
- Involved in both regional and contact metamorphism.

Heat in Regional Metamorphism

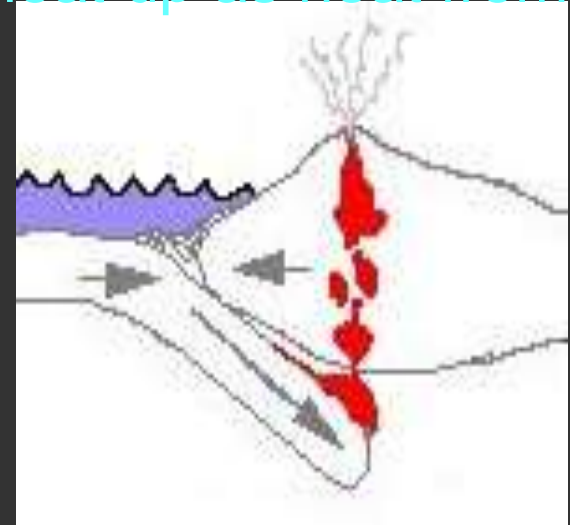
- Heat responsible for regional metamorphism in mountain environments is produced as a result of:

1) Geothermal gradient

Temperature increases 30 degrees Celsius for each kilometer below the surface.

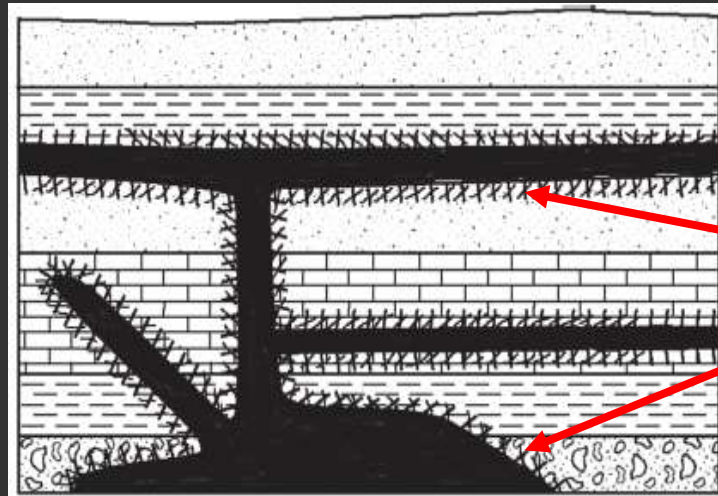
2) Intrusion of hot molten rock called magma

Causes the surrounding rock to heat up as heat from magma radiates outward.



Heat in Contact Metamorphism

- Occurs when rock is in contact with, or near, a mass of magma (Heat).
- Changes are caused by the high temperatures of the molten rock, which “bake” the surrounding rock.
- Examples include: Marble and Hornfels.



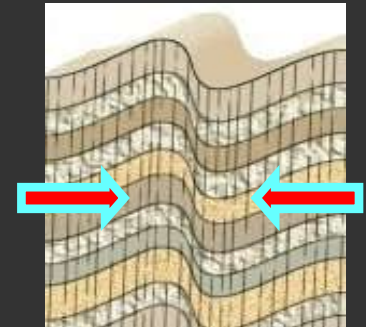
Contact Metamorphism is indicated by the “xxxx” in the diagram.

2) Pressure:

➤ **Mainly caused by:**

1) the weight of the material above which causes compression to act equally in all directions.

2) stress caused by compressional forces as tectonic plates push against one another. These are directional and cause the rock to be squeezed which result in folds and a foliated texture.



- Increases with depth beneath Earth's surface.
- Involved mostly with regional metamorphism.

3) Chemically Active Fluids:

- Influence on the metamorphism of rocks is huge.
- Water located in pore spaces of rocks is a common fluid involved in metamorphism.
- Water helps move ions through solid rock allowing it to recrystallize into a more stable structure, and help in ion exchange between minerals which allows completely different minerals to form. Ex: Garnet

Sample Problem

Contrast the conditions necessary for rock to change by regional metamorphism compared to that of contact metamorphism.

Answer:

Regional metamorphism occurs in mountainous environments, where rocks are exposed to high heat from igneous intrusions and high pressure caused by compressional forces.

Contact metamorphism can occur in any environment where a heat source (molten rock) causes the surrounding rock to change.

Thus, regional metamorphism is caused by high heat and high pressure, whereas, contact metamorphism is caused by heat only.

Sample Problem

How can contact metamorphism distinguish an igneous intrusion from a buried lava flow?

Answer:

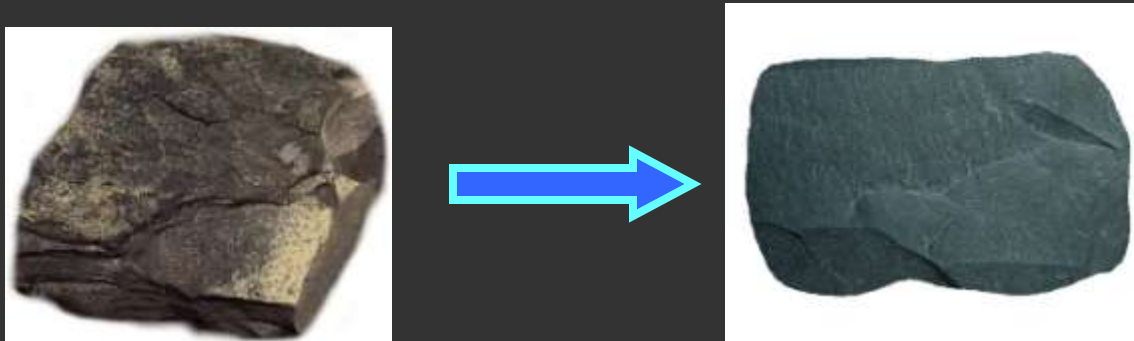
Contact metamorphism would reveal if an igneous rock unit was an intrusion or a lava flow by looking at where the metamorphism is located. An intrusion would have metamorphism above and below the igneous rock unit, whereas, a lava flow would only show metamorphism below the igneous rock unit.

Agents of Metamorphism - the Finale

- The degree of metamorphism and the effect of each metamorphic agent varies from one environment to another. The result can be:

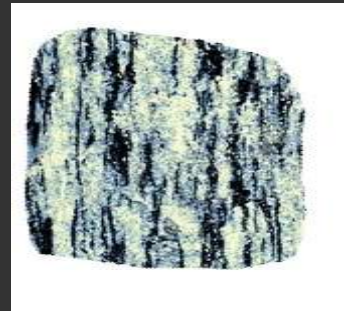
1) Low-Grade Metamorphism

- Rocks are subjected to small changes in temperatures and pressures which result in slight changes to the rock.
- Example: Shale changes to form slate.



2) High-Grade Metamorphism

- Rocks are subjected to extreme temperatures and pressures (close to that at which rocks melt) which result in great changes to the rock.
- Example: Granite changes to form Gneiss.



Sample Problem

List the agents which cause metamorphism to occur and explain how it can change quartz sandstone to form quartzite.

Answer:

Agents of metamorphism include, heat, pressure and chemically active fluids.

Quartz sandstone is composed of sand grains cemented together and may contain water in its pore spaces. Heat and pressure causes the quartz grains to recrystallize. The chemical recrystallization of the minerals is accelerated because of the activity of fluids (water) in the rock which moves the ions around. This causes larger, more dense interlocking crystals to form. This is an example of a non-foliated texture.