

# Metamorphism / Metamorphic Rocks

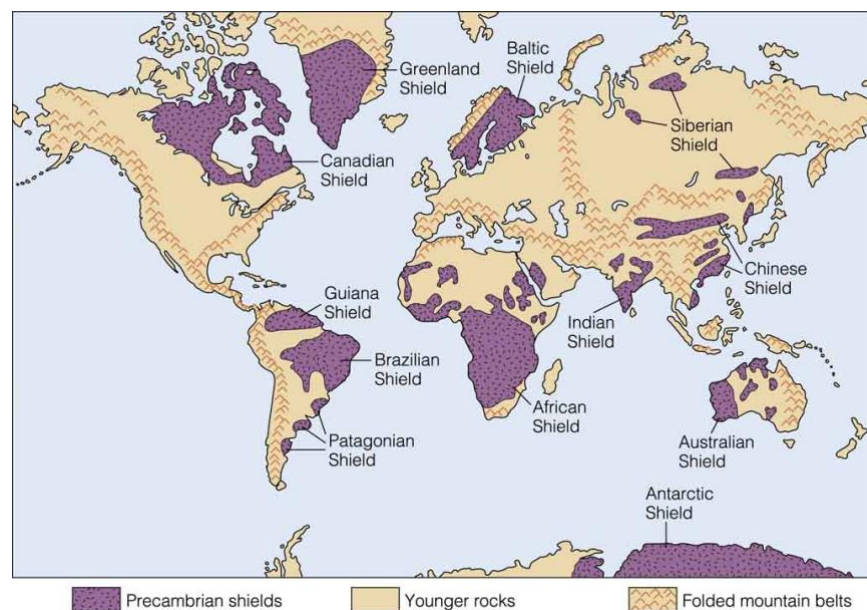
**Metamorphism:** occurs when rocks are subjected to *heat*, *pressure*, and/or *other environmental* conditions  
- The rock remains a solid during this time

## - Why Should You Study Metamorphic Rocks?

- Exposed metamorphic rocks make up large parts of continents
- Certain minerals in metamorphic rocks give clues about the conditions existing when they formed
- Used widely as building materials and manufacturing

## - Why does Metamorphism occur?

- Minerals are only stable only within certain temperature and pressure ranges.
- Minerals will decompose and rearrange to form different minerals that are stable at the new temperature and pressure

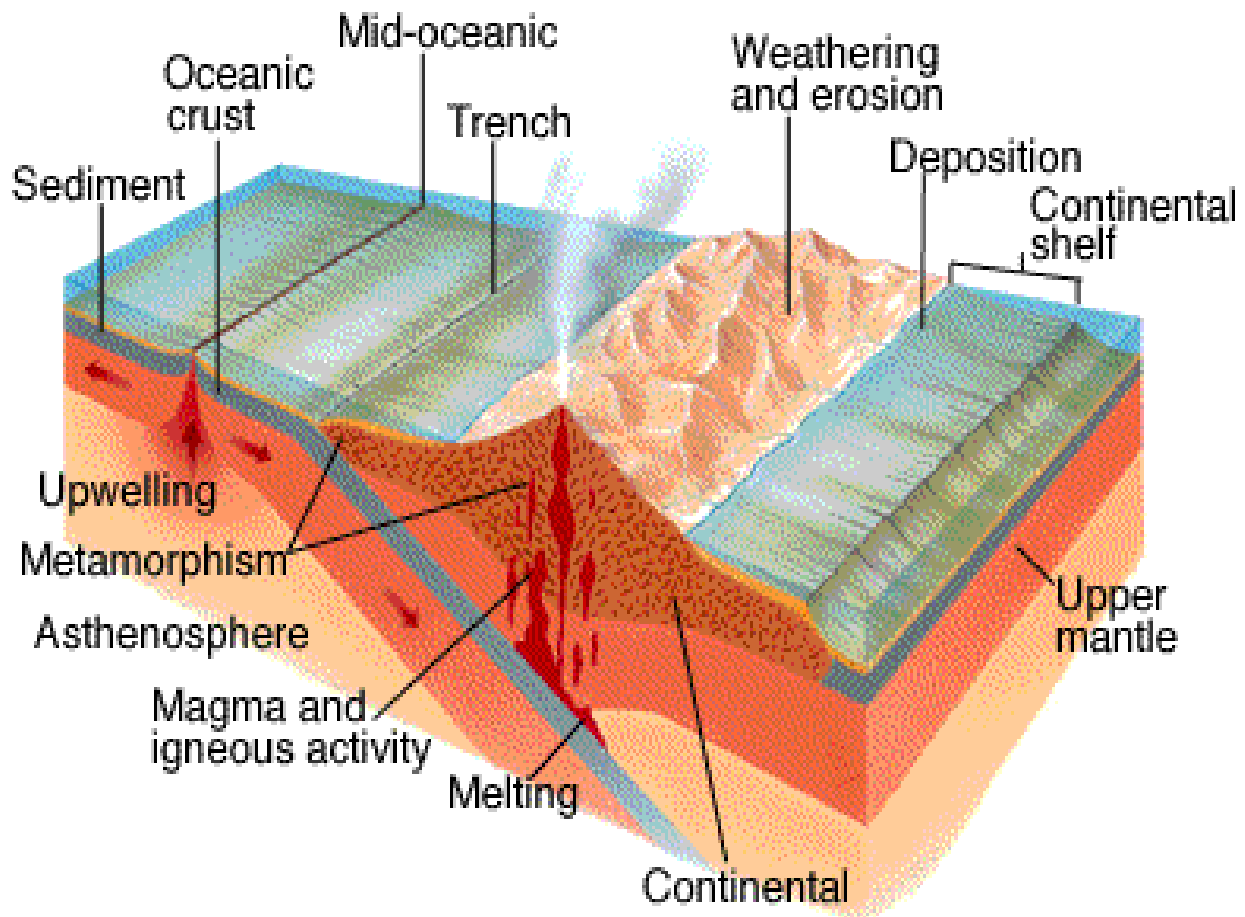


## - Factors that Cause Metamorphism

\* Temperature and Pressure! \* & Fluid activity

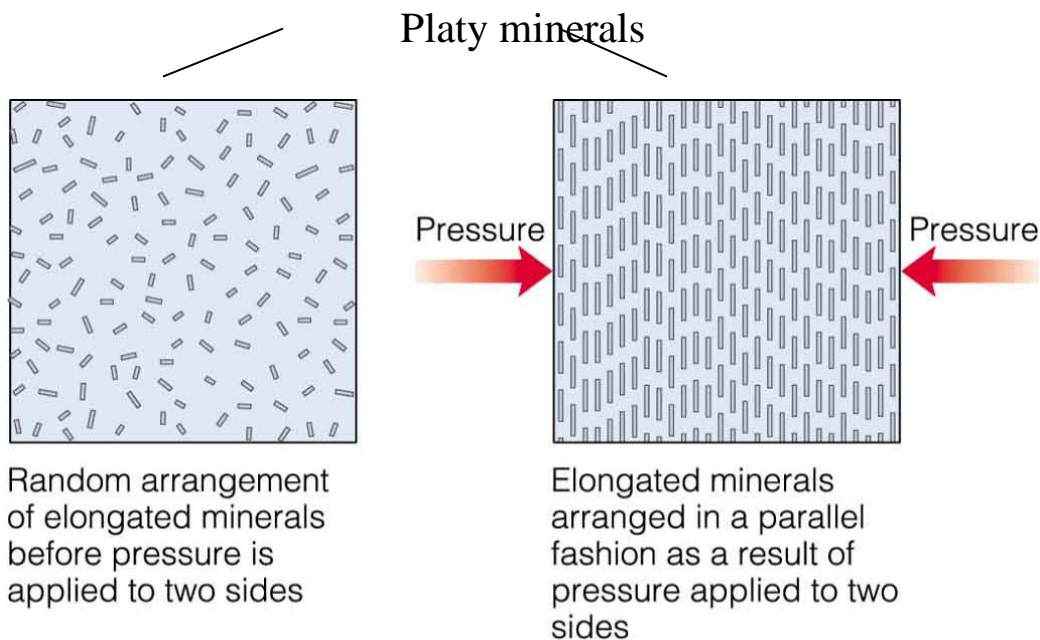
### - Temperature

- The deeper you go, the hotter it gets
  - Geothermal gradient =  $20-30^{\circ} \text{C/Km}$
  - Depth  $\downarrow$  Temp  $\uparrow$
- Increases the rate of chemical reactions that produce different minerals
- Heat sources
  - intrusive magma
  - deep burial along subduction zones



## - Pressure

- The deeper you go the more pressure there is
  - **lithostatic pressure:** from the weight of overlying rocks
    - Depth ↓ Temp ↓
  - Expressed in kilobars
    - 1 kilobar = 1000 atmospheres
    - 1 atmosphere = 14.7 lb/in<sup>2</sup>
    - 1 kilobar = 14700 lb/in<sup>2</sup>
  - Pressure increases .3 kilobar/km
  - Mineral grains are more closely packed
  - Recrystallization may occur
  - **Differential pressure:** from unequal forces applied to the rock
- **Deformation:** Changes in the shape of the rock due to mechanical forces. Results in foliation (layering). Foliation is perpendicular to pressure.



\*The layers are said to have Slaty Cleavage\*

## - Fluid Activity

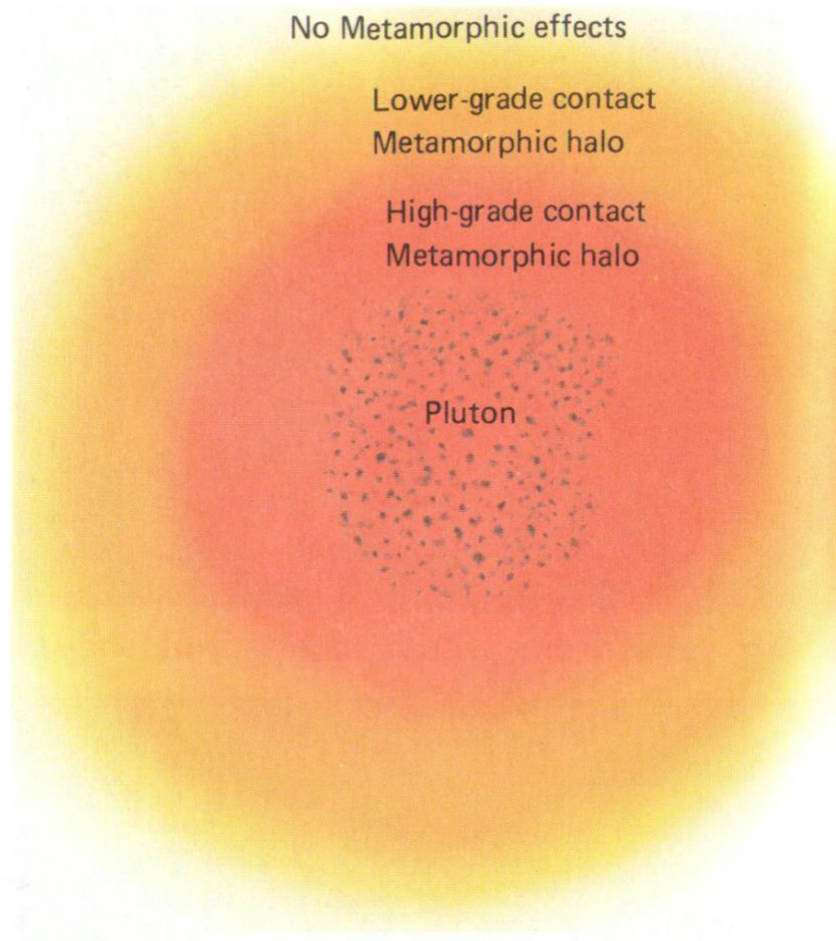
- water and carbon dioxide are almost always present in some amount in metamorphic regions
- these fluids enhance metamorphism by increasing the rate of chemical reactions

## - Fluid Source

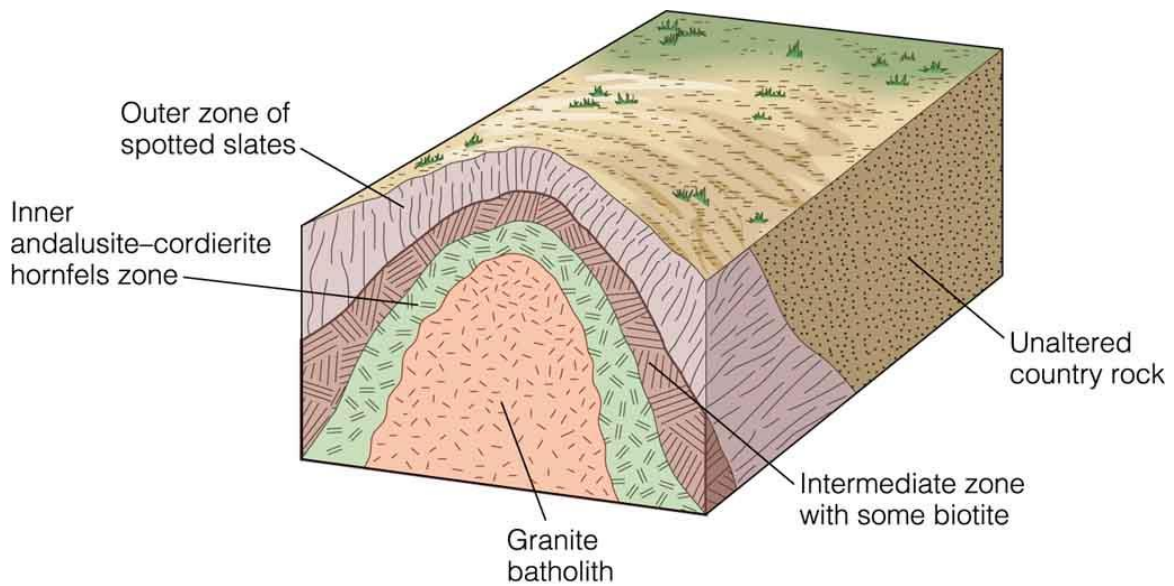
- water trapped in the pore space of sedimentary rocks (groundwater)
- from cooling magma (juvenile water)
- dehydration of water-bearing minerals that are subjected to heat and pressure: water released due to metamorphism (metamorphic water)

## Types of Metamorphism

- **Contact Metamorphism:** produced when a body of magma alters the surrounding country rock
  - causes old minerals to decompose and new ones to form, causes metamorphism to occur
- Factors in contact metamorphism
  - initial temperature and size of the intrusion
  - presence and chemistry of fluids
- Metamorphic aureoles (halo)
  - zones of mineral assemblages surrounding intrusion



Contact metamorphic halo surrounding a pluton

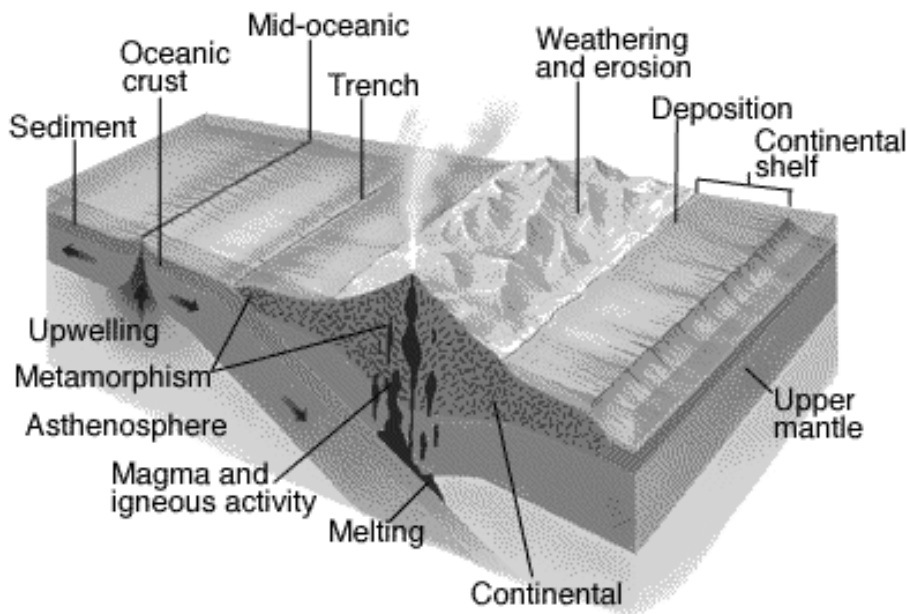


- Rock Characteristics
  - Nonfoliated
  - Little to no deformation

- Typical Contact Metamorphism Rocks
  - *Hornfels*: dark to black
  - *Skarn (tactite)*: Contact metamorphism of carbonate rocks: limestone or dolomite
  - usually, large grained or crystals

## - Regional Metamorphism

- occurs when 2 lithospheric plates collide and squeeze and deform rocks as a result
- highly deformed
- associated with mountain building
- produces most metamorphic rocks; makes up the shields
- results from extreme heat and pressure generated by the processes at convergent plate boundaries
- covers large geographic areas, and usually shows a gradation of deformation corresponding to areas of the most intense heat/pressure

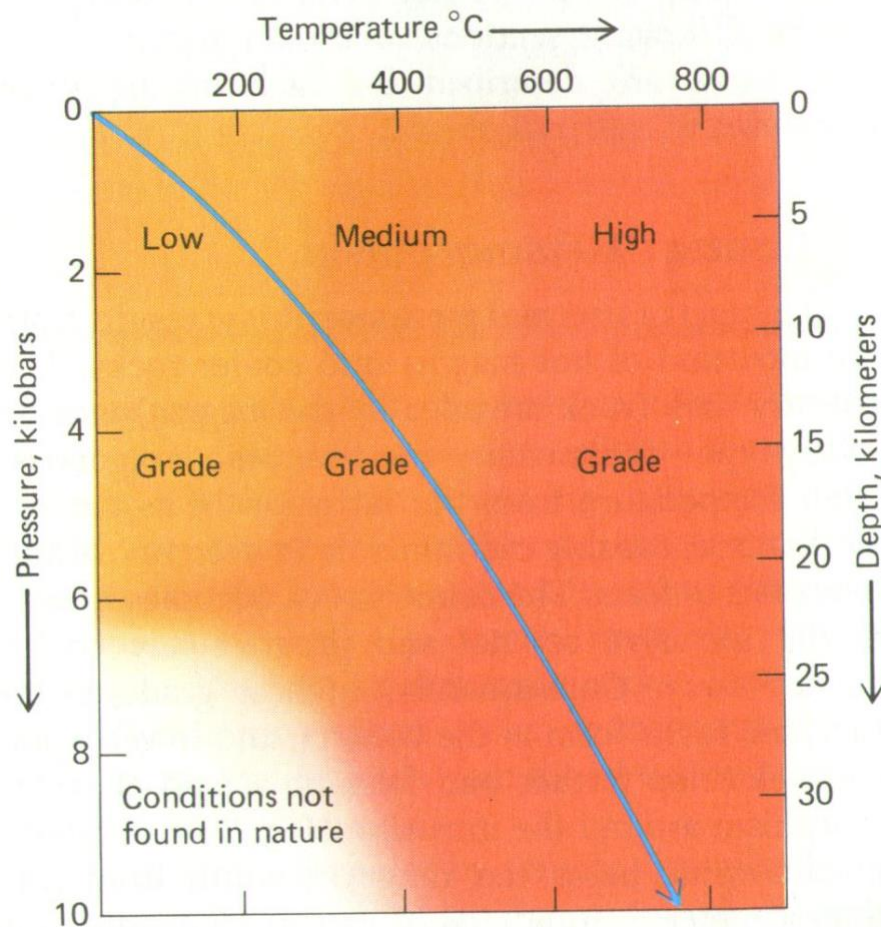


- certain minerals are known to form under specific conditions of temperature and pressure: *index minerals*
- low, intermediate, and high grades of metamorphism are recognized, based on conditions and the resulting mineral assemblages

## Types of Metamorphism and Metamorphic Rocks

Metamorphism is divided into three general categories on the basis of the causes of metamorphism.

**Figure 7–8** Temperature, pressure, and depth ranges of low-, medium-, and high-grade metamorphism. The arrow represents a “normal” geothermal gradient such as found within a stable craton.



## - Foliated Metamorphic Rocks

- Heat and differential pressure cause minerals to arrange themselves in a parallel fashion called foliation
- size and shape of crystals determines texture; fine to coarse
- with increasing grain size, common foliated metamorphic rocks include:

### - Slate



### - Phyllite



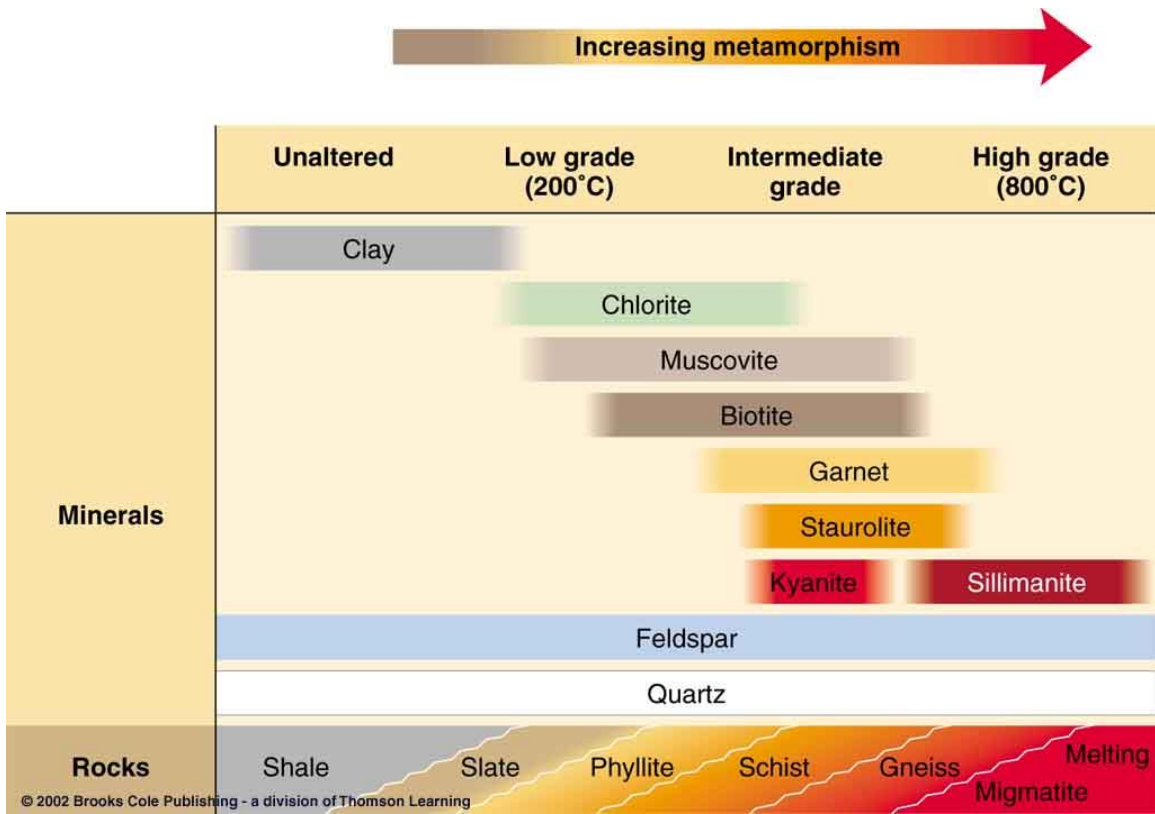


- Schist



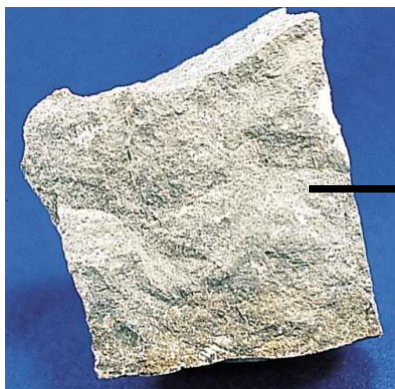
- Gneiss





## - Regional Burial

- (subset of regional): occurs when rock is buried at depths greater than 2 Km
  - Lots of pressure; 1 cubic foot of granite equals 168 lbs.
  - Non-foliated
  - Common rocks
    - *Marble*: parent rock is limestone

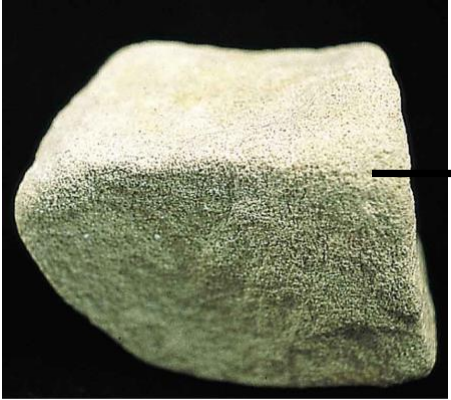


Limestone



Marble

- *Quartzite*: parent rock is quartz sandstone



Quartz sandstone



Quartzite

- In sandstone (A) fractures run between the sand grains. In quartzite (B) fractures run through the grains

