

Metamorphic Rocks

- **METAMORPHISM:** a process that occurs typically at elevated temperature and pressure to produce changes in texture and assemblage of minerals present in the original, or parent rock
- Includes recrystallization: making new minerals from original minerals, or changing the texture of the rock
- Metamorphism is a solid state transformation.

Factors of Metamorphism

- **High temperature:** lower limit ~150°C (diagenesis) and upper limit ~ 700°C to 900°C (melting of granite or basalt)
- **High pressure:** commonly due to overlying rock or force applied during mountain building
- **Shear stress:** deformation of rock, typically in association with mountain building
- **Presence of fluids** (especially H₂O): active in making and breaking chemical bonds

Styles of Metamorphism

- **Contact metamorphism**
 - Achieved as heat energy passes from a cooling body of magma into the enclosing (or host) rock
 - Occurs at **high temperature** and (typically) low pressure
 - Normally affects a small area.
- **Regional metamorphism**
 - Associated with mountain-building
 - **High temperature, high pressure and shear stress**
 - Affects a large area.

Metamorphic Grade

- Low-grade (mild) metamorphism: small changes in texture and/or mineralogy of parent rock (150-200°C)
- High-grade (extreme) metamorphism: radical changes in texture and/or mineral composition of the rock

Metamorphic Texture

- **Foliation:** Parallel alignment of platy or elongate mineral grains (mica/amphibole) in a rock caused by directed stress.
- Foliated textures:
 - **slaty cleavage:** parallel alignment of microscopic platy minerals (mainly mica). **LOW-GRADE METAMORPHISM**
 - **phyllitic texture:** parallel, but wavy, foliation of fine-grained platy minerals (mainly mica and chlorite) exhibiting a shiny or glossy luster. **LOW-GRADE METAMORPHISM**
 - **schistosity:** parallel to sub-parallel foliation of medium to coarse-grained platy minerals. **INTERMEDIATE TO HIGH-GRADE METAMORPHISM**
 - **gneissic layering:** discontinuous light and dark layering due to mineral segregation. **INTERMEDIATE TO HIGH-GRADE METAMORPHISM**

Metamorphic Texture (continued)

- **Nonfoliated** texture:
 - absence of parallel layers of platy minerals
 - may exhibit stretched grains (ductile deformation)
 - normally composed of stubby, interlocking grains approximately the same size

Textural Changes

- Other changes that can occur during metamorphism:
 - Crystals grow in size.
 - Minerals can become segregated from one another to form compositional layering (as in gneiss).
 - Crystal shapes can become distorted (ductile deformation).
 - New minerals can form:
 - polymorphic transformation
 - reshuffling of atoms to form new minerals with no change in bulk chemical composition

Mineral Assemblages

Depend upon:

- chemical composition of parent rock
- intensity of metamorphism (involving temperature, pressure, shear stress)

Mineral assemblage can change with no change in bulk chemical composition.

Shear Stress (directed stress)

- Distortion or deformation (change in shape or size, or both)
- Development of lineation: single, preferred orientation of elongated crystals (such as hornblende)
- Development of foliation: crystals with platy habit (such as mica) lining up parallel

Index Minerals

- Diagnostic minerals indicate restricted range of pressure-temperature conditions of metamorphism.
- General appearance with increasing metamorphism:
 - Low grade-----→high grade
 - Mica appears (clay disappears)→garnet and staurolite appear; amphibole increases→pyroxene increases (mica disappears)
 - H₂O-rich-----→H₂O-absent

Increasing Metamorphic Grade

Mudstone/shale→ slate → phyllite → schist
→ gneiss

(fine-grained) → (medium-coarse grained)

Bulk Composition

- Although a mineral assemblage may change with an increasing grade of metamorphism, the bulk chemical composition of the original parent rock commonly does not change (except for loss of water).
- Examples:
 - Quartz sandstone-----quartzite
 - Limestone/dolomite-----marble
 - Basalt-----amphibolite
 - Granite-----granite gneiss