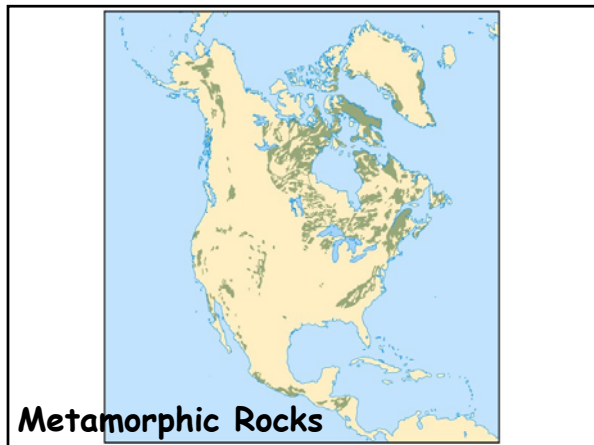


### Metamorphic Rocks

- Recrystallization or deformation in solid state
- New environment = new minerals
- Growing minerals create a new texture

Conglomerate      Metaconglomerate



- Recrystallization
  - T, P or change in pore fluid composition
  - Original features destroyed

Limestone      Marble

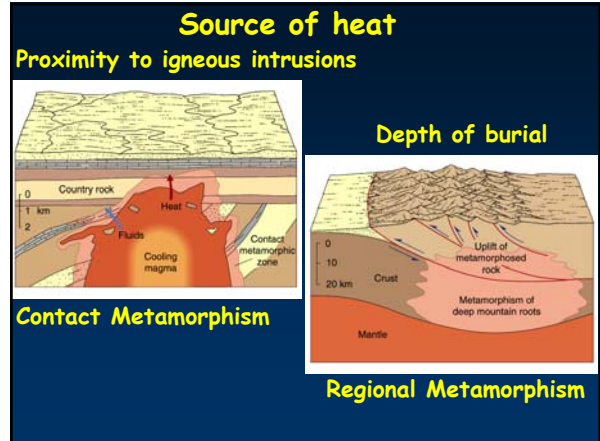
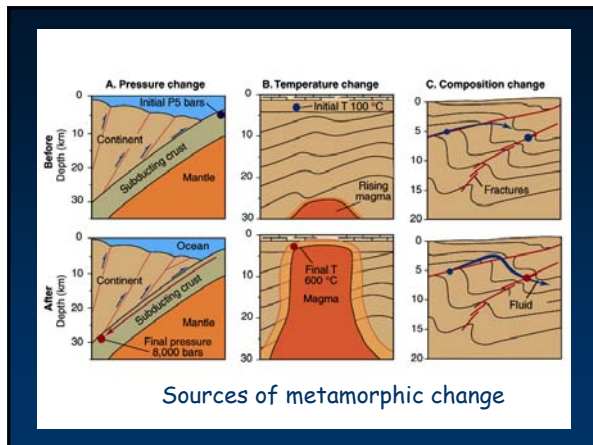


## Metamorphism

- Textural changes
  - New minerals grow and replace old minerals
- Metamorphic conditions influence crystal growth

## Origin of Metamorphic Rocks

- Temperatures above **200°C**
  - High Pressures (approx. 10,000 ft deep)
- Metamorphism ends when melting begins (~700°C)





## Origin of Metamorphic Rocks

- T & P determine degree of metamorphism & mineral assemblage
  - Low-grade metamorphism
  - Intermediate-grade metamorphism
  - High-grade metamorphism

## Origin of Metamorphic Rocks

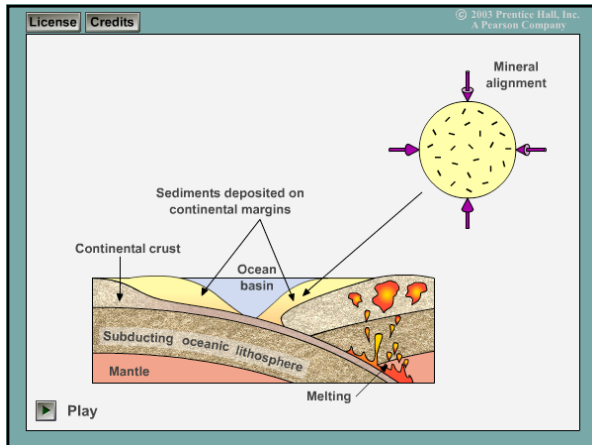
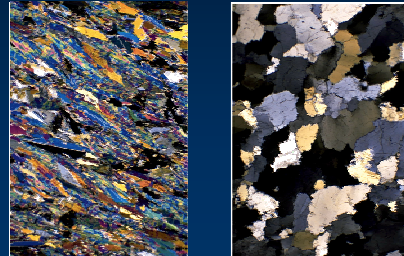
- Role of fluids
  - water and  $CO_2$ , dissolved ions
  - Fluids interact with rock
  - "Hydrothermal" alteration, ore deposits

## Deformation

- Pressure increases
- Stress
  - Uniform Stress 
  - Differential Stress 

## Deformation

- Mineral growth responds to stress
  - Foliation, foliated texture
  - Nonfoliated texture
  - Mylonite - Intense shear stress



## Metamorphic Rocks

- Classified by texture and composition
  - foliated & nonfoliated rocks
  - Mineral composition
    - Provide T & P conditions

## Foliated Rocks

SHALE	SLATE	SCHIST	GNEISS
Homogeneous	Slaty cleavage	Conspicuous foliation	Layering
Clay minerals	Microscopic mica grains	Large mica grains	Large feldspars and micas
Crystal growth			
Intensity of metamorphism →			

Progressive metamorphism of shale

## Foliated Rocks



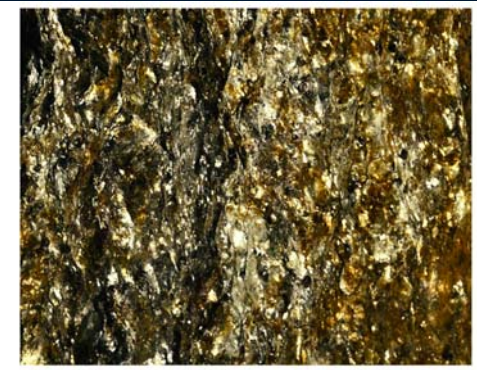
Slate - originate from Shales, Micas form

### Foliated Rocks



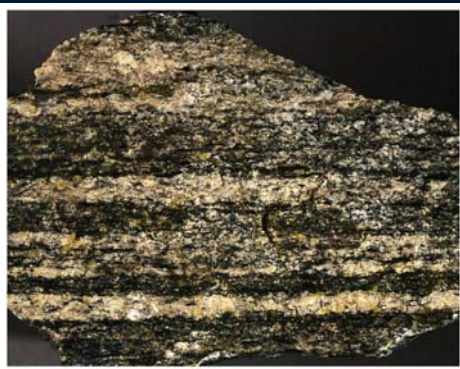
Recrystallization proceeds further than Slate

### Foliated Rocks



Schist - Coarsely crystalline Micas

### Foliated Rocks



Gneiss - Layering, Micas and Feldspars

### Nonfoliated Rocks



Marble - Sedimentary features destroyed

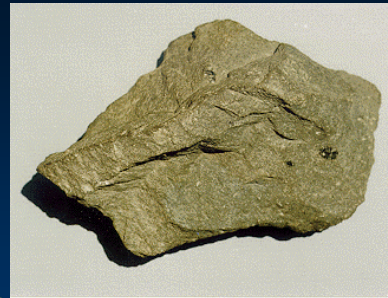
### Nonfoliated Rocks



• Sandstone

• Quartzite

### Nonfoliated Rocks



- Greenstones
- Low-grade metamorphism of mafic rocks

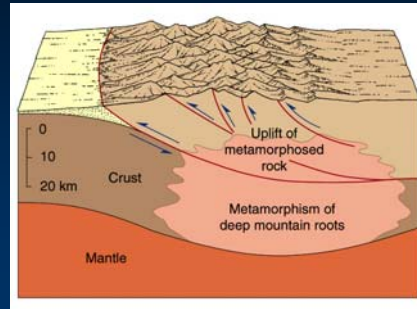
## Nonfoliated Rocks



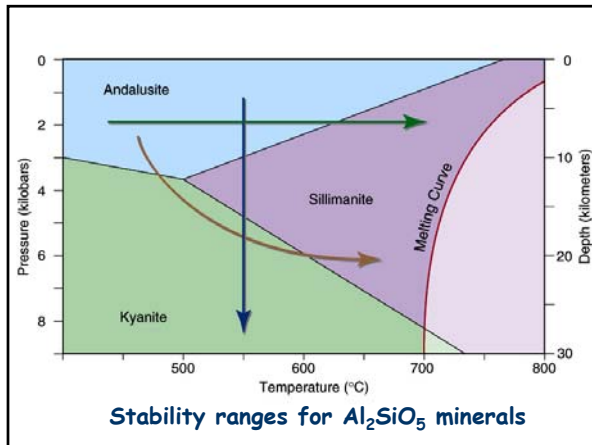
Granulite - High grade metamorphism

## Regional Metamorphic Zones

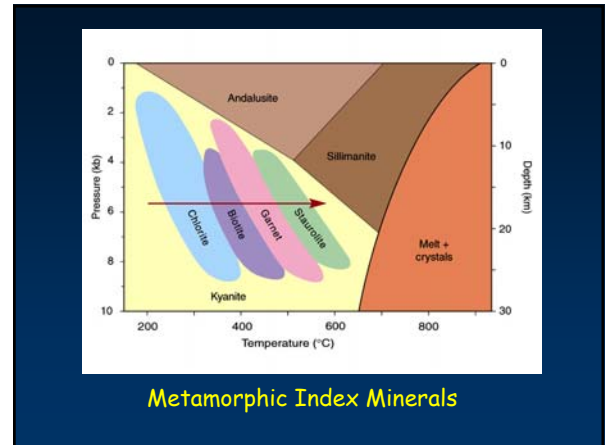
### Depth of burial



Metamorphic zones are defined by index minerals

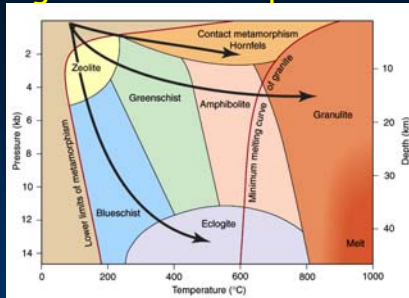


Stability ranges for  $Al_2SiO_5$  minerals

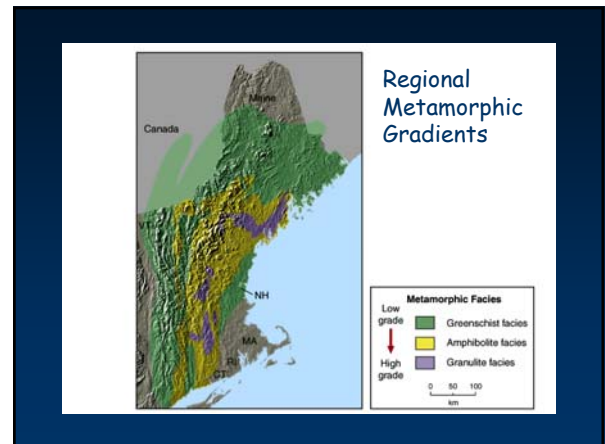


Metamorphic Index Minerals

## Regional Metamorphic Zones



Different mineral assemblages form at a given P & T for various parent rocks  
- Define a **metamorphic facies**



# Metamorphic Rocks & Tectonics

