

ENGINEERING GEOLOGY

CE1301

Lecture #5 Metamorphic rocks

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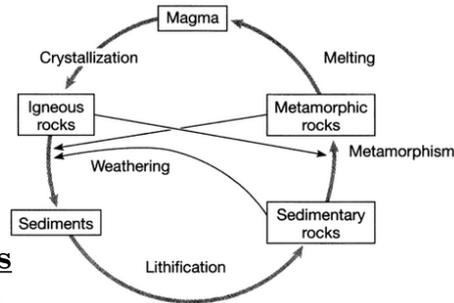
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WHAT ARE METAMORPHIC ROCKS?

Metamorphic rocks: Formed within the earth's crust from pre-existing rocks through the action of heat and pressure.

- The metamorphism “*change in form*” process involves the growth of existing minerals with rearrangement or changing of the overall chemical composition keeping that the solid state of the rock is retained.
- If complete melting occurs, the process is igneous rather than metamorphic.



Metamorphic processes

1- Contact metamorphism:

- ❖ when the metamorphism reaction occurs locally at the zone of contact (few centimeters to 2 kilometers).
- ❖ Examples of this type are skarns and hornfels.

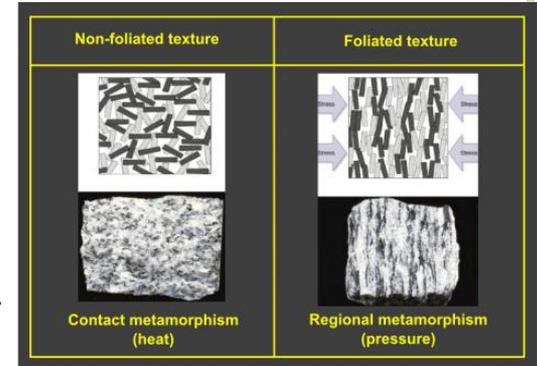


2- Regional metamorphism:

- ❖ Occurs on extremely large areas (thousands of square kilometers) and thicknesses of 1 kilometer or more.
- ❖ The increased heat weakens chemical bonds and accelerates the rate of chemical reaction, thus encouraging new minerals to form.
- ❖ The pressure encourages crystals to align themselves in a manner that will minimize pressure effects.
- ❖ The final outcome is the formation of new minerals, of increased size, oriented in a preferred direction.
- ❖ For sedimentary rocks, metamorphism occurs in sedimentary basins at depths 9-12 km. to bring these rocks to the surface, extensive uplift and erosion must have occurred.

Texture of metamorphic rocks

Foliation: refers to the pattern of mineral alignment during metamorphism (mostly with regional metamorphism) where minerals tend to align in parallel flat layers or elongated grains in segregated bands of colors. Foliated rocks tend to break along planes of weakness associated with the foliation.



Source:
<https://leakuhta.wordpress.com/2013/11/18/under-pressure-metamorphic-rocks/>

Types of Foliation

1- Slaty cleavage: consists of fractures along smooth planes in a rock that are separated by distances measuring less than a millimeter.

2- Phyllitic cleavage: consists of parallel fractures that are closely spaced but generally farther apart than slaty cleavage.

3- Schistose cleavage: consists of flakes or plates that are visible to the naked eye. The plates are formed by mica sheets or by needle-shaped minerals such as hornblende.

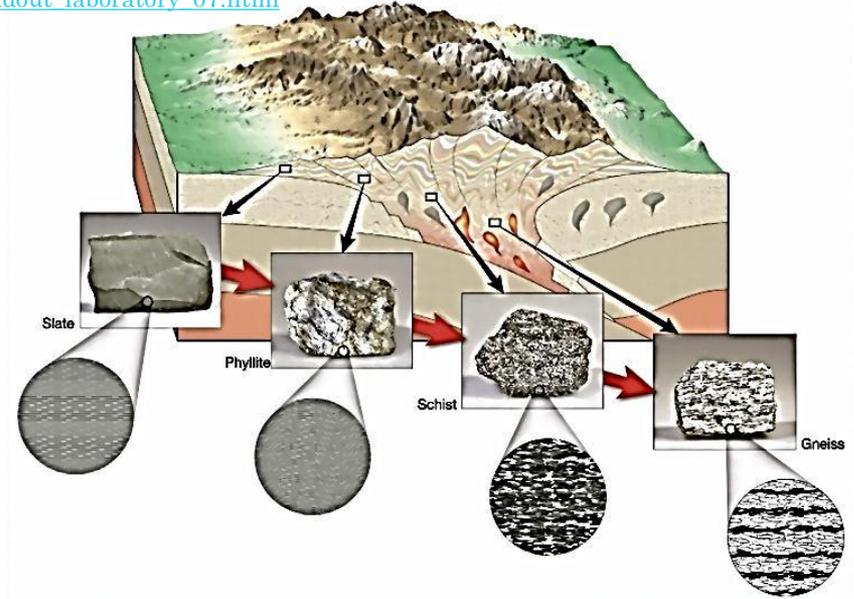
4- Gneissic structure: consists of alternating bands of coarsely crystalline minerals a few millimeters or centimeters thick.

Types of metamorphic rocks

Slate: is a rock formed from shale through low-grade metamorphism. The slaty cleavage is a result of microscopic flakes of muscovite.

Phyllite: has the same composition as slate but with larger pieces and greater quantity of muscovite. It has higher grade of metamorphism than slate.

Schist: the most abundant rock formed by regional metamorphism. The visible flakes of minerals can be for example muscovite, biotite, talc. The needle-shaped minerals can be for example hornblende.



Low Grade **High Grade**

Gneiss: is a coarse grained metamorphic rock with a banded appearance caused by alternating layers of silicate minerals such as quartz and feldspar. It is formed during high grade regional metamorphism.

Other rocks such as:

marble: composed almost entirely of calcite or dolomite and formed by either contact or regional metamorphism.

Quartzite: non-foliated formed by the metamorphism of quartz sandstone.

Metamorphic grade

- ❖ As the intensity of heat and pressure increase, the grade increases. A sequence of changes can be noted with increasing grade of metamorphism.



Engineering considerations of metamorphic rocks

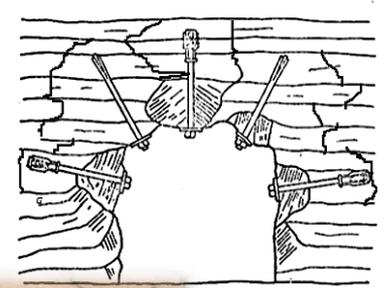
- ❖ 1- Foiled metamorphic rocks when crushed commonly gives flat and elongated shapes. If used in concrete, they cause directional properties in hardened concrete.
- ❖ 2- Gneiss containing abundant mica can show problems if used as a concrete aggregate because of the failure on cleavage plane caused by freezing-thawing, drying-wetting effects.
- ❖ 3- Schists typically are not used as aggregates because of the abundant mica present.
- ❖ 4- Foliated rocks possess prominent directional properties. Shear strength, permeability, thermal conductivity and seismic velocity are affected by the direction of foliation. Therefore care should be taken that loads (from dams, bridges and building foundations) are not transferred to foliated rocks in direction parallel to the foliation.
- ❖ 5- Coarse grained gneisses, like granites, lose gradation by abrasion when used as aggregates for construction.
- ❖ 6- Slate, schist and phyllite are subject to rock overbreak during blasting of rock cuts or tunnels because of their pronounced rock cleavage. High stress concentrations in tunnels may occur for the same reason.
- ❖ 7- The stability of rock slopes is greatly affected by the pattern of foliation with respect to the rock slope direction. When foliated dips steeply into an opening, rock slides commonly occur. Rocks bolts or tendons may be needed to prevent such failure.

- ❖ 8- Phyllite and argillite can yield alkali-silica reactive aggregates.
- ❖ 9- Marble is subject to the same problems as limestone. Solution cavities and channels may develop, resulting in leakage of reservoirs and collapse of newly formed sinkholes.
- ❖ 10- Quartzite is a massive, hard rock and has a major abrasive effect on crushing and sizing equipment. It is more expensive than most rocks because of this property.

[Source: www.chicken-wire.org](http://www.chicken-wire.org)



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