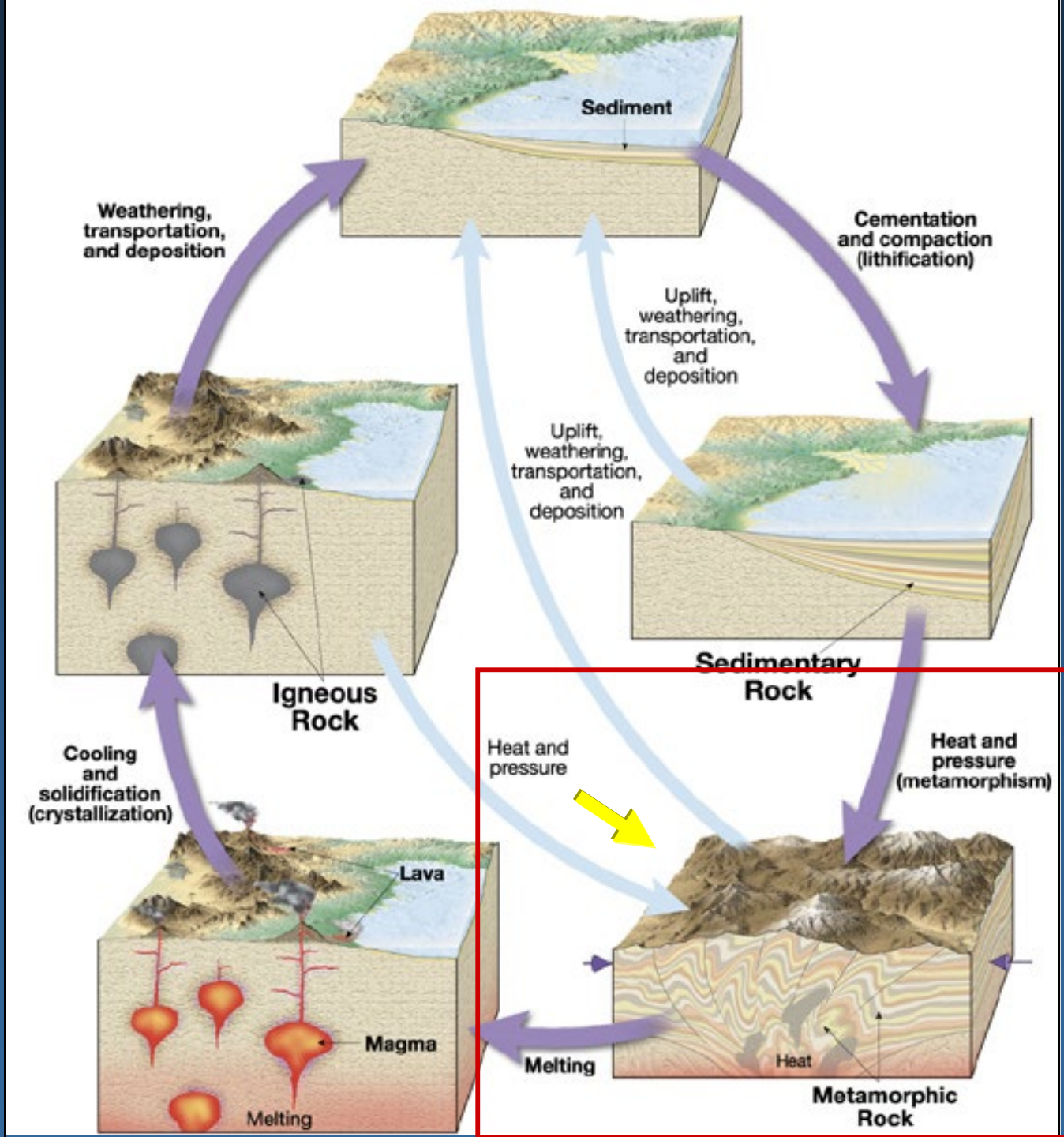
Metamorphism & Metamorphic Rocks

((adapted from Brunkel, 2012)


Sediment
Weathering, transportation, and deposition
Cementation and compaction (lithification)
Uplift, weathering, transportation, and deposition
Uplift, weathering, transportation, and deposition
Igneous Rock
Sedimentary Rock
Cooling and solidification (crystallization)
Heat and pressure
Heat and pressure (metamorphism)
Lava
Magma
Melting
Melting
Heat
Metamorphic Rock

Metamorphic Rocks

- Changed rocks- with heat and pressure
  - But not melted
  - Change in the solid state
- Textural changes (always)
- Mineralogy changes (usually)

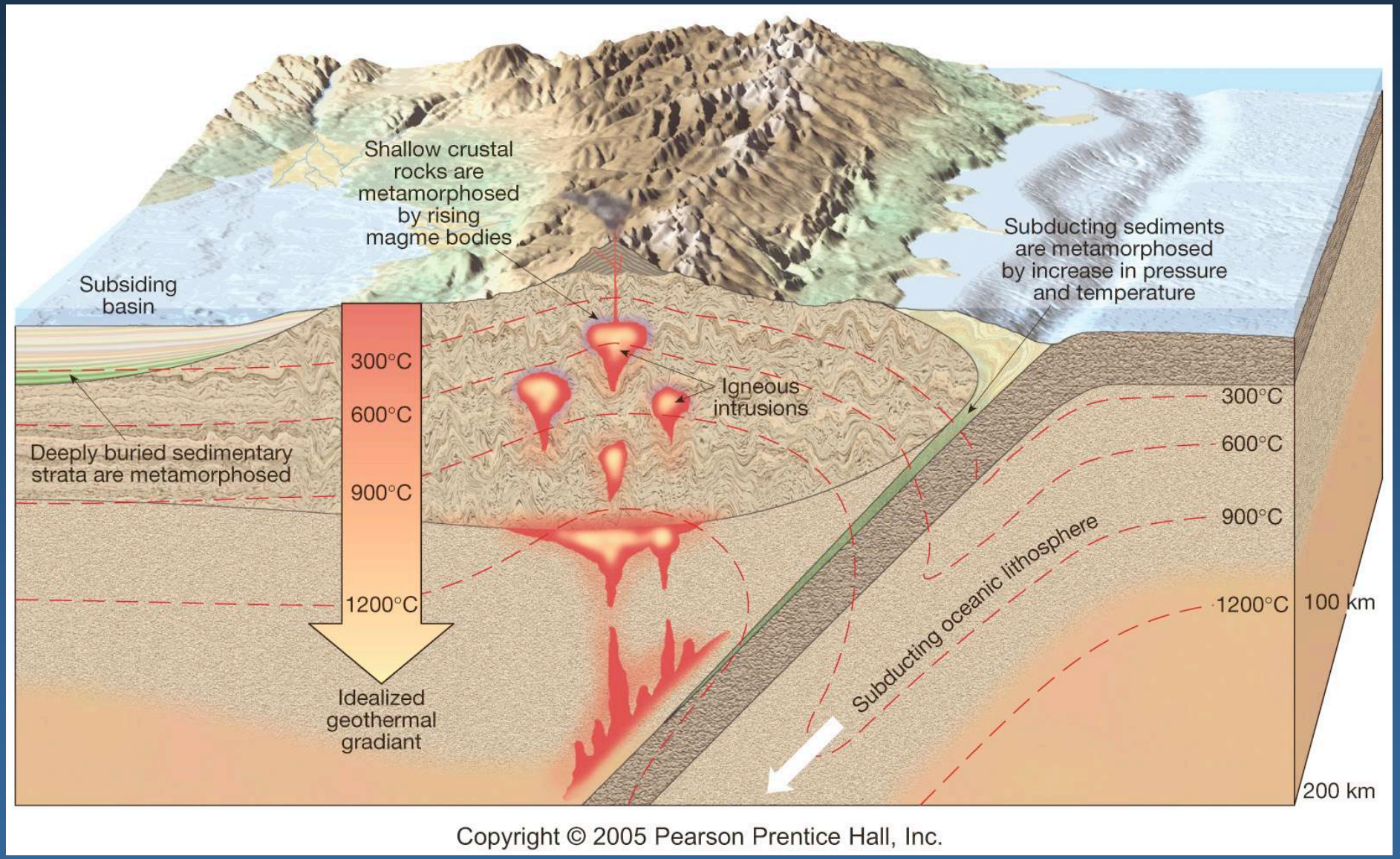
Metamorphism

- The mineral changes that transform a parent rock to into a new metamorphic rock by exposure to heat, stress, and fluids unlike those in which the parent rock formed.

granite

gneiss

Geothermal gradient



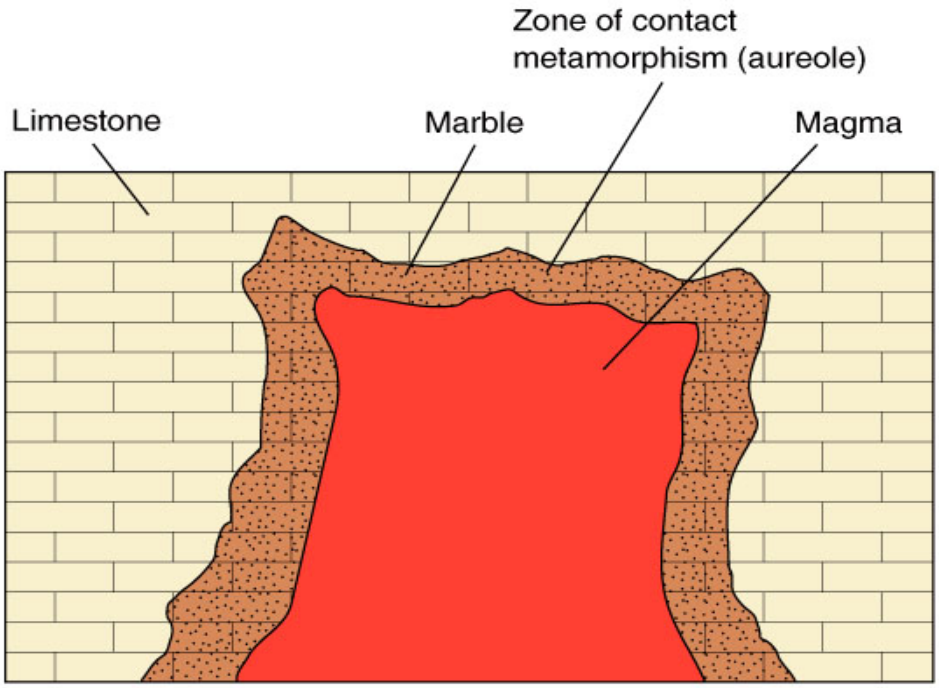
Types of Metamorphism

- Contact metamorphism –
  - Happens in wall rock next to intrusions
  - HEAT is main metamorphic agent

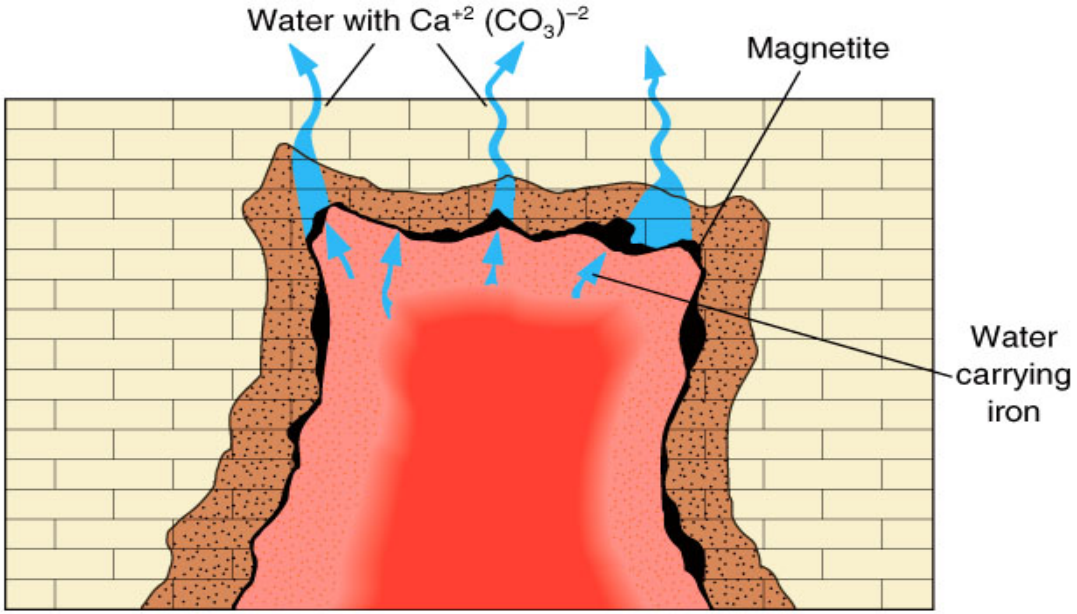
- **Contact metamorphism**

Contact Metamorphism

- Local- Usually a zone only a few meters wide
- Heat from plutons intruded into "cooler" country rock
- Usually forms nonfoliated rocks



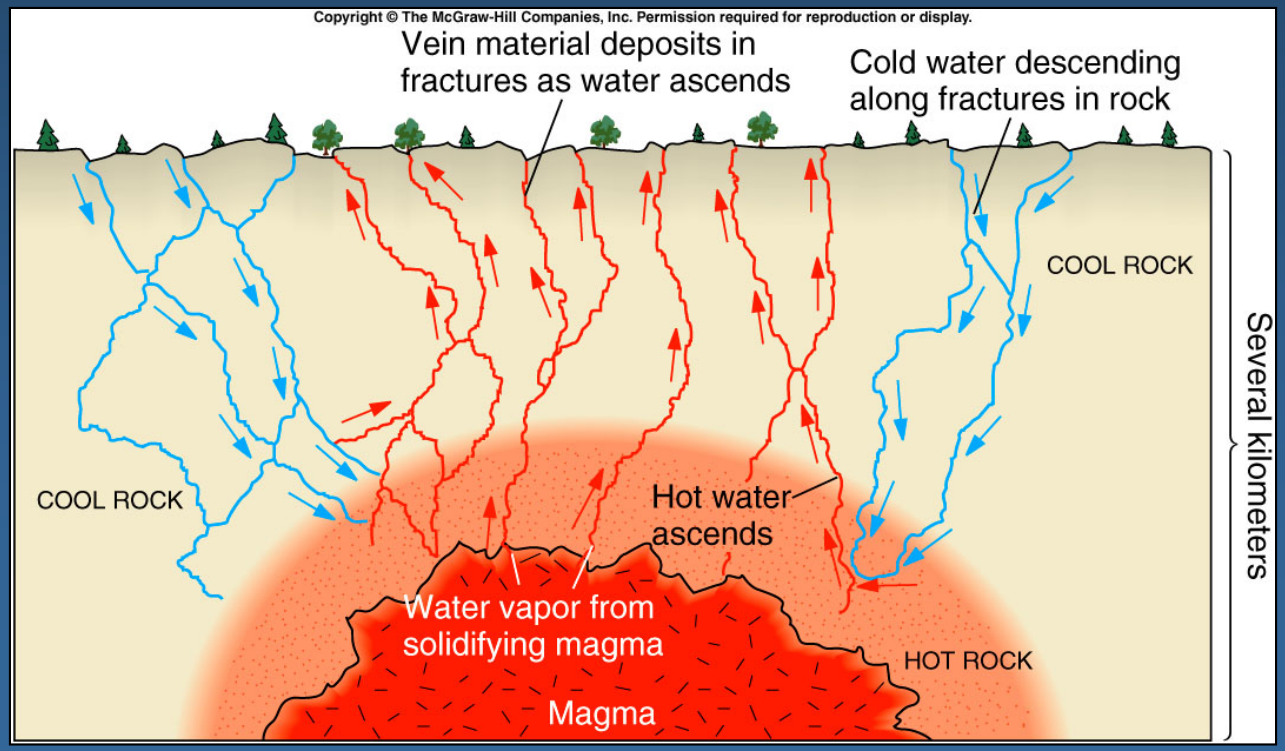
A



B

Types of Metamorphism

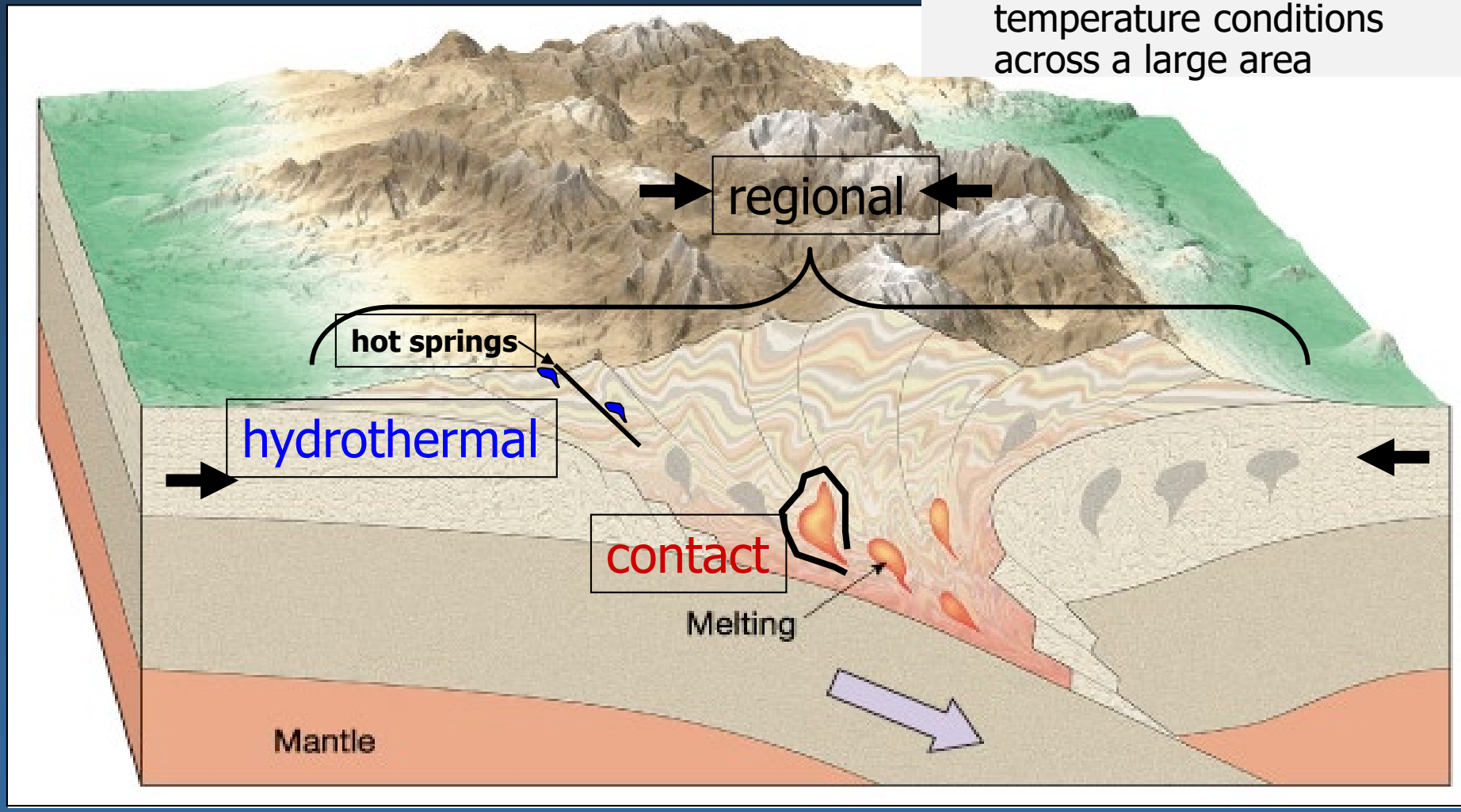
- **Hydrothermal metamorphism –**
  - Happens along fracture conduits
  - **HOT FLUIDS are main metamorphic agent**



Types of Metamorphism

- **Regional** metamorphism –
  - Happens during **mountain building**
  - Most significant type
  - **STRESS** associated with plate convergence &
  - **HEAT** associated with burial (geothermal gradient) are main metamorphic agents

- **Contact metamorphism**
- **Hydrothermal metamorphism**
- **Regional metamorphism**
  - Wide range of pressure and temperature conditions across a large area



- **Regional metamorphism**

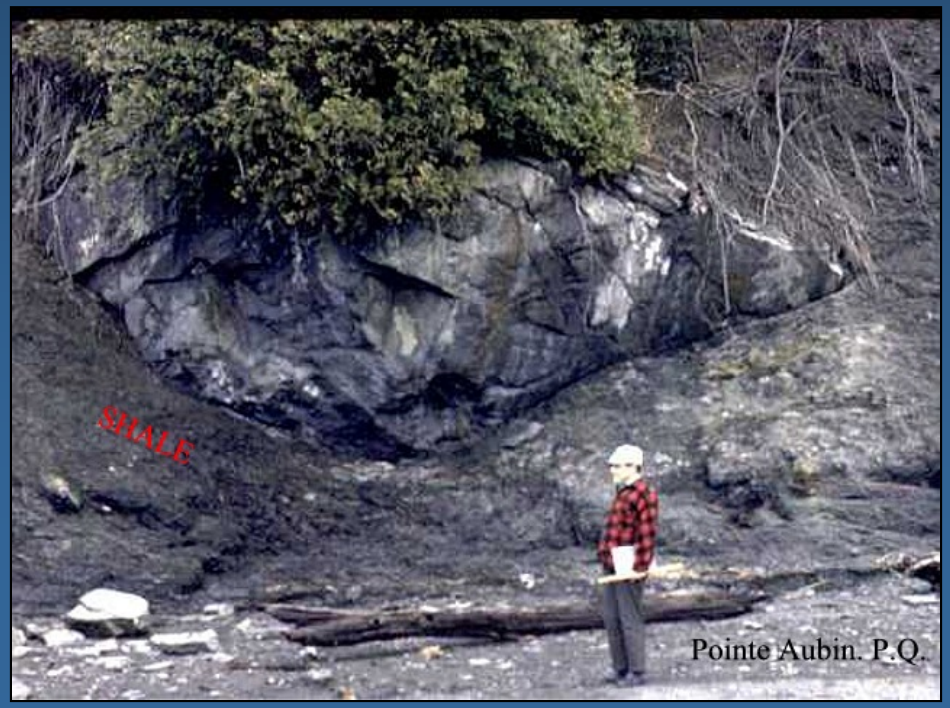
Other types of Metamorphism

- Burial
- Fault zones
- Impact metamorphism

Tektites

Metamorphism and Plate Tectonics

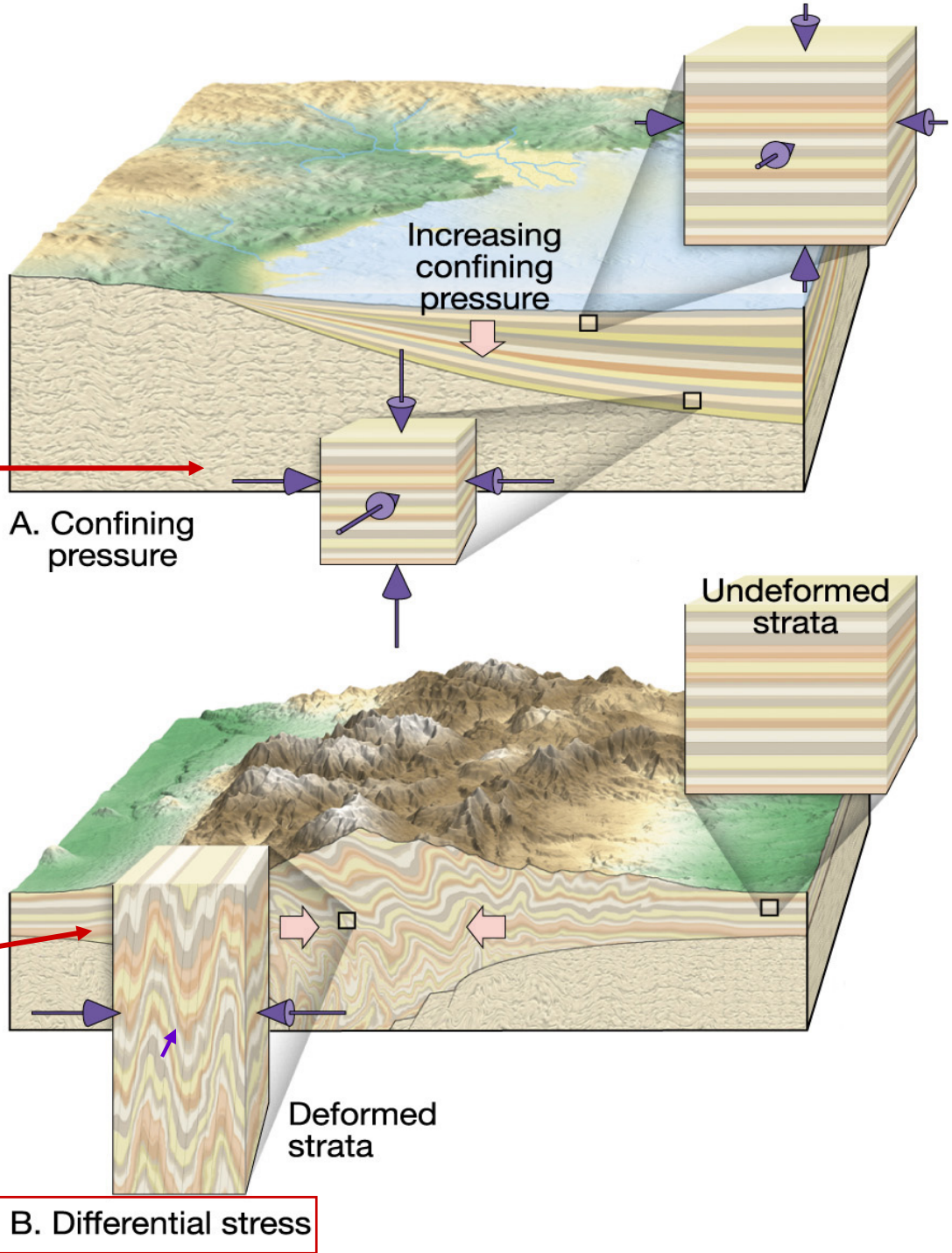
- Fault zone metamorphism
- Mélange- chaotic mixture of materials that have been crumpled together



Stress

(pressure)

- From **burial** beneath younger sediments (**lithostatic stress** -equal in all directions)
- From **tectonic stress** at convergent margins (**differential stress** -different in all directions)



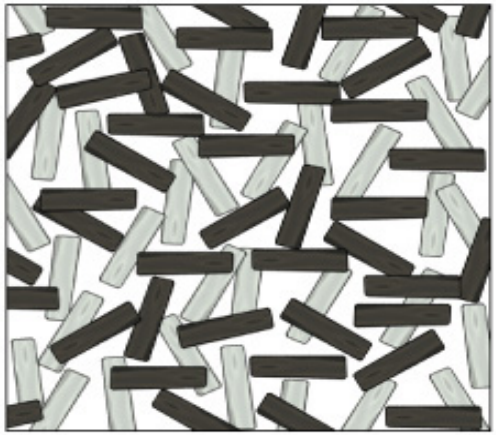
Metamorphic textures

- **Texture** refers to the size, shape, and arrangement of grains within a rock

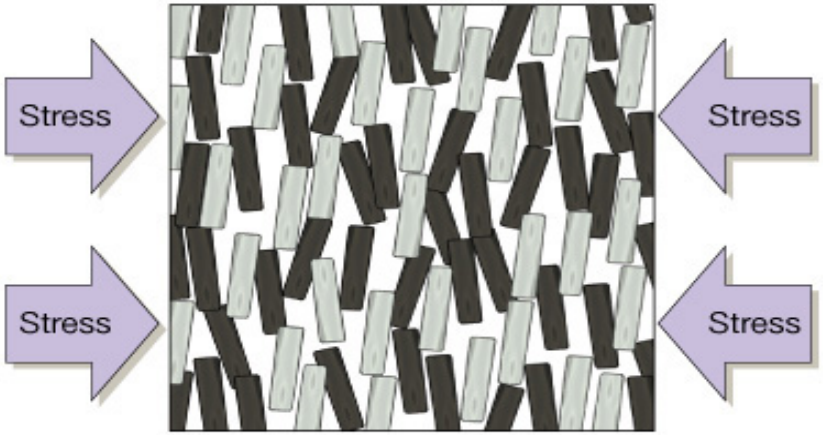
- **Foliation** – any planar arrangement of mineral grains or structural features within a rock

  - **Examples of foliation**
    - Parallel alignment of platy and/or elongated minerals

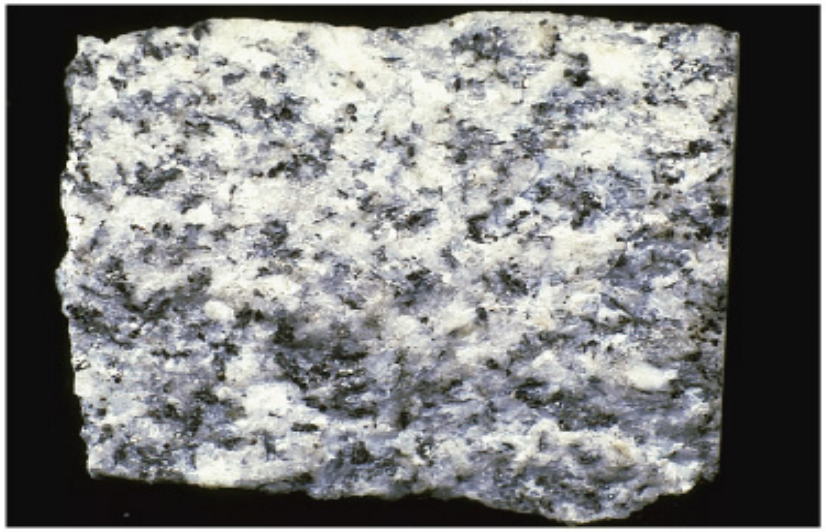
Stress

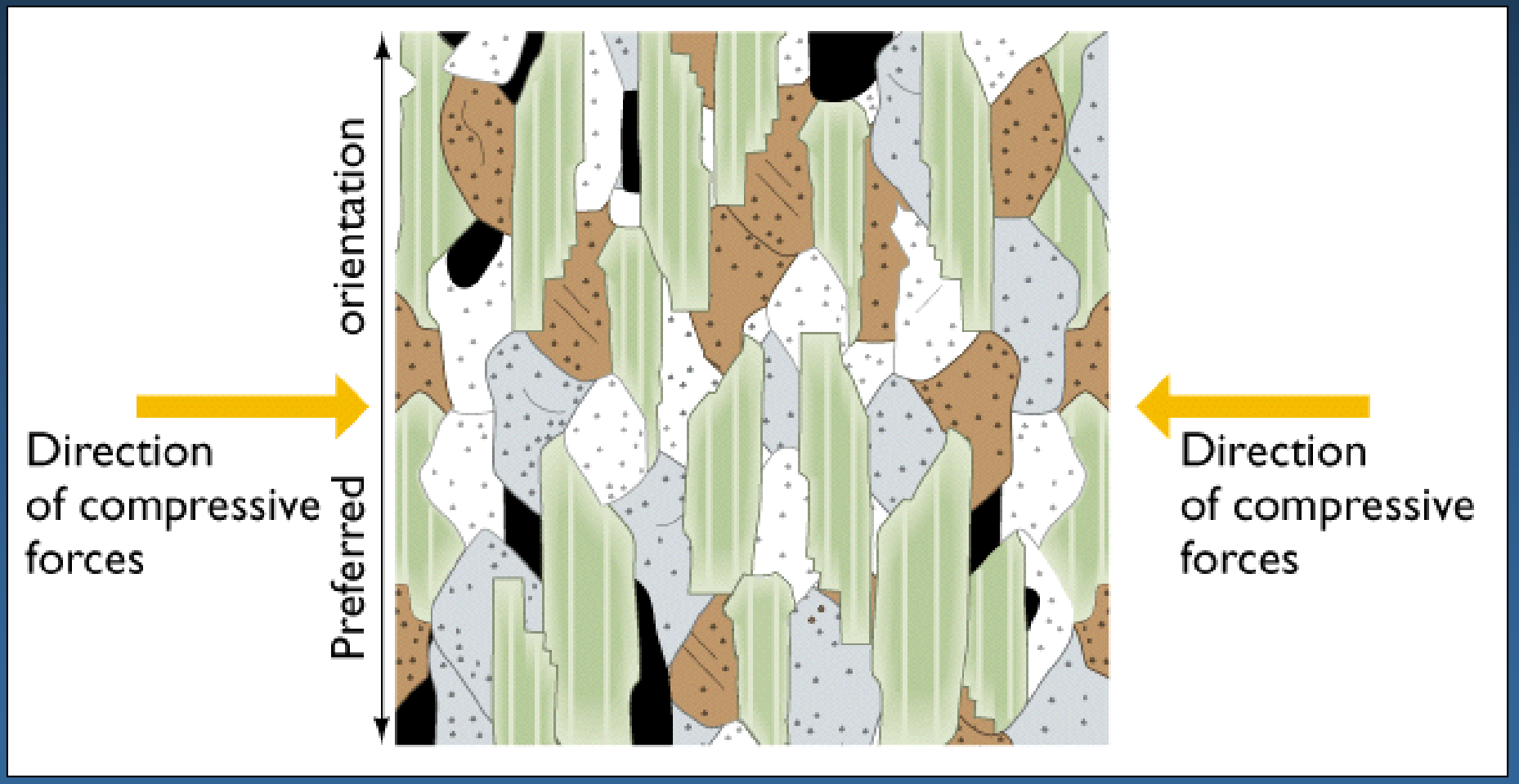


Before metamorphism



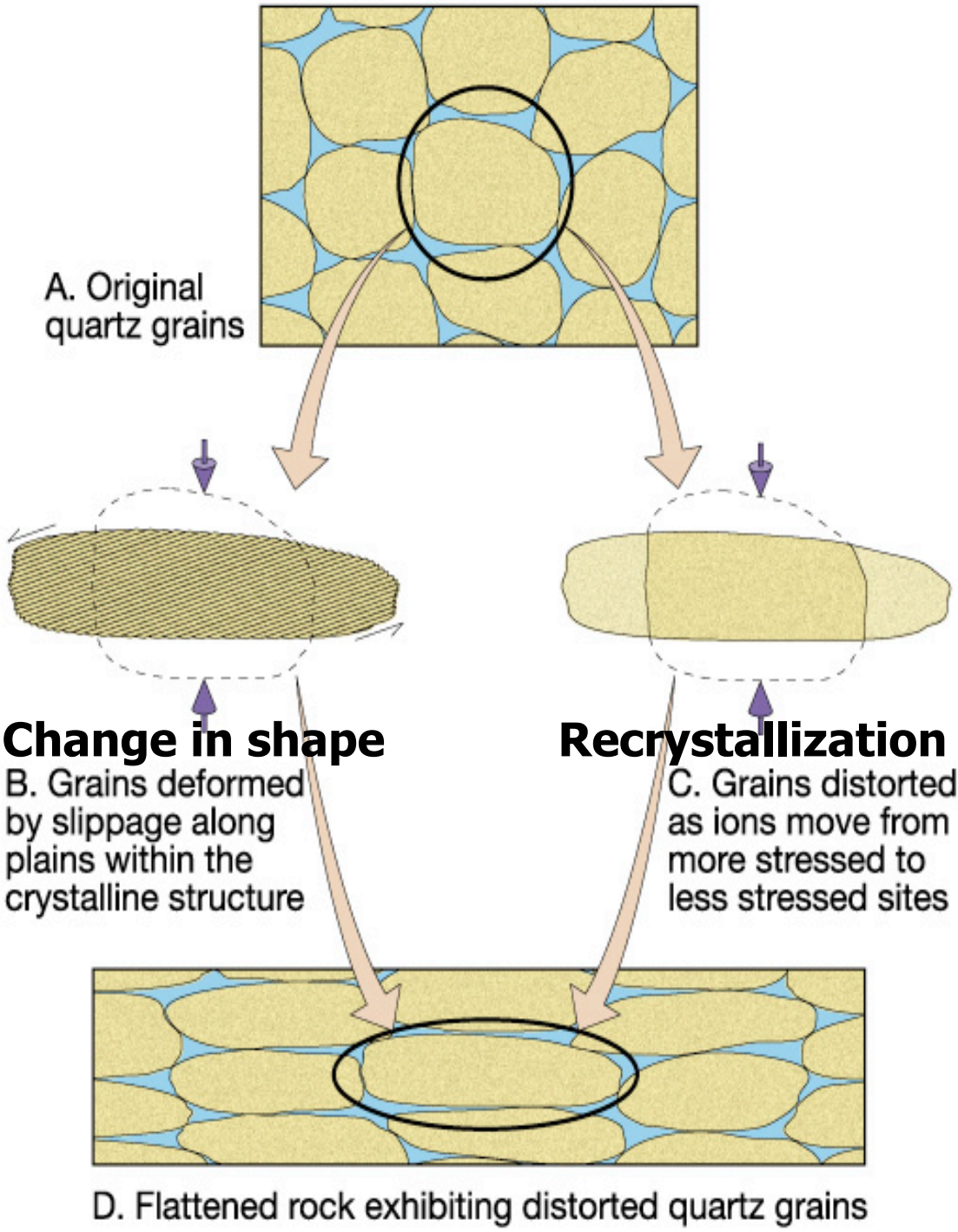
After metamorphism




Direction
of compressive
forces
Preferred
orientation
Direction
of compressive
forces

Recrystallization
Of minerals in the direction of preferred orientation

Change of shape
equidimensional grains changed into elongated shapes that are aligned



Metamorphic Rock Names: 2 Types:

1. FOLIATED Metamorphic Rocks

- Named mainly from their foliation type

NAME	FOLIATION TYPE
–Slate (Phyllite)	Slaty texture
–Schist	Schistocity
–Gneiss	Gneissic Texture

2. NON-FOLIATED metamorphic rocks

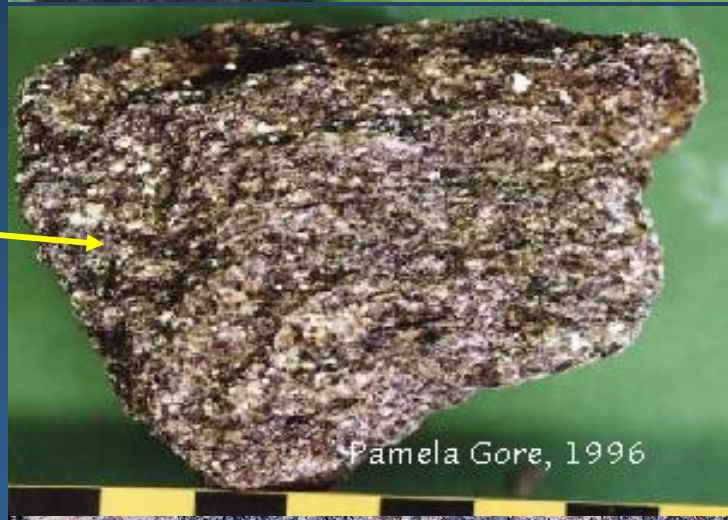
Foliated Metamorphic Textures

- Slaty texture

  (Phyllite)

- Schistosity

- Gneissic texture



Increasing Metamorphic Grade for same parent rock

(Note increase in size of crystals)

- **Slaty texture**
  - Closely spaced planar surfaces along which rocks split
  - Formed by alignment of microscopic mica through rotation, recrystallization, and change in shape.
- **Rock Name:** Slate **Parent:** Shale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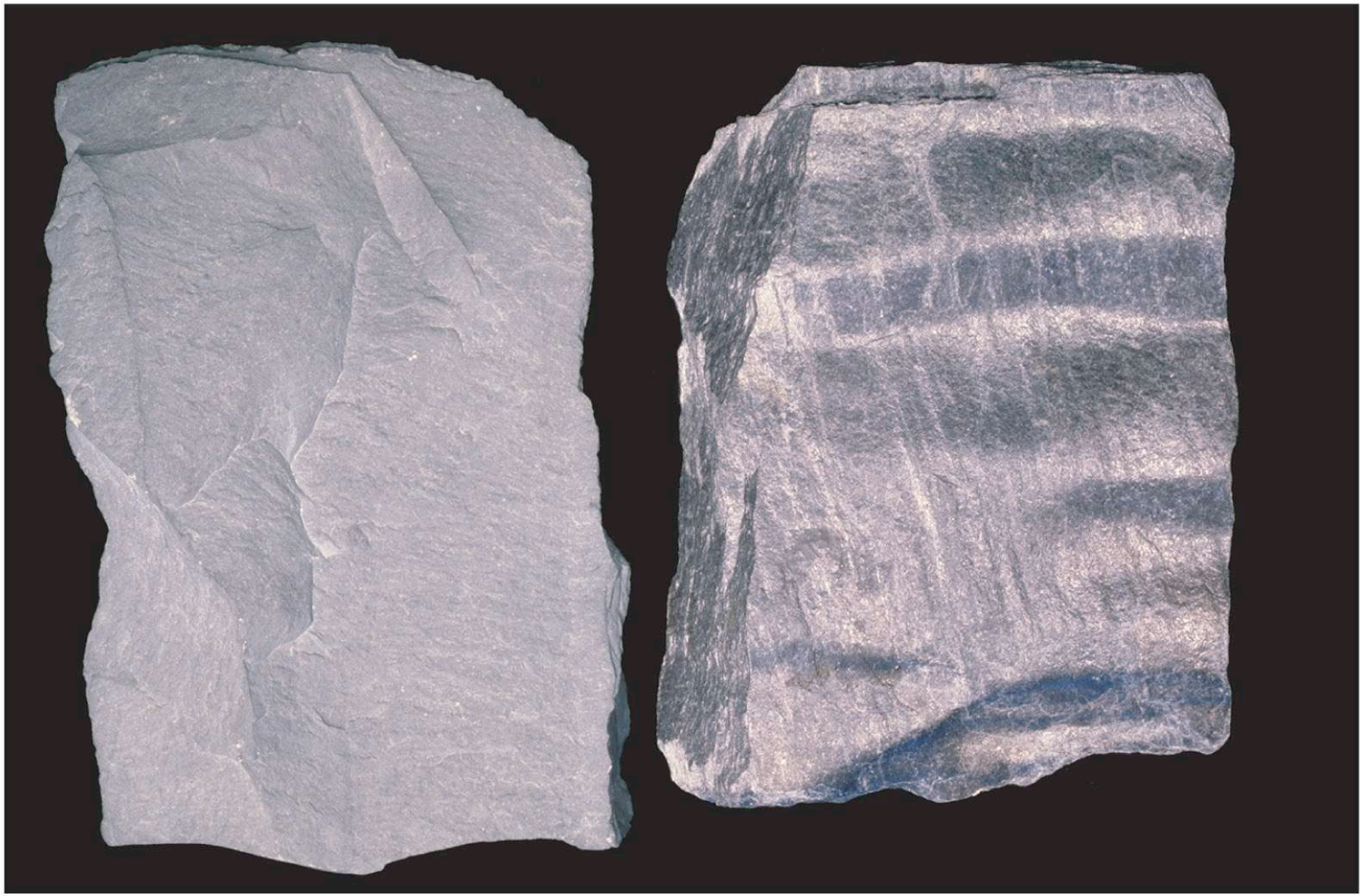
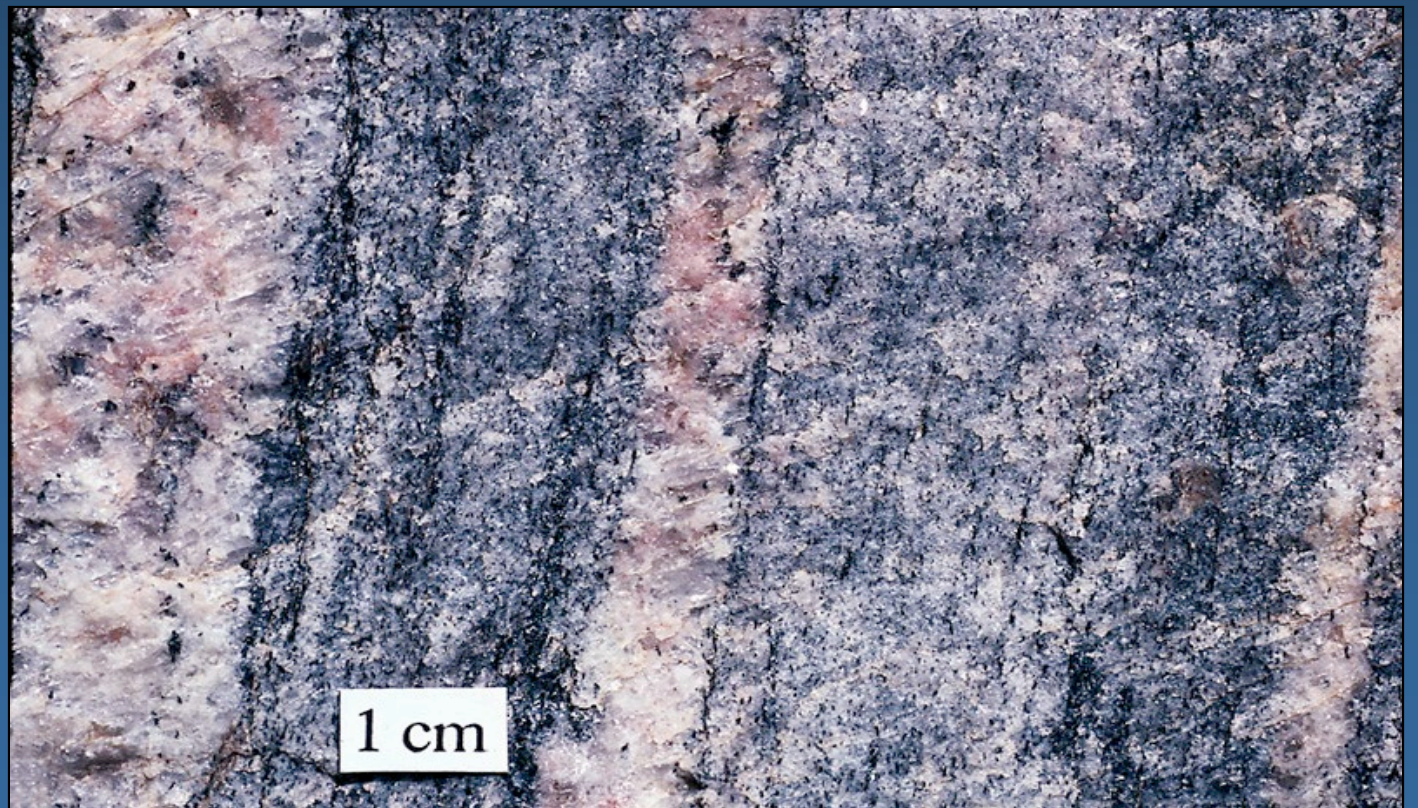
Slate and Phyllite

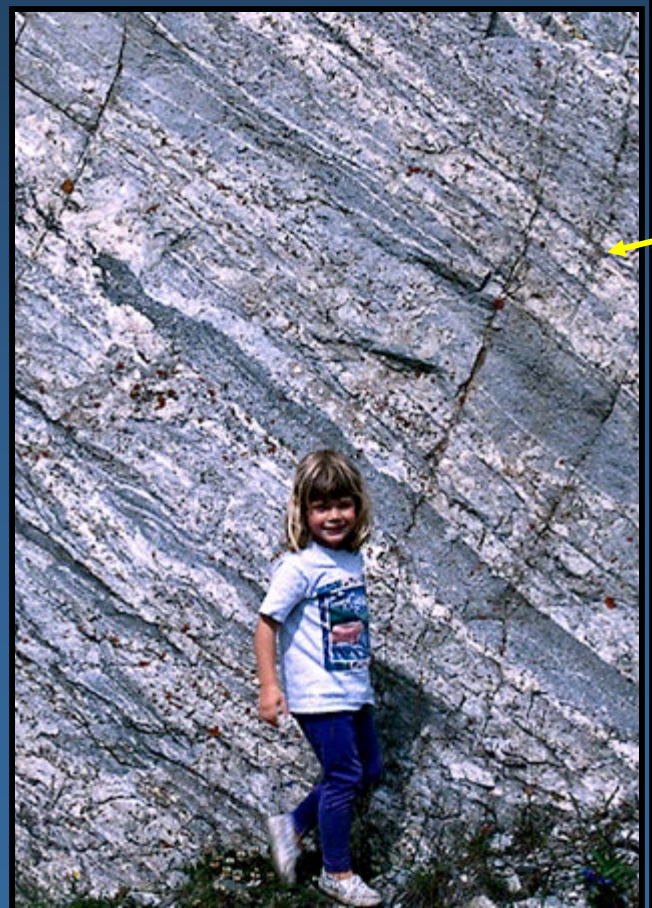


- **Schistosity**
  - Foliation formed mainly by visible platy minerals (muscovite, biotite)
- **Rock Name:** Schist
  - with modifier for dominant mineral: biotite schist, muscovite schist
- **Parent:** Slate

- **Gneissic Texture**
  - Foliation due to segregation of minerals into:
    - **light bands** of nonferromagnesian silicates (quartz, feldspar, muscovite)
    - **dark bands** of ferromagnesian silicates (biotite, amphibole, pyroxene)

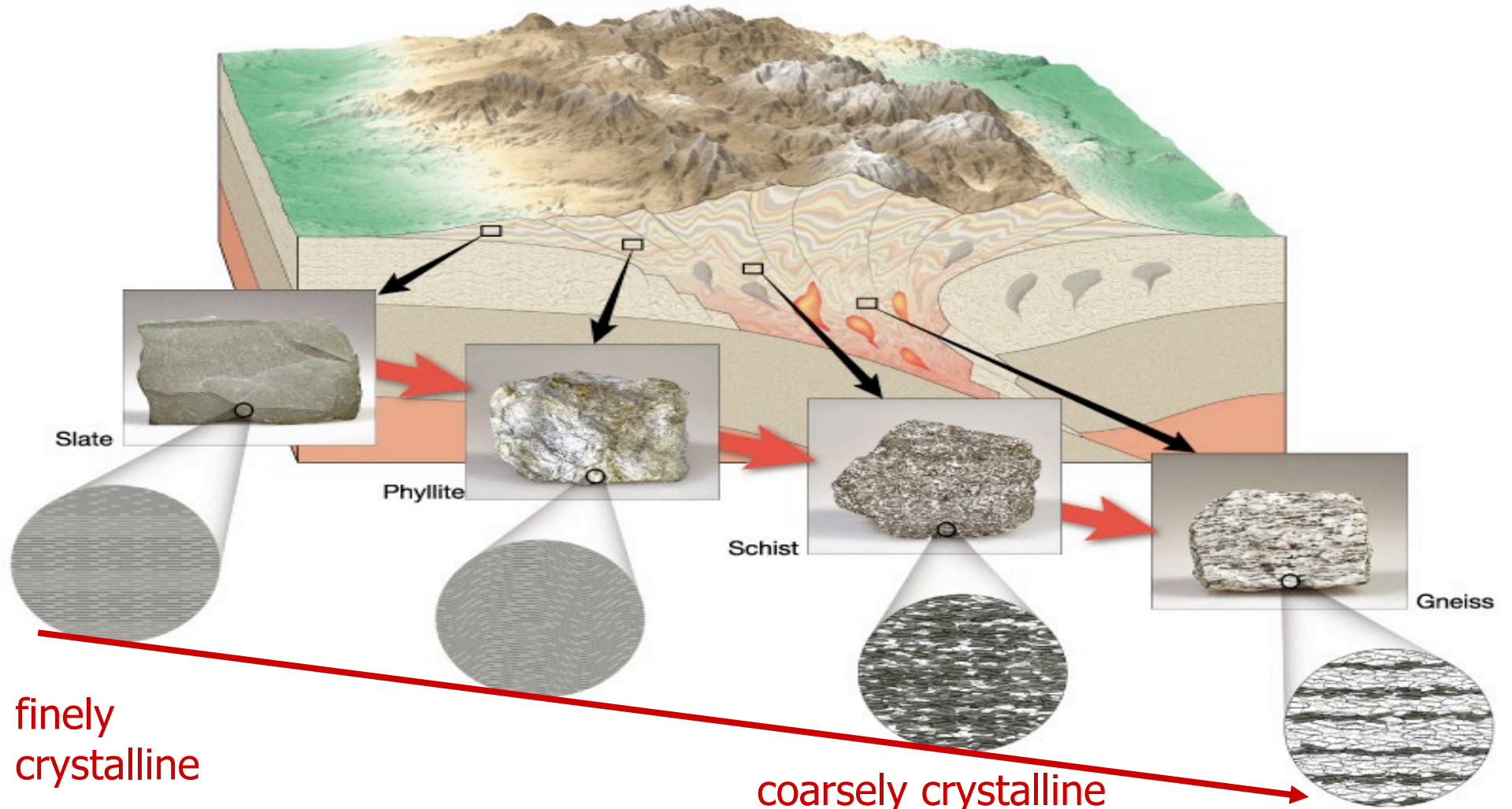


- **Gneissic Texture**
  - Highest grade of metamorphic rock (most heat & stress)
- **Rock Name:** Gneiss -with modifier for dominant dark mineral: **biotite** gneiss, **hornblende** gneiss



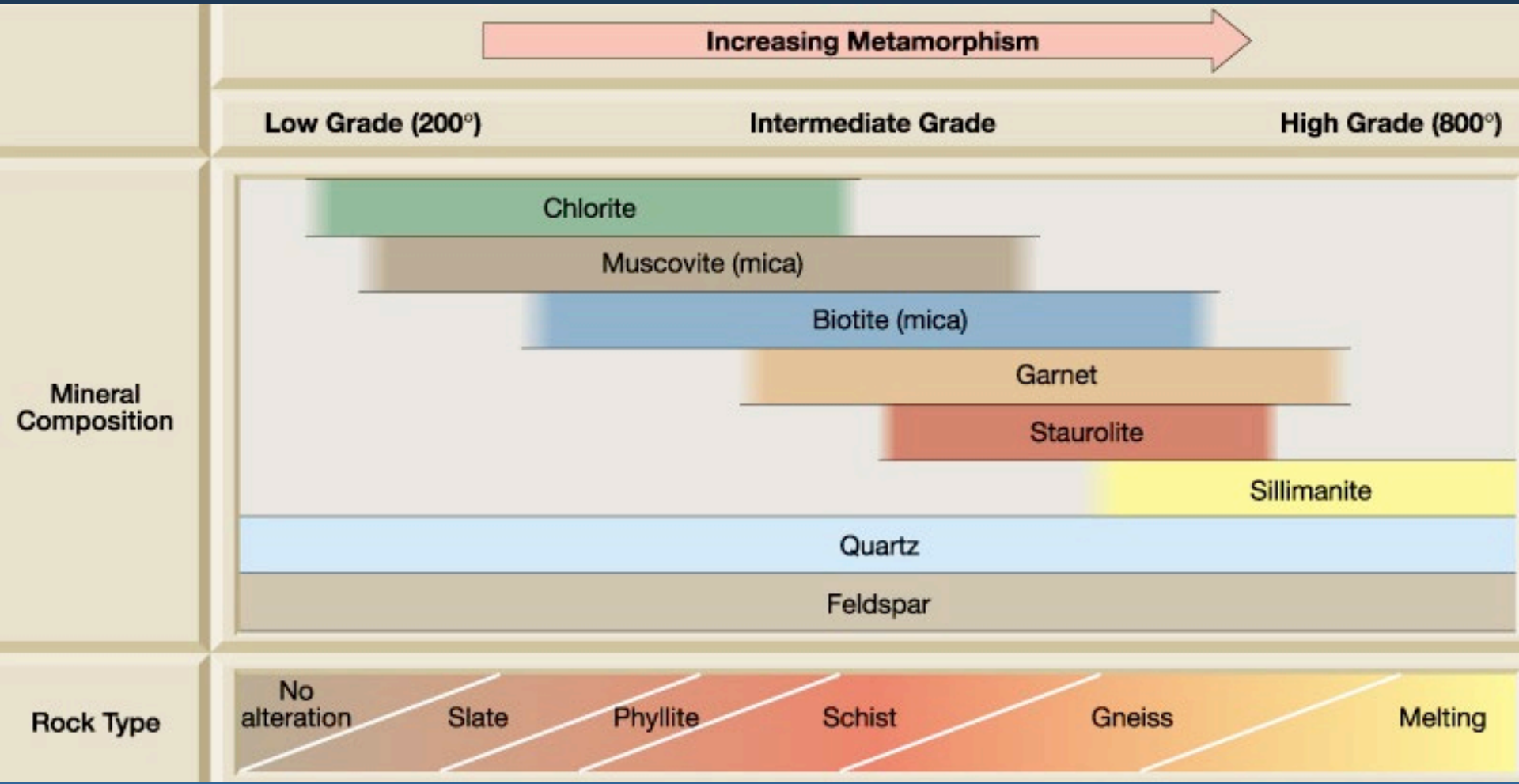
Metamorphic grade in foliated rocks

- For same parent rock (i.e., shale), transitions from slate to gneiss indicate increasing depth of burial inside a mountain belt along a convergent plate boundary



Metamorphic grade in foliated rocks

- For same parent rock (shale), transitions from slate to gneiss also display change in metamorphic minerals.



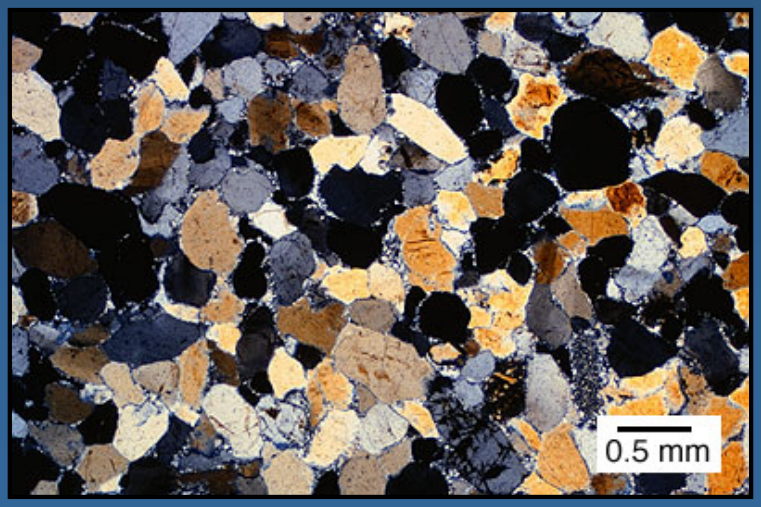
Metamorphic Rock Names: 2 Types

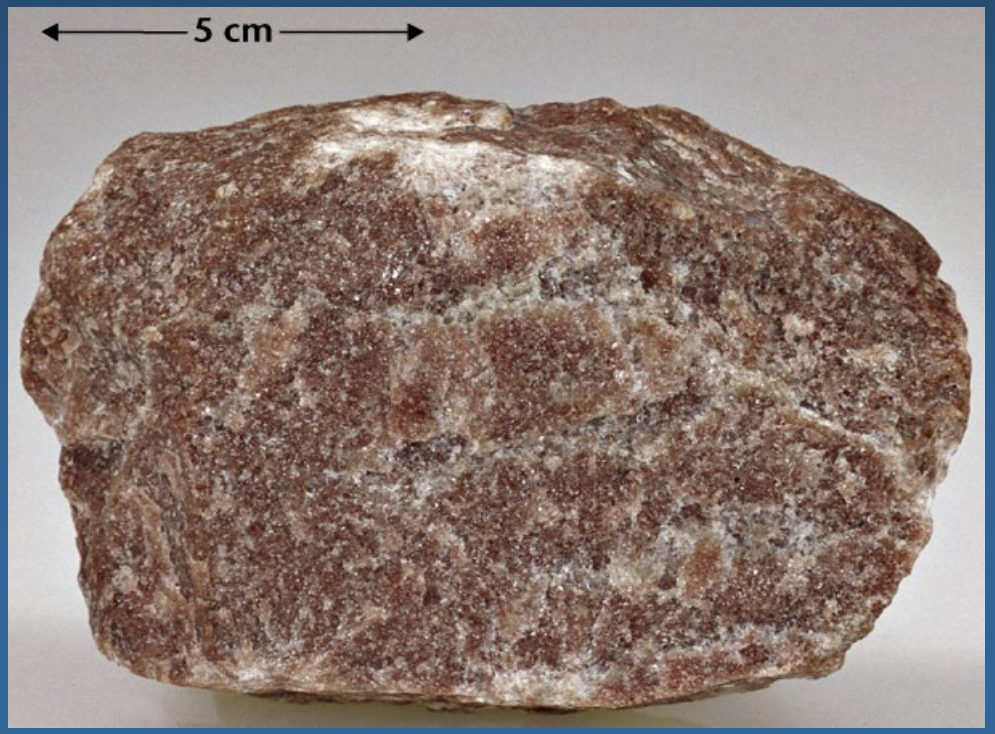
1. **FOLIATED Metamorphic Rocks –layered or banded**
2. **NON-FOLIATED metamorphic rocks**
   - **Named mainly from the mineralogy inherited from their parent rock**

NAME	MINERAL	PARENT
Marble	Calcite	Limestone
Quartzite	Quartz	Quartz Sandstone

Nonfoliated metamorphic rocks

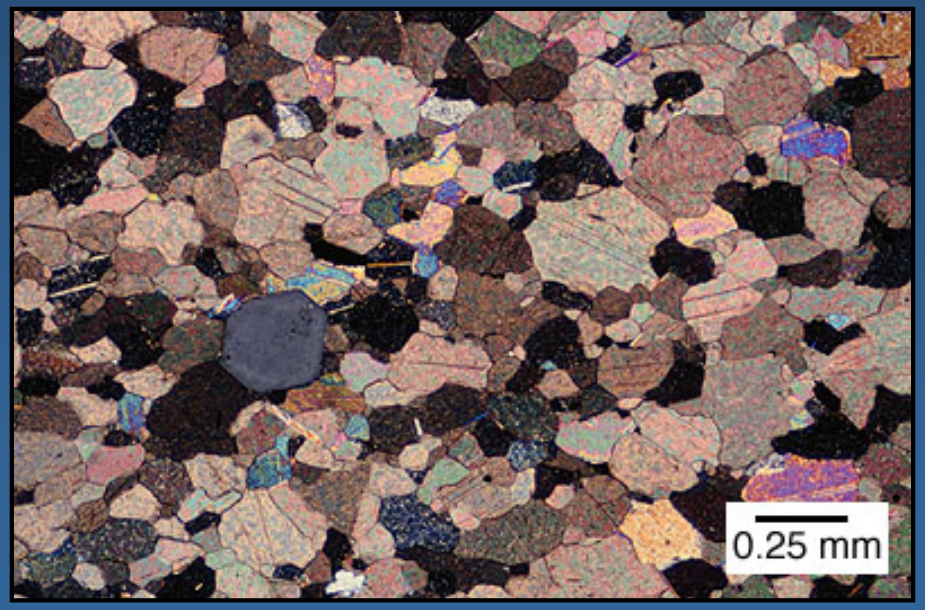
Quartizite – formed from quartz-rich sandstones, often have a "sugary" surface





Nonfoliated metamorphic rocks

Marble – metamorphosed limestones and dolomites, texture is inter-grown calcite x-tals



Engineering with Metamorphic

- Jointing
- Foliation sheets - anisotropy
- Weathering products
- Discontinuity infilling
- Grade variablilty