Metamorphic Rocks

http://soest.hawaii.edu/coasts/
Metamorphic rocks are former igneous, sedimentary or metamorphic rocks that have changed their texture and composition.

Change is a result of pressure (directed stress) and heat

• Solid state reaction
• No net change in chemistry (ideally – role of groundwater)
• Recrystallization of new minerals from old minerals
Solid state reaction requires that minerals recrystallize without melting. Here shale (A) composed of clay minerals made of the elements silica, aluminum, iron, magnesium, sodium and others experiences metamorphism. As temperature and pressure conditions increase (B) the elements recombine to form new compounds that are in equilibrium with the new conditions. The result is a metamorphic rock (C) called “Gneiss” with new minerals aligned with the pressure field. These are quartz, garnet, plagioclase and biotite.
Three types of metamorphism:

Cataclastic Metamorphism – grinding and shearing of rock

Contact Metamorphism – heat/baking of rock

Regional Metamorphism – pressurization/heating of rock
Texture and Composition

Cataclastic – no composition change – texture is sheared/ductile, foliated

Contact – composition change – texture is nonfoliated

Regional – composition change is gradational – texture is foliated

**index minerals**
- chlorite
- muscovite
- biotite
- garnet
- sillimanite
Mylonite is formed by crushing in fracture zones where two pieces of rock slide and grind past one another - shearing.

Minerals become aligned and layered upon each other by the shearing action.

Originally round quartz grains (q) are squashed and pulled like taffy

Each grain is surrounded by mylonite (m).
Cataclastic – no composition change – texture is sheared/ductile, foliated

Rock - Mylonite
Metamorphic Aureoles – zones of metamorphic minerals formed by heat of intrusion
Contact Metamorphic Rocks

Quartzite
SiO$_2$

Interlocking grains in both

Marble
CaCO$_3$
Contact – composition change – texture is nonfoliated

Rock - Marble

Rock - Quartzite
Temperature and pressure increase in the crust, eventually leading to melting. As a result, rock may experience different grades of metamorphism depending on the conditions. The concept of *gradational change*, from low-grade metamorphism to high-grade metamorphism, reflects the significance of the changes that occur.
Granite

Uniform Stress

Directed Stress

Directed Stress

Lower stress

Intermediate stress

Higher stress

Granite

Gneiss
Flattened Conglomerate Pebbles

Directed stress
Foliation through a microscope
Index Minerals

Increasing temperature and pressure (metamorphism)

Diagenesis

Low-grade

High-grade

Shale (sedimentary)

Slate

Phyllite (metamorphic)

Schist, gneiss

Clay

Chlorite

Muscovite mica

Biotite mica

Garnet

Kyanite

Sillimanite

Feldspars

Quartz

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Regional – composition change is gradational – texture is foliated

Increasing metamorphism

index minerals
chlorite
muscovite
biotite
garnet
sillimanite

Slate
Phyllite
Schist
Gneiss

Increasing metamorphism
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Metamorphic Rocks (7)

Contact Metamorphic
- Marble

Regional Metamorphic
- Slate (L)
- Phyllite (R)
- Schist

Cataclastic Metamorphic
- Mylonite

Gneiss