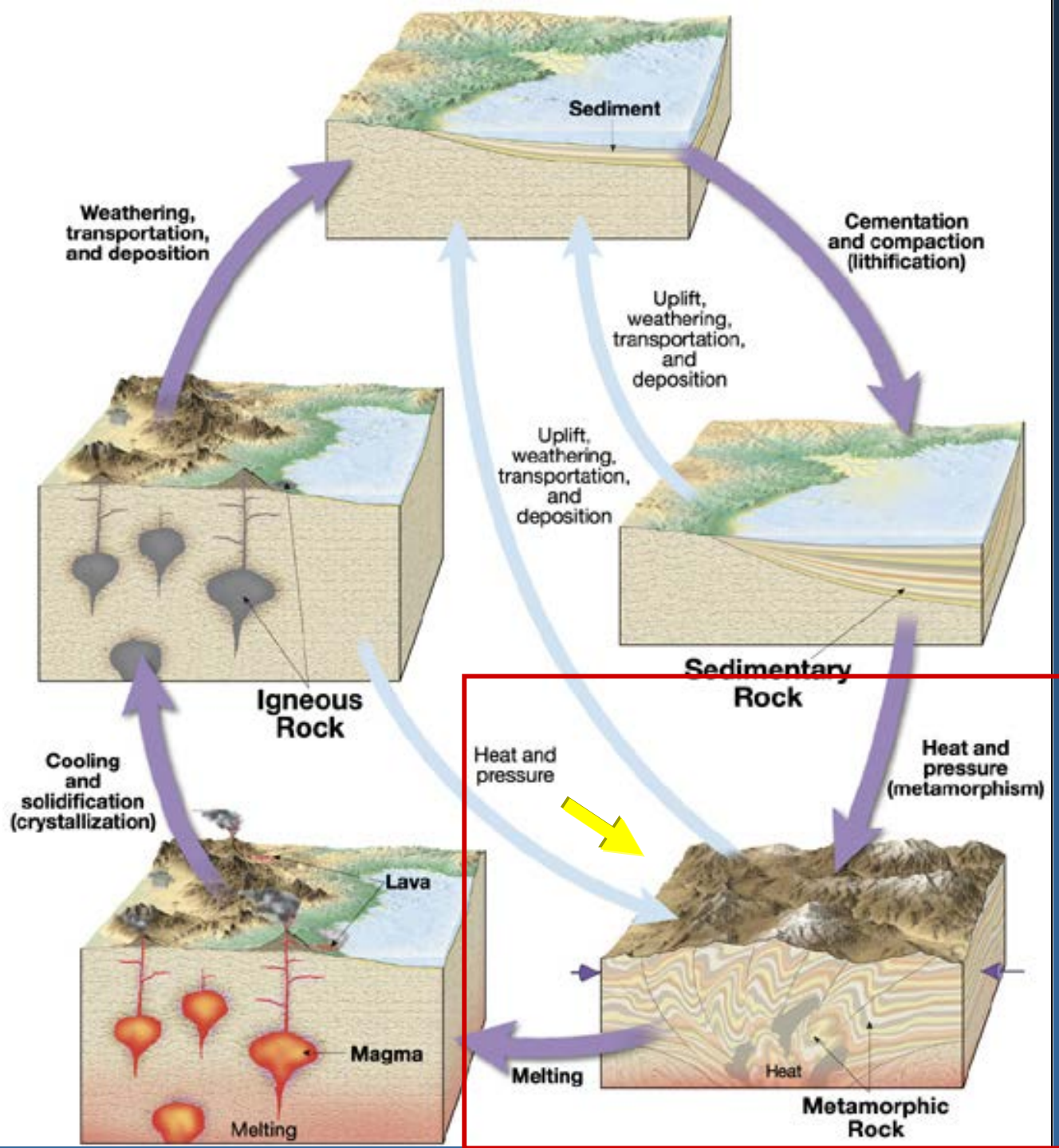


Metamorphism & Metamorphic Rocks

((adapted from Brunkel, 2012))





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.



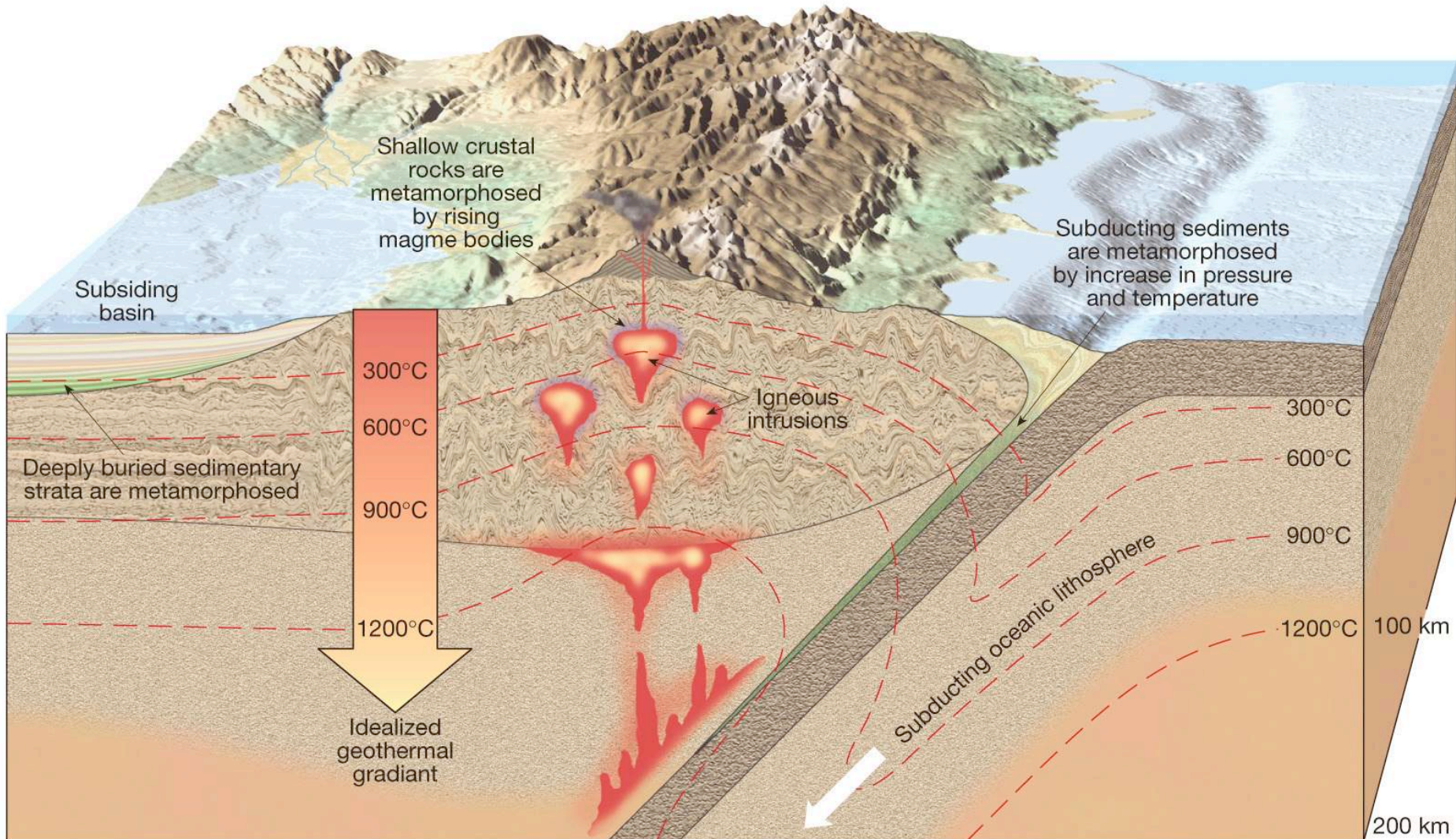
granite



gneiss



Geothermal gradient



Types of Metamorphism

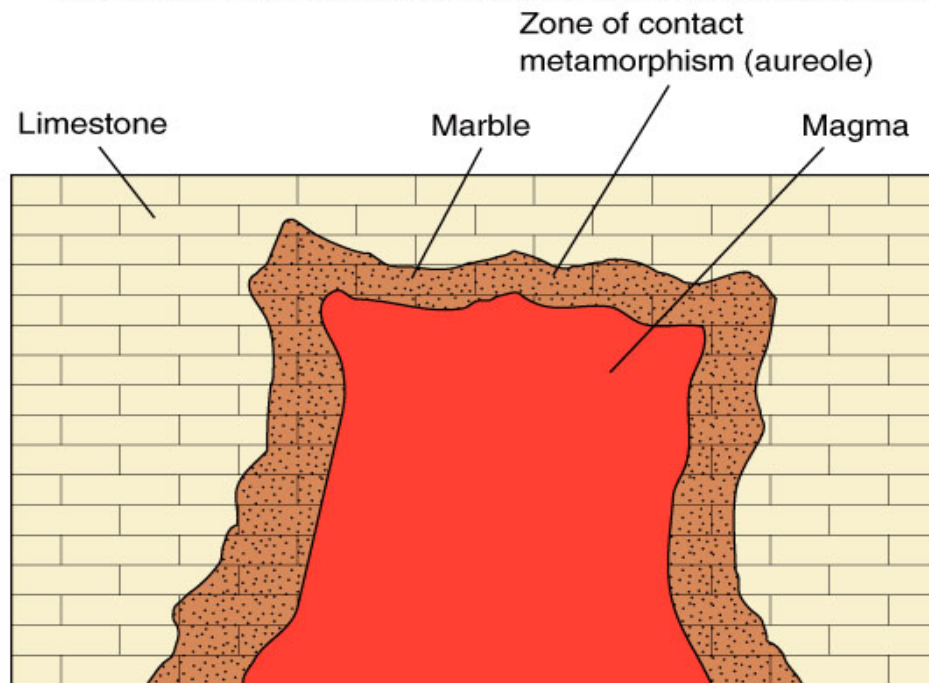
- Contact metamorphism –
 - Happens in wall rock next to intrusions
 - **HEAT** is main metamorphic agent

- Contact metamorphism

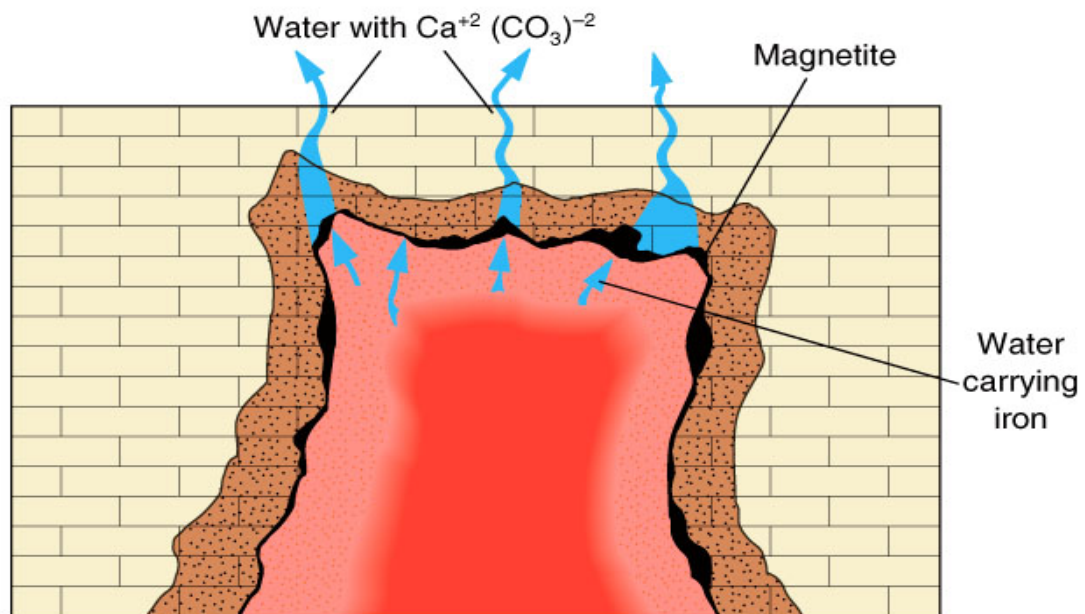


Contact Metamorphism

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



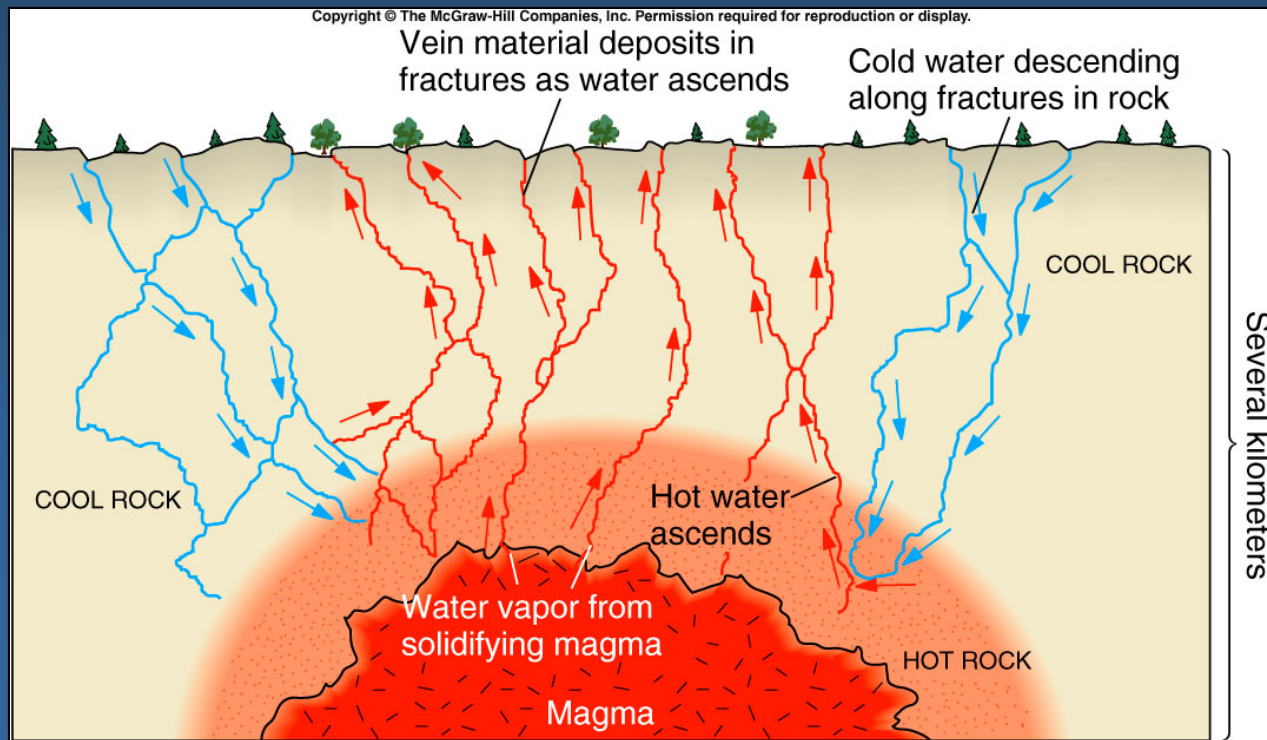
A



B

Types of Metamorphism

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

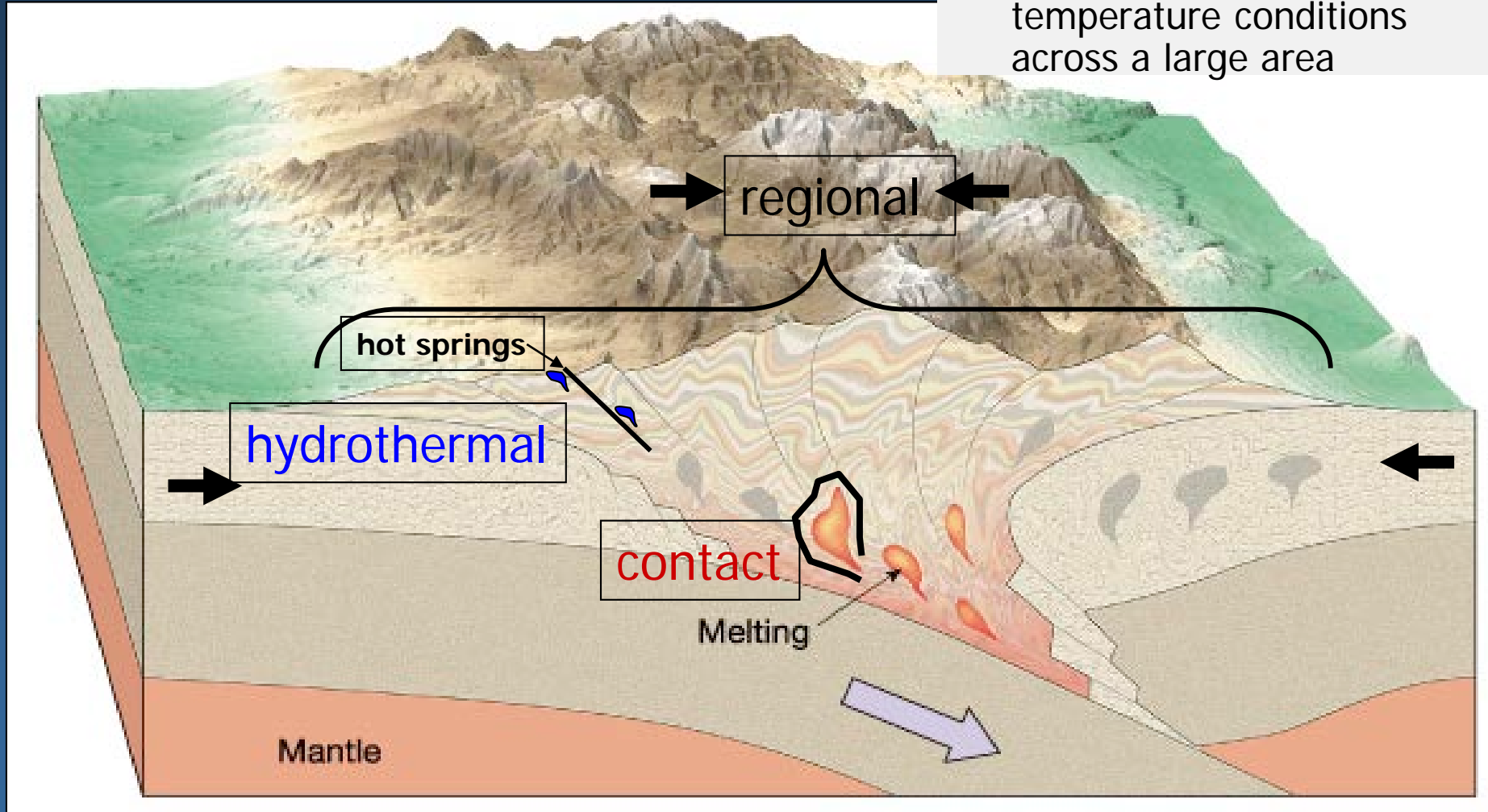


Types of Metamorphism

- 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



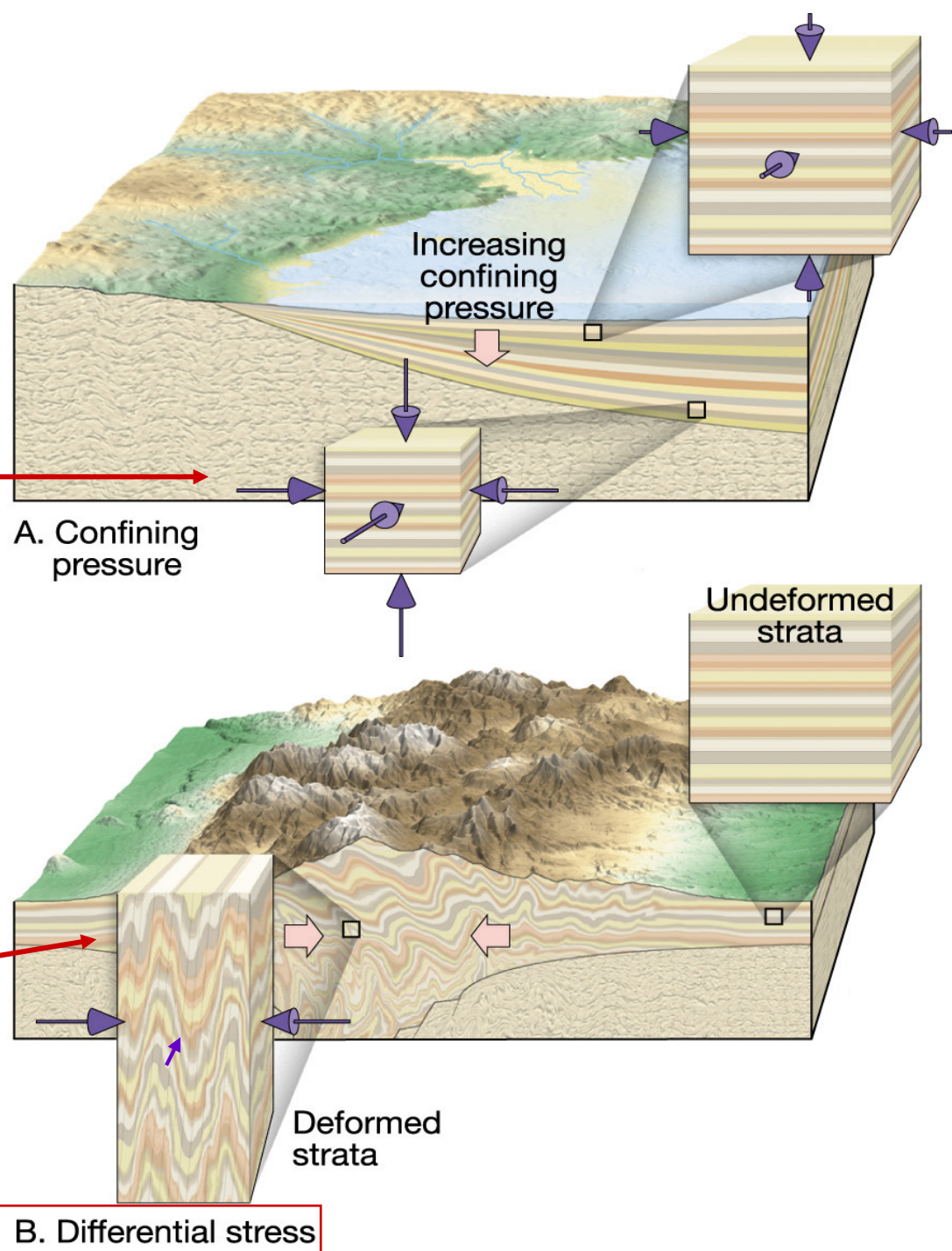
Metamorphism and Plate Tectonics

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



Stress (pressure)

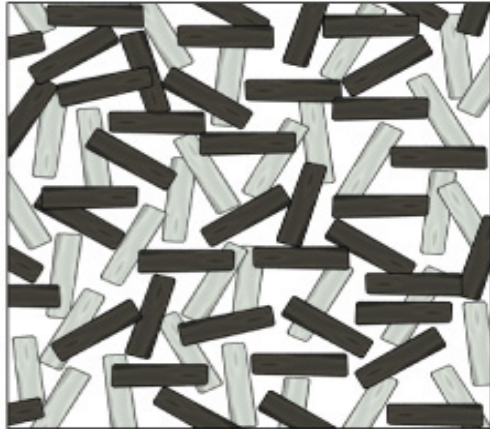
- From **burial** beneath younger sediments (**lithostatic stress** -equal in all directions)
- From **tectonic stress** at convergent margins (**differential stress** -different in all directions)



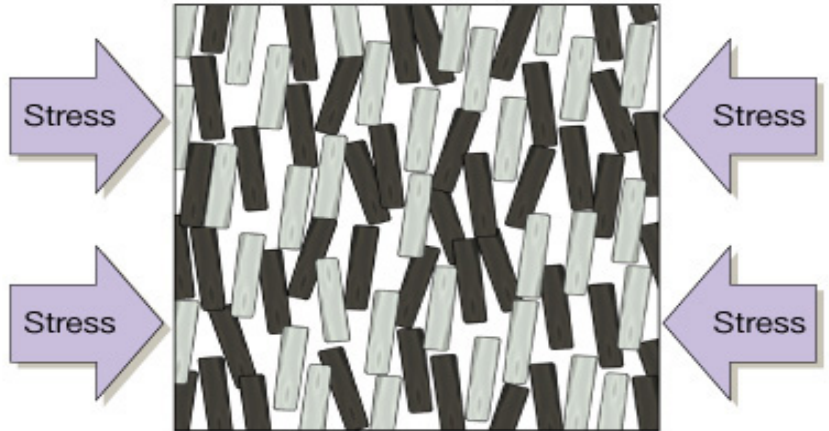
Metamorphic textures

- **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

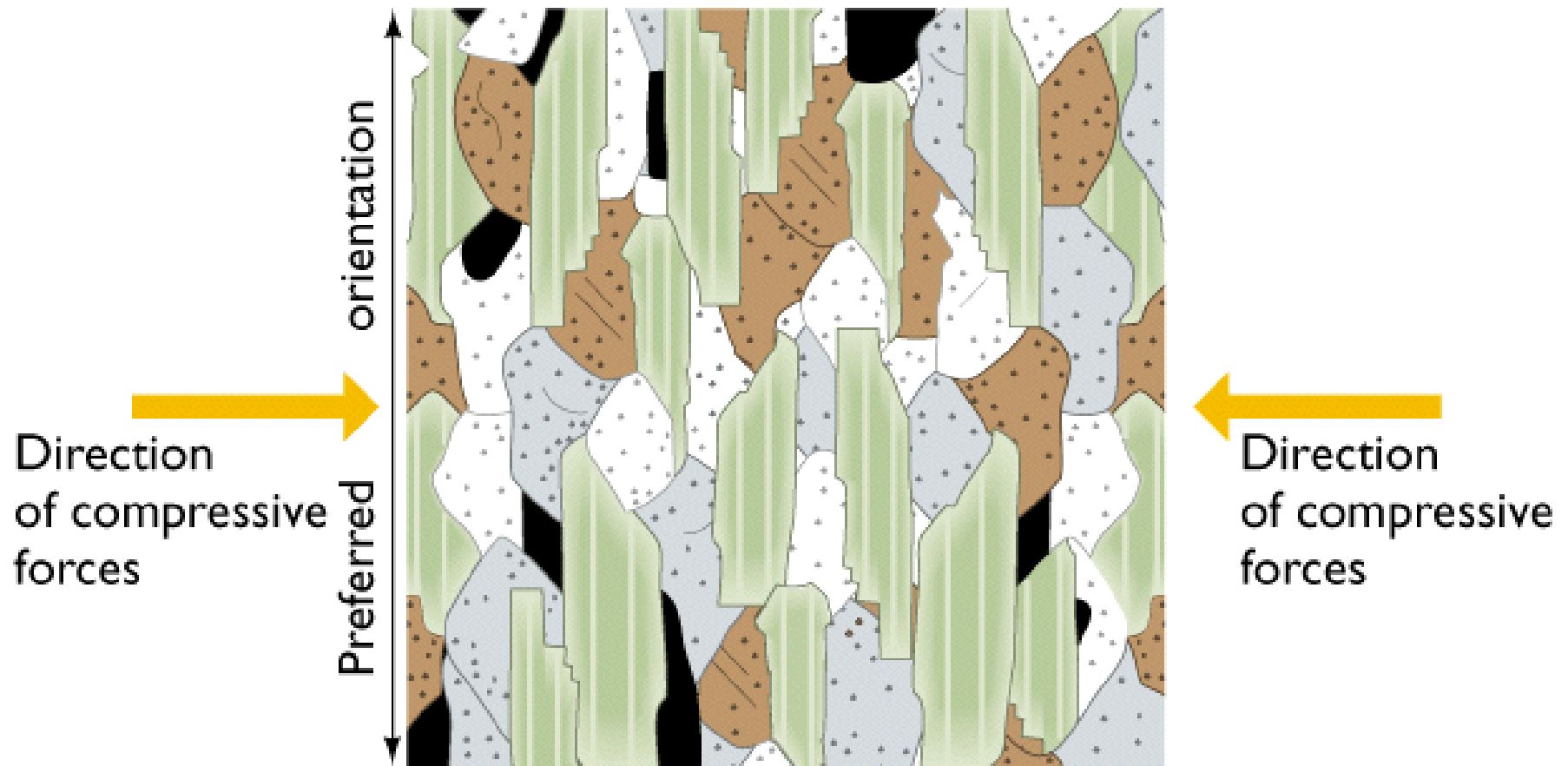


Before metamorphism



After metamorphism



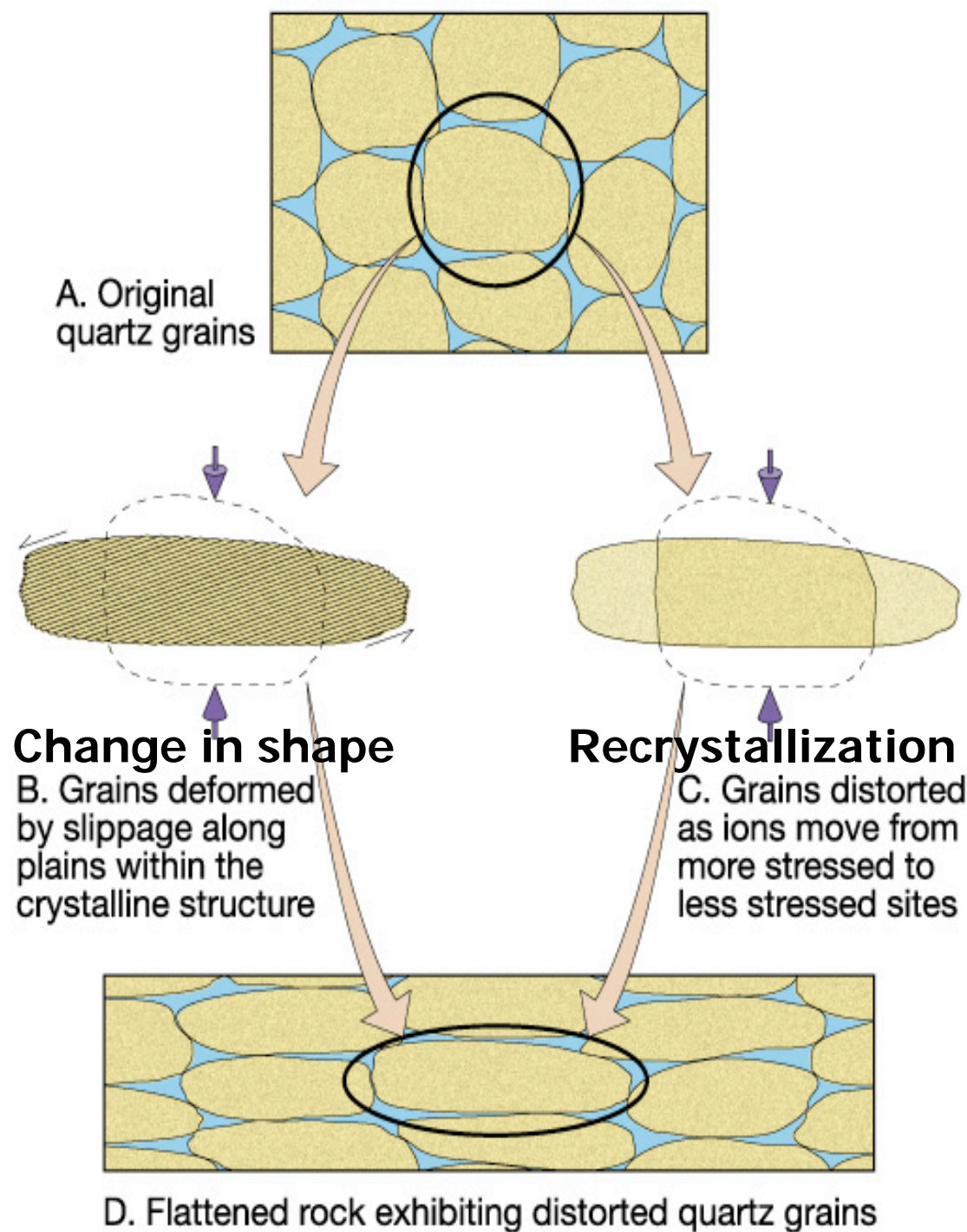


Recrystallization

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

<u>NAME</u>	<u>FOLIATION TYPE</u>
-------------	-----------------------

–Slate	Slaty texture
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(Phyllite)	
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–Schist	Schistosity
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–Gneiss	Gneissic Texture
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2. NON-FOLIATED metamorphic rocks

Foliated Metamorphic Textures

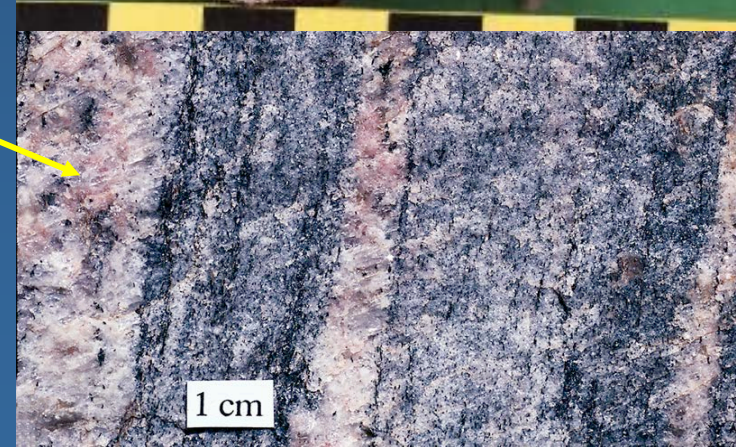
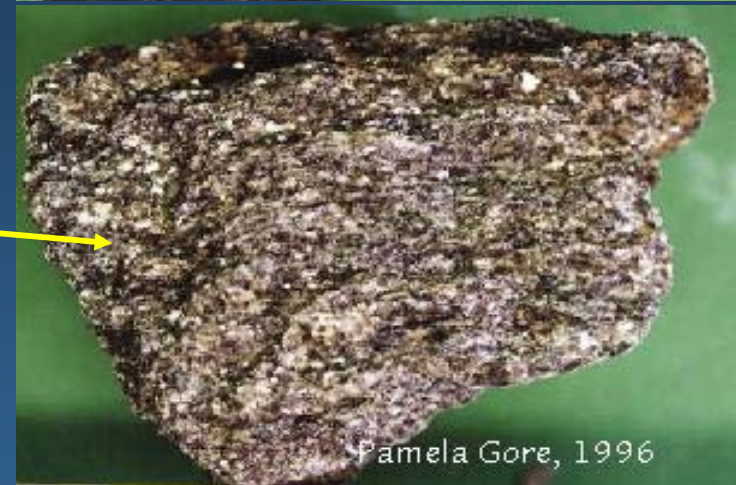
- Slaty texture

(Phyllite)

- Schistosity

- Gneissic texture

**Increasing Metamorphic Grade
for same parent rock**
(Note increase in size of crystals)

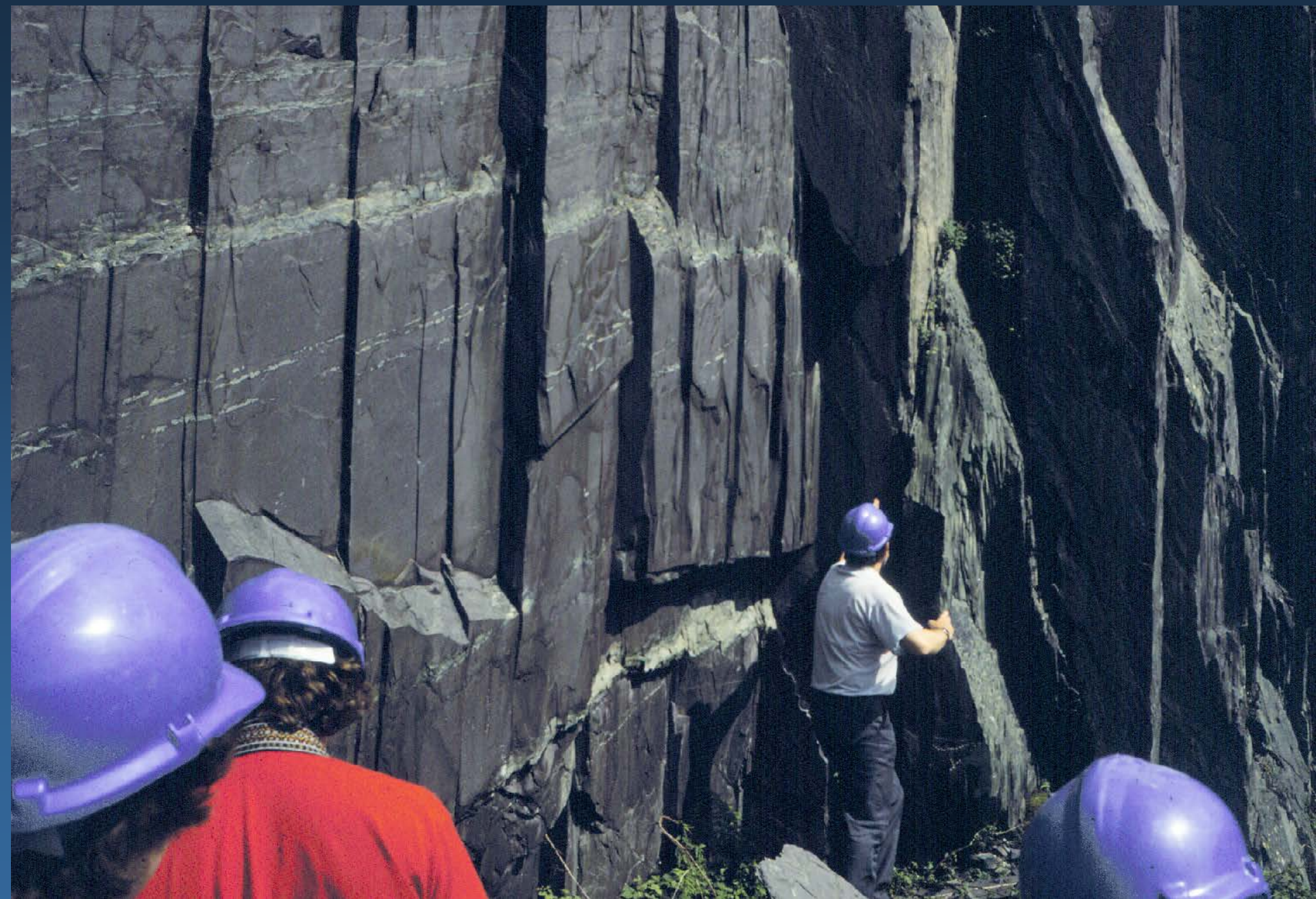


- **Slaty texture**

- Closely spaced planar surfaces along which rocks split
- Formed by alignment of microscopic mica through rotation, recrystallization, and change in shape.

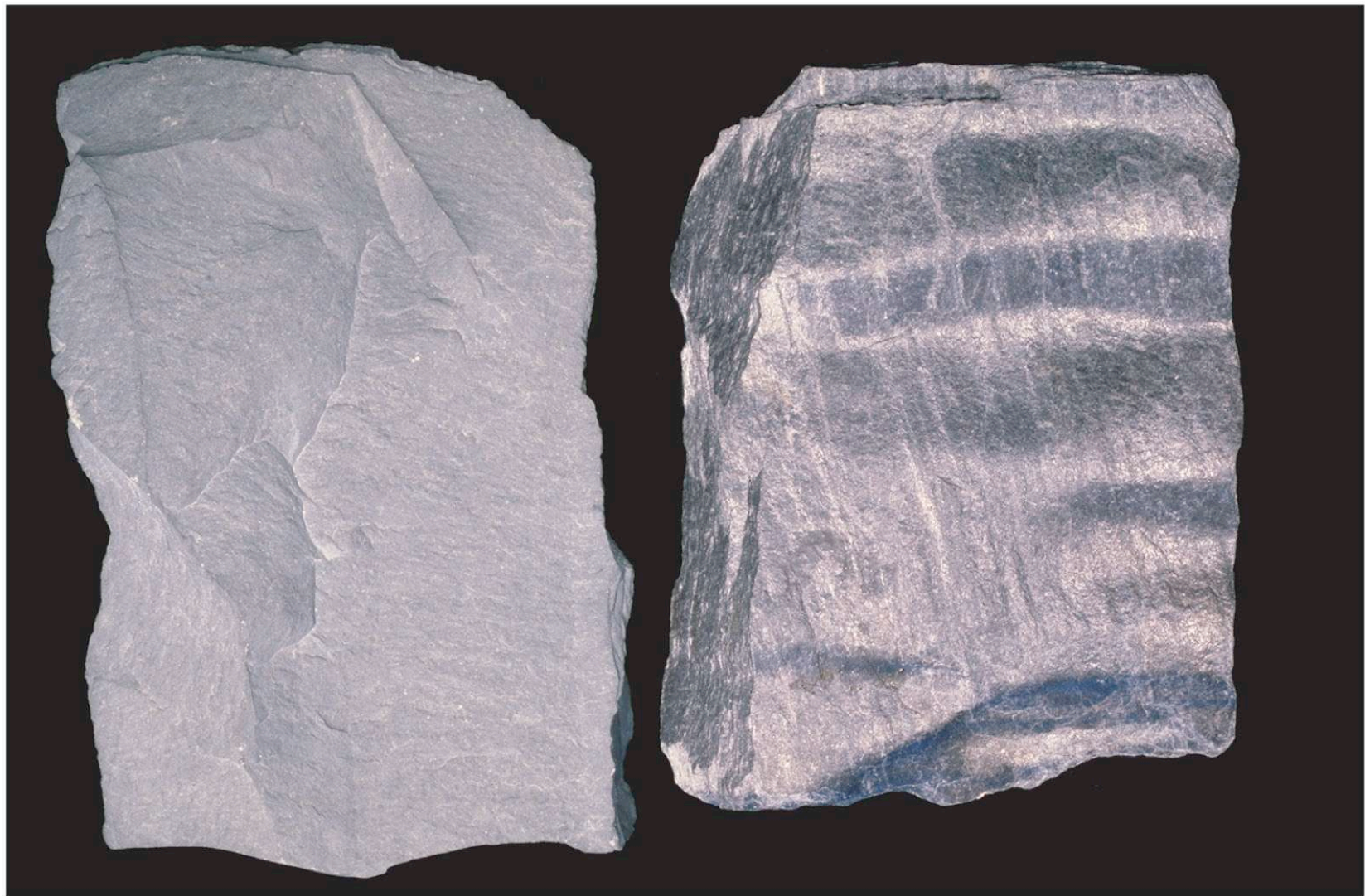
- **Rock Name:** Slate **Parent:** Shale







Slate and Phyllite



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- **Schistosity**

- Foliation formed mainly by visible platy minerals (muscovite, biotite)

- **Rock Name:** Schist

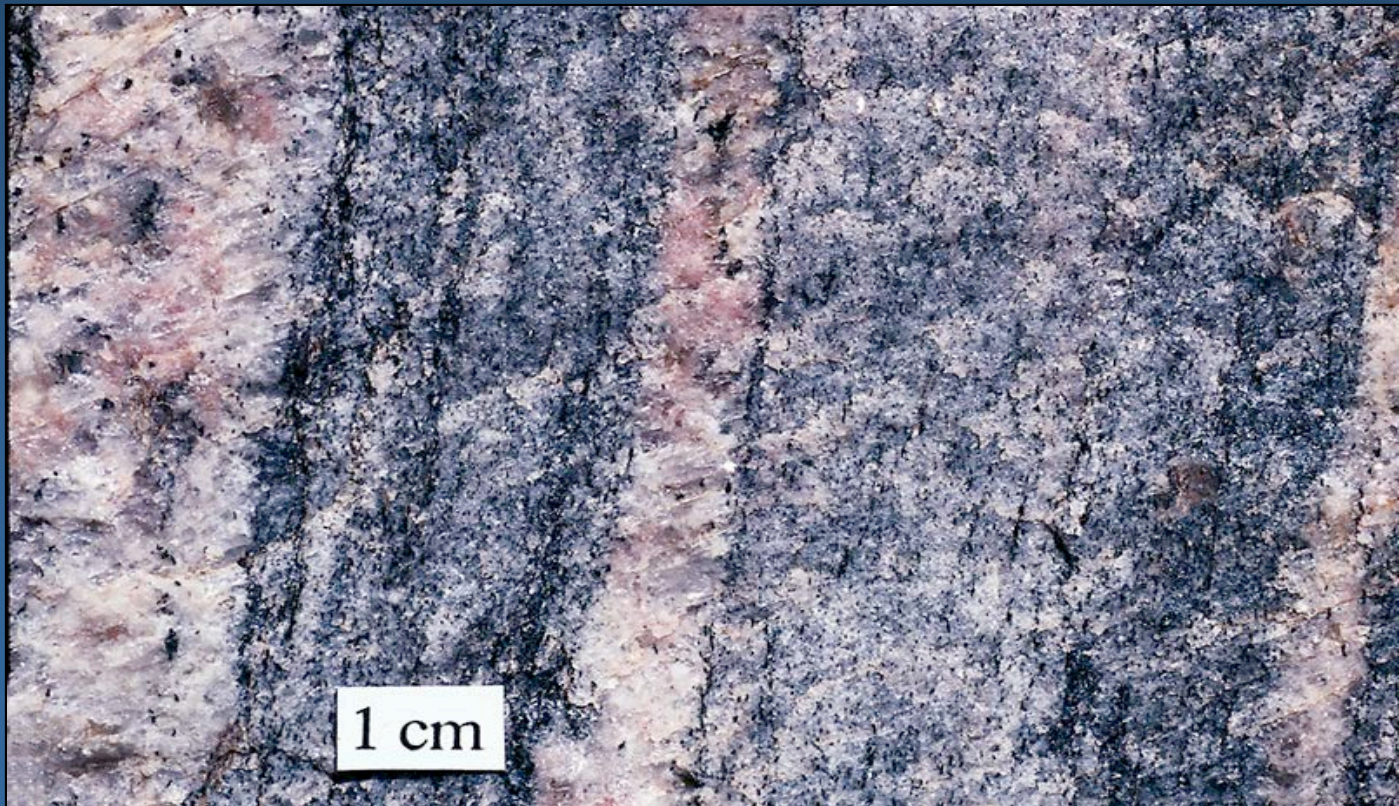
- with modifier for dominant mineral: **biotite** schist, **muscovite** schist

- **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**

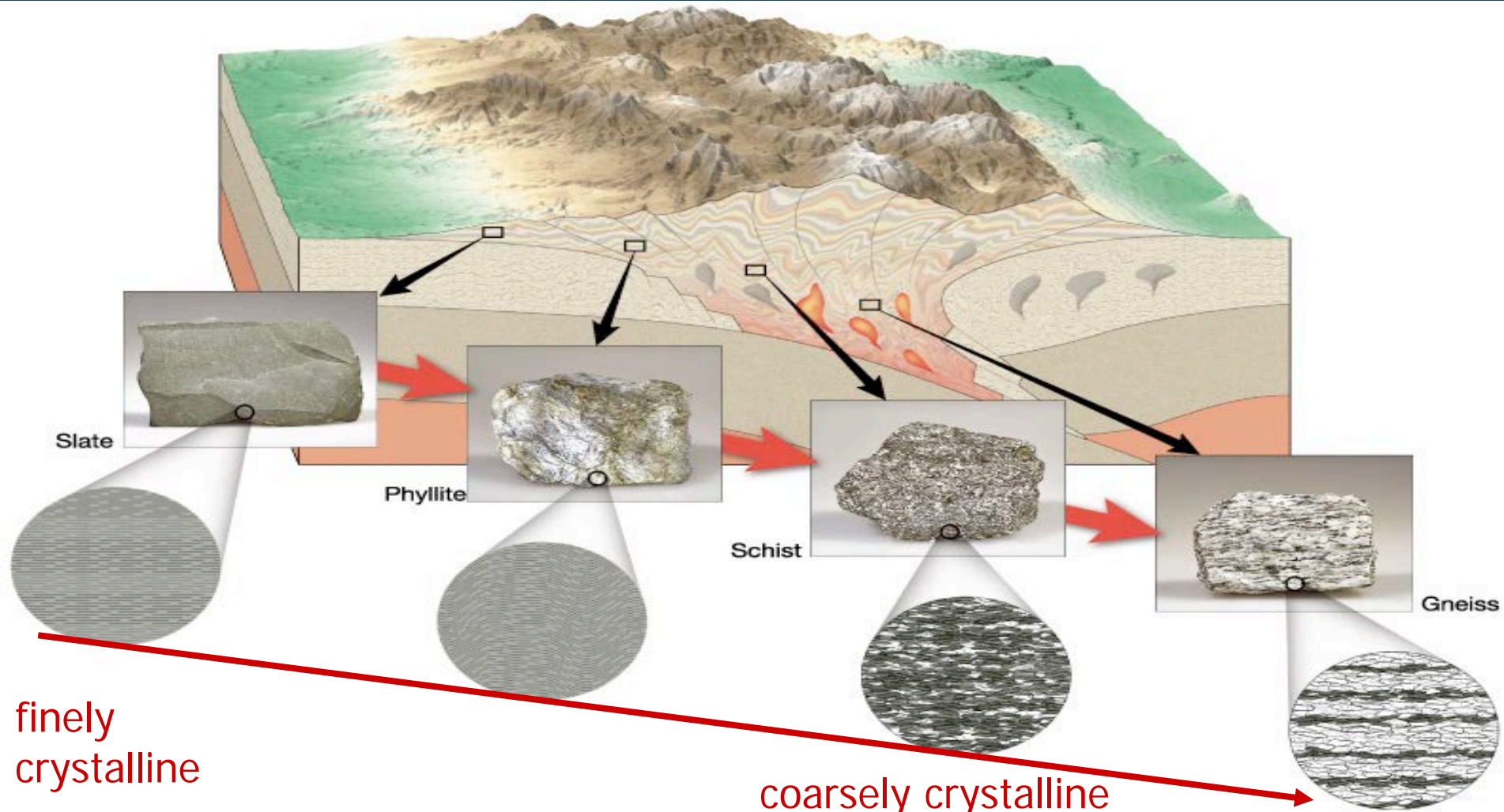
- Highest grade of metamorphic rock (most heat & stress)

- **Rock Name:** Gneiss -with modifier for dominant dark mineral: **biotite** gneiss, **hornblende** gneiss



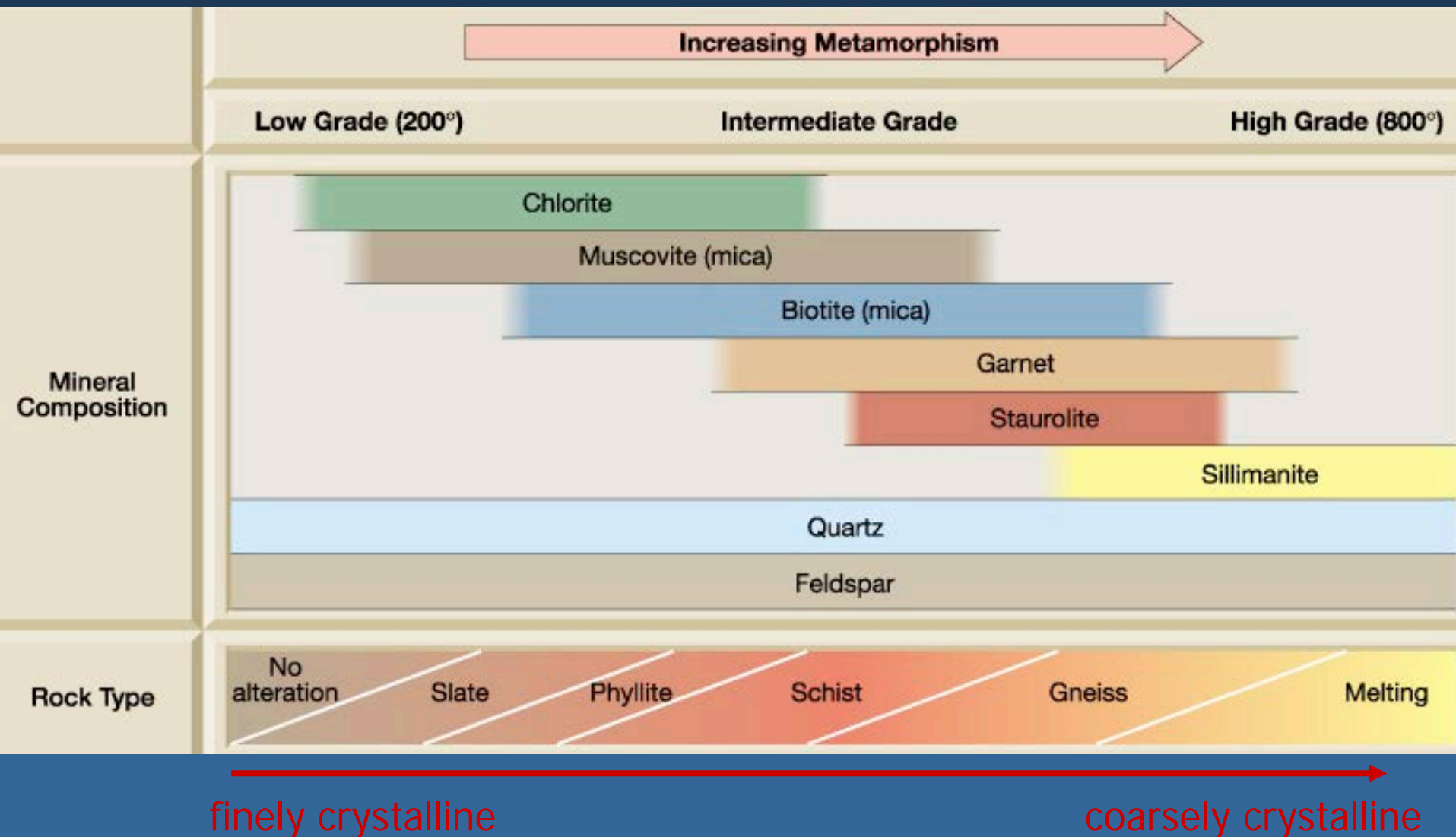
Metamorphic grade in foliated rocks

- 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

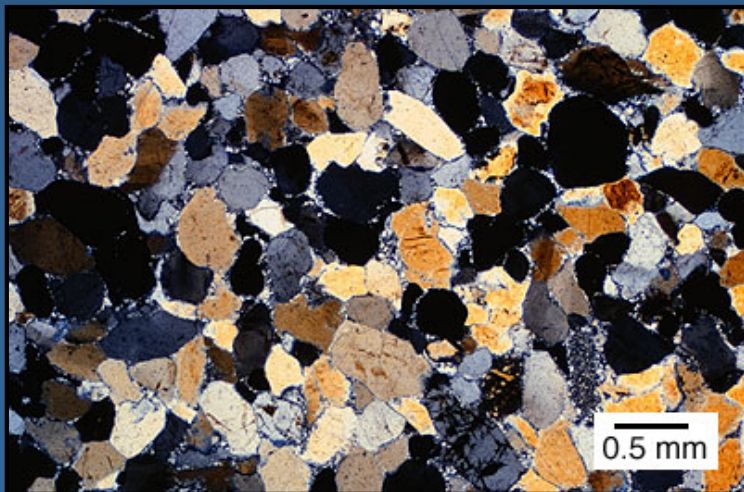
2. NON-FOLIATED metamorphic rocks

- Named mainly from the mineralogy inherited from their parent rock

<u>NAME</u>	<u>MINERAL</u>	<u>PARENT</u>
Marble	Calcite	Limestone
Quartzite	Quartz	Quartz Sandstone

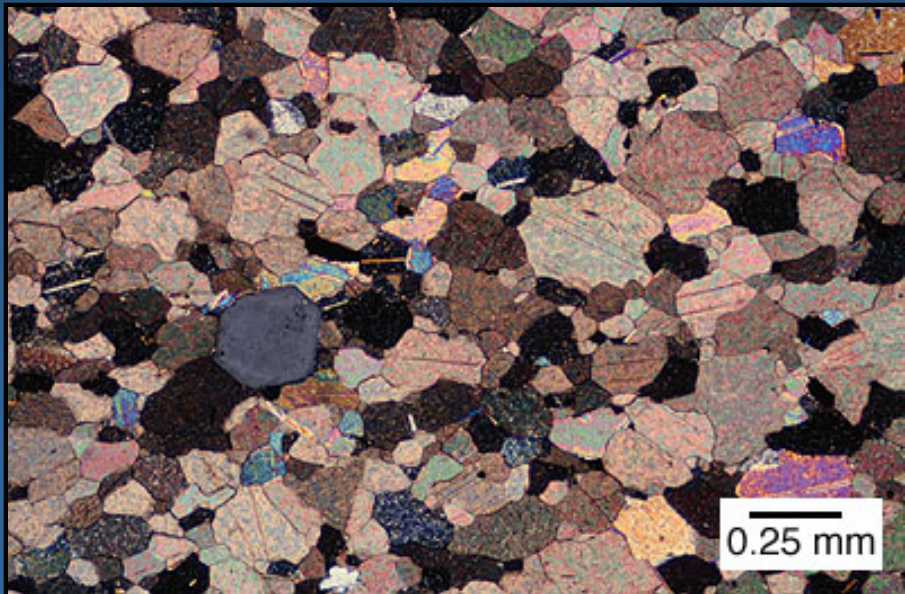
Nonfoliated metamorphic rocks

Quartzite – 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 variability