

# PRIMARY STRUCTURES

H. Muhammad Ridha Adhari, S.T., M.Sc



Dept. of Mining Engineering  
Faculty of Engineering  
Syiah Kuala University  
Darussalam, Banda Aceh

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# Course Outline

- Igneous Structures
- Metamorphic Structures
- Summary



# **IGNEOUS STRUCTURES**

# Igneous rocks

## 1. Intrusive rocks.

Cooled beneath the surface of the Earth. During the process of intruding, flowing, settling and/or cooling, igneous rocks can develop primary structures.

## 2. Extrusive rocks.

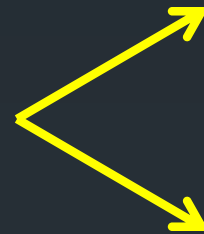
Formed either from lava that flowed over the surface of the Earth and cooled under air or water, or from ash that exploded out of a volcanic vent.



### Structures Associated with Intrusions:

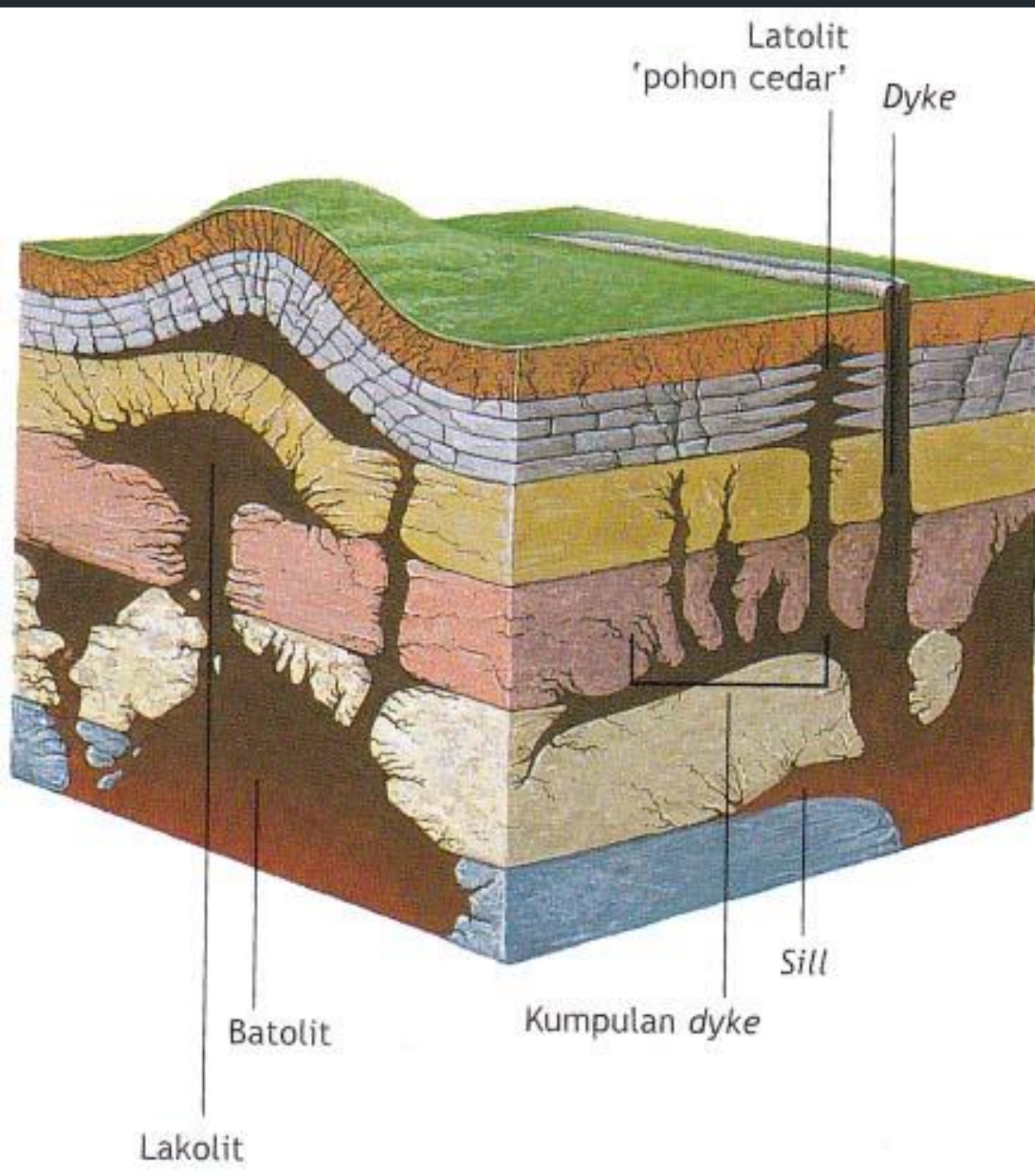
- Concordant : Sill, Laccolit, Lopolith.
- Discordant : Dyke, Batolith, Stock.

# Igneous Structures



### Structures Associated with Extrusion:

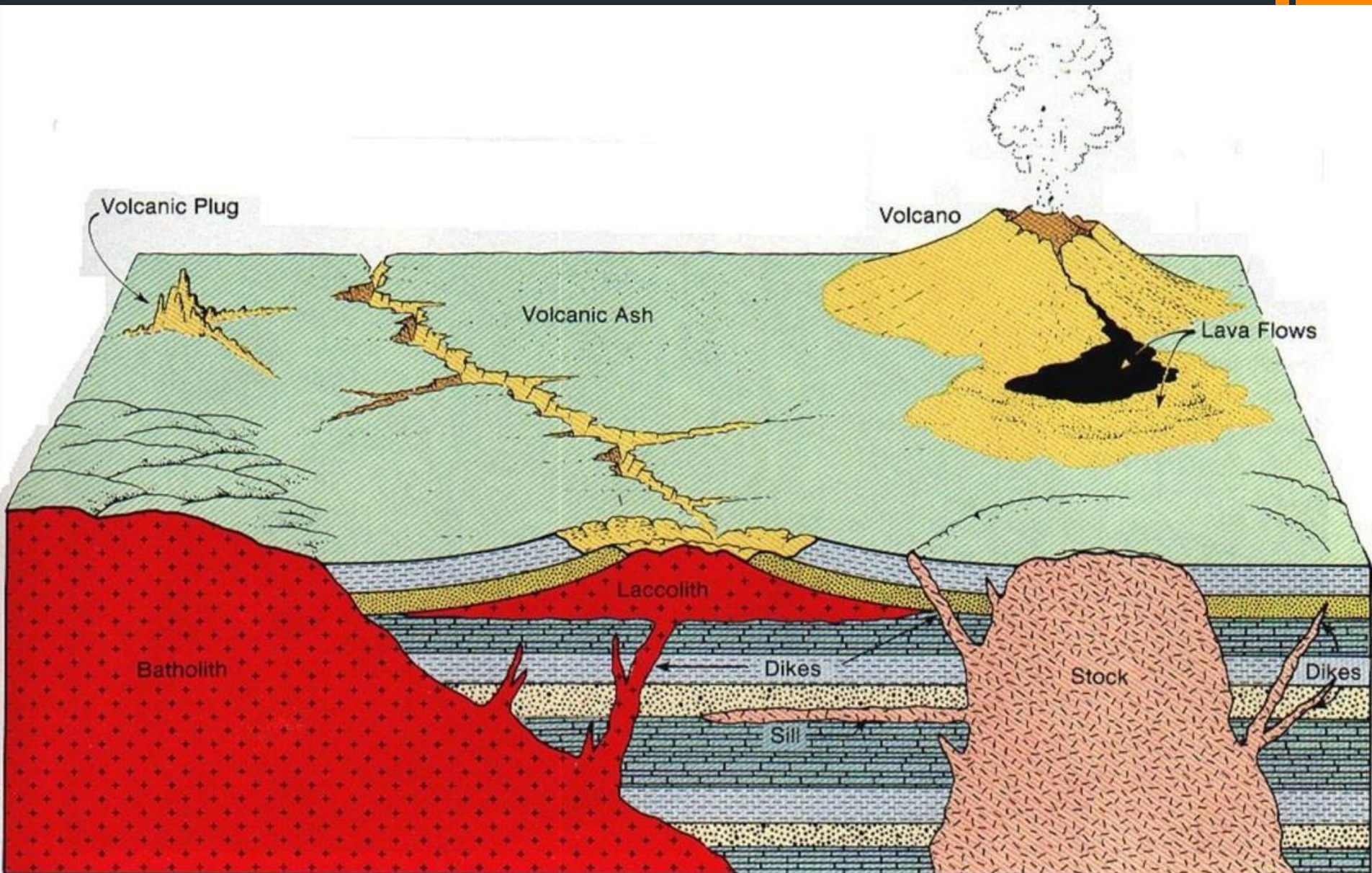
- Magma, Lava bantal, lava ropy, etc.
- Masif, Glassy, Vesikuler, Amigdaloidal, Kekar kolom, kekar berlembar, etc.



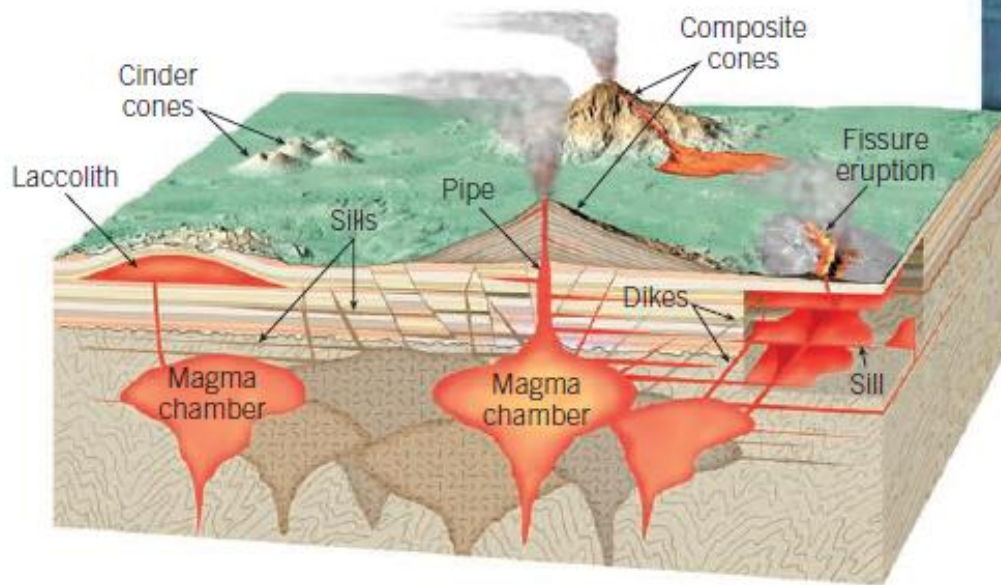
## Structures Associated with Intrusions:

- Concordant : Sill, Laccolit, Lopolith.
- Discordant : Dyke, Batolith, Stock.

# Structures Associated with Intrusions



**A. Interrelationship between volcanism and intrusive igneous activity.**

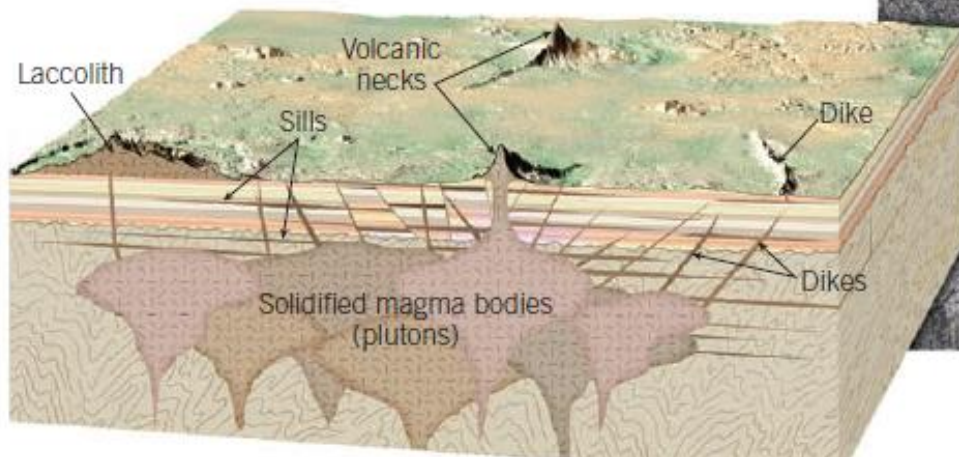


USGS



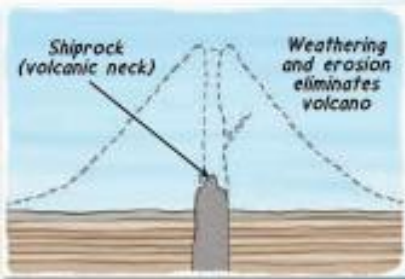
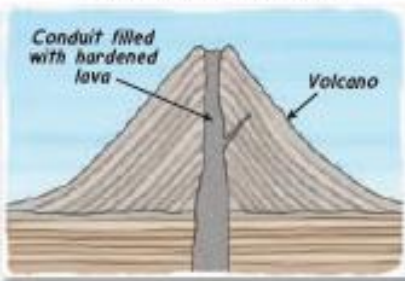
Marli Miller

**B. Basic intrusive structures, some of which have been exposed by erosion.**

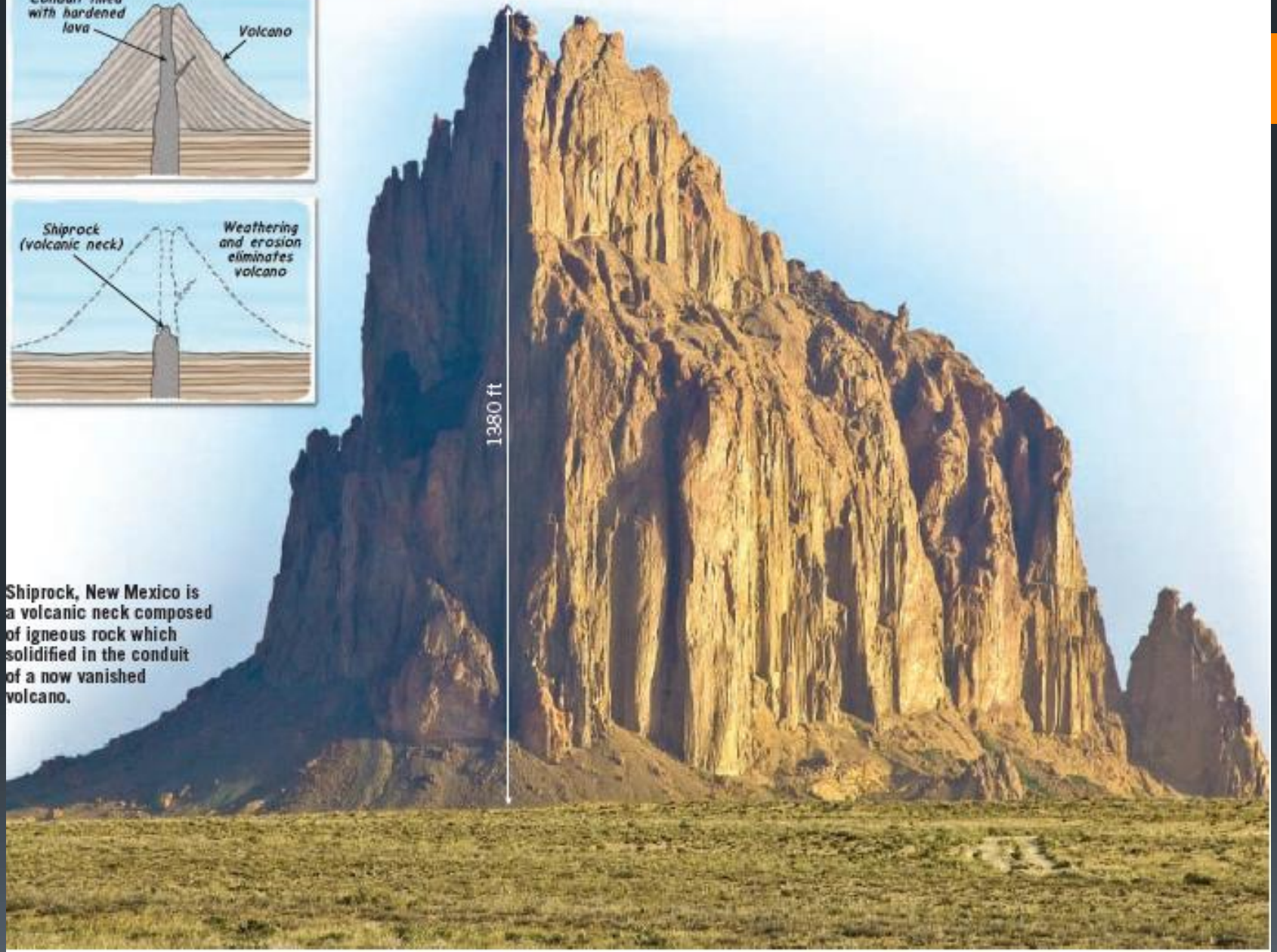




## Geologist's Sketch



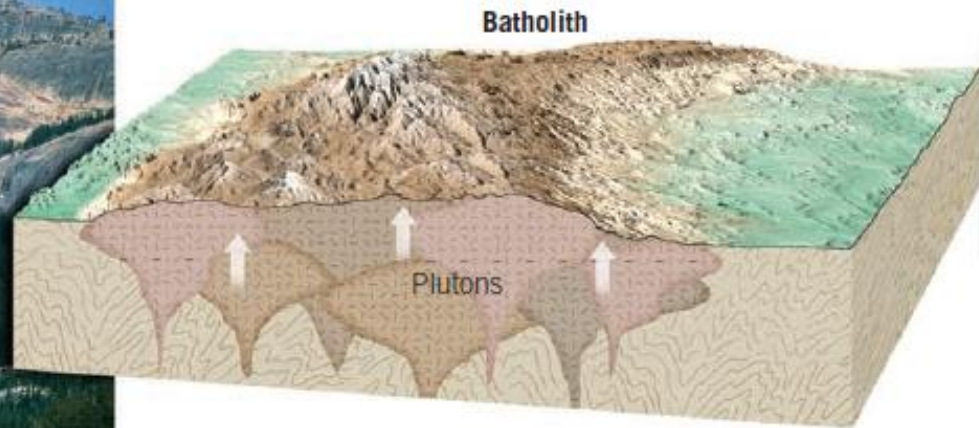
Shiprock, New Mexico is a volcanic neck composed of igneous rock which solidified in the conduit of a now vanished volcano.

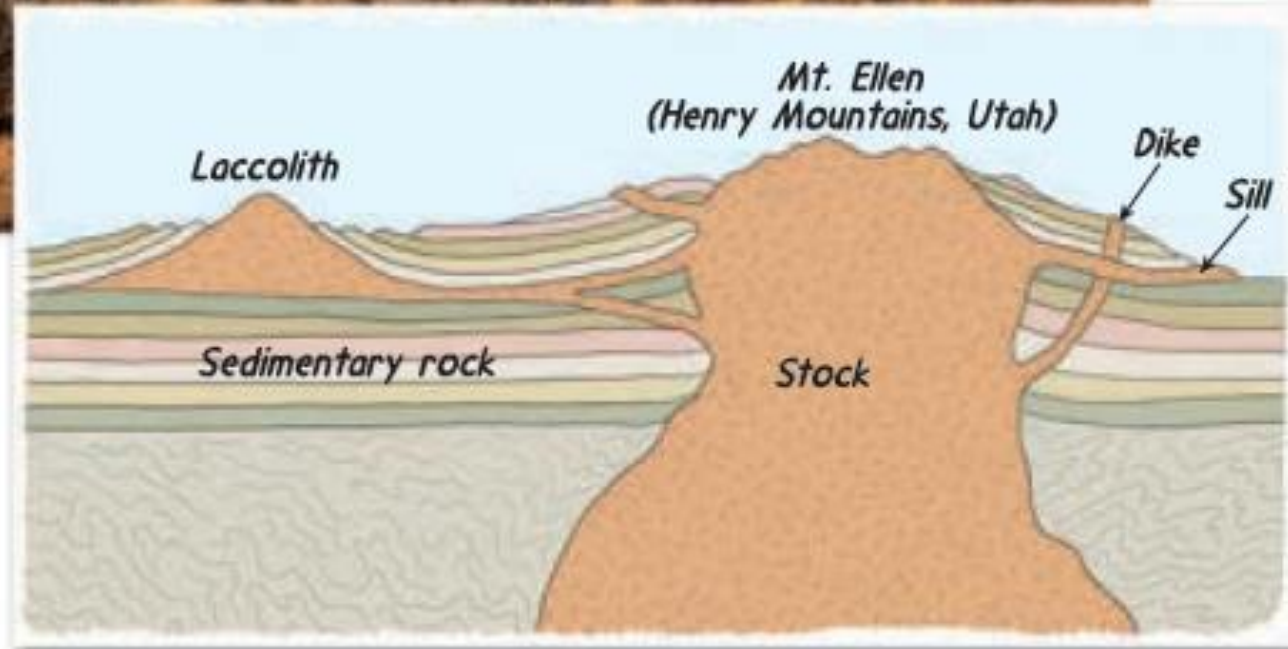


Volcanic neck

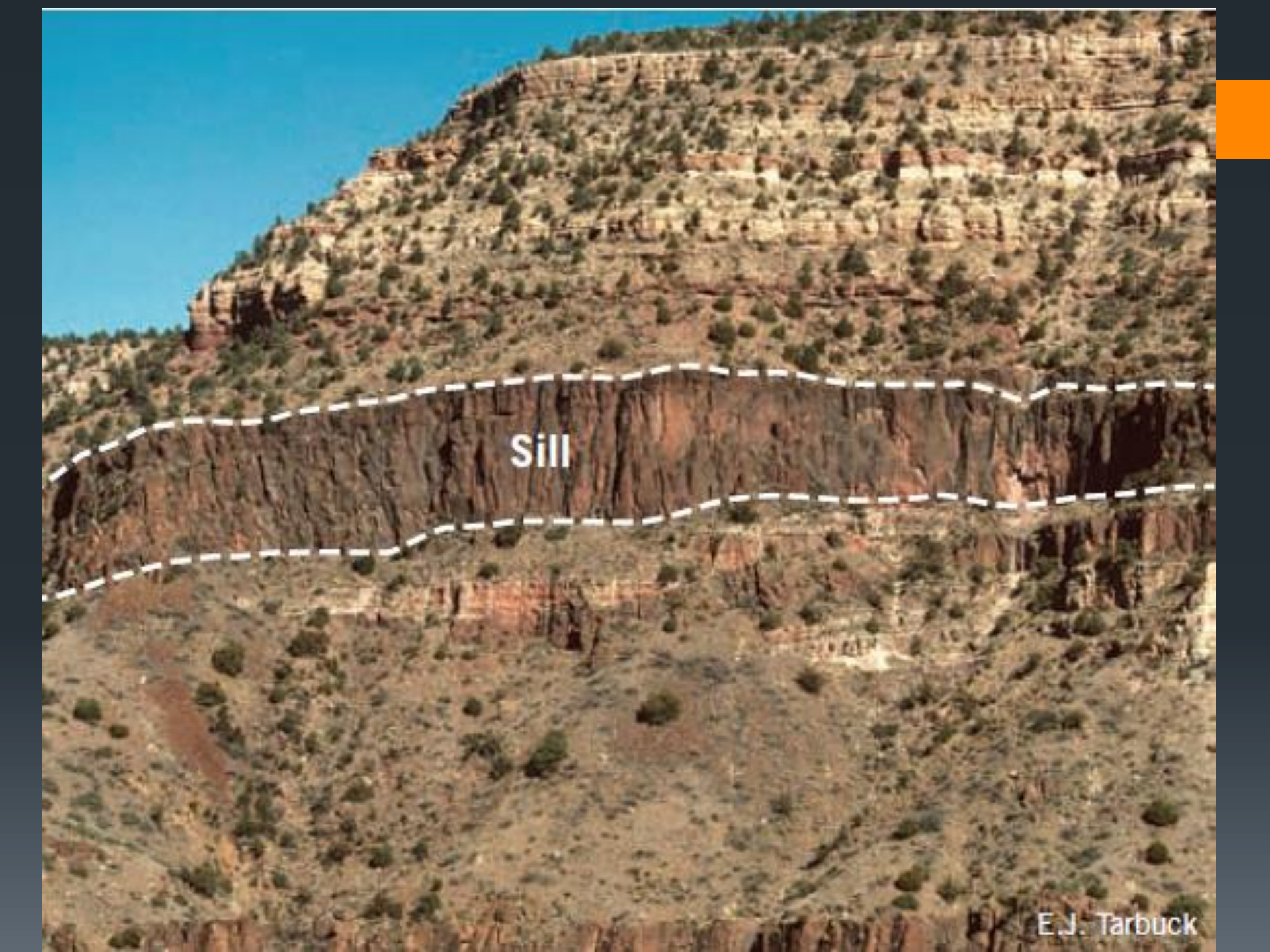


C. Extensive uplift and erosion exposed a batholith composed of several smaller intrusive bodies (plutons).





**Geologist's Sketch**

A photograph of a geological outcrop showing a dark, layered rock formation labeled "Sill" with white dashed lines indicating its boundaries. The rock is dark brown to black and has a vertical, columnar texture. It is situated between two lighter-colored, more horizontally layered rock units. The surrounding landscape is arid and hilly, with sparse vegetation and a clear blue sky.

Sill

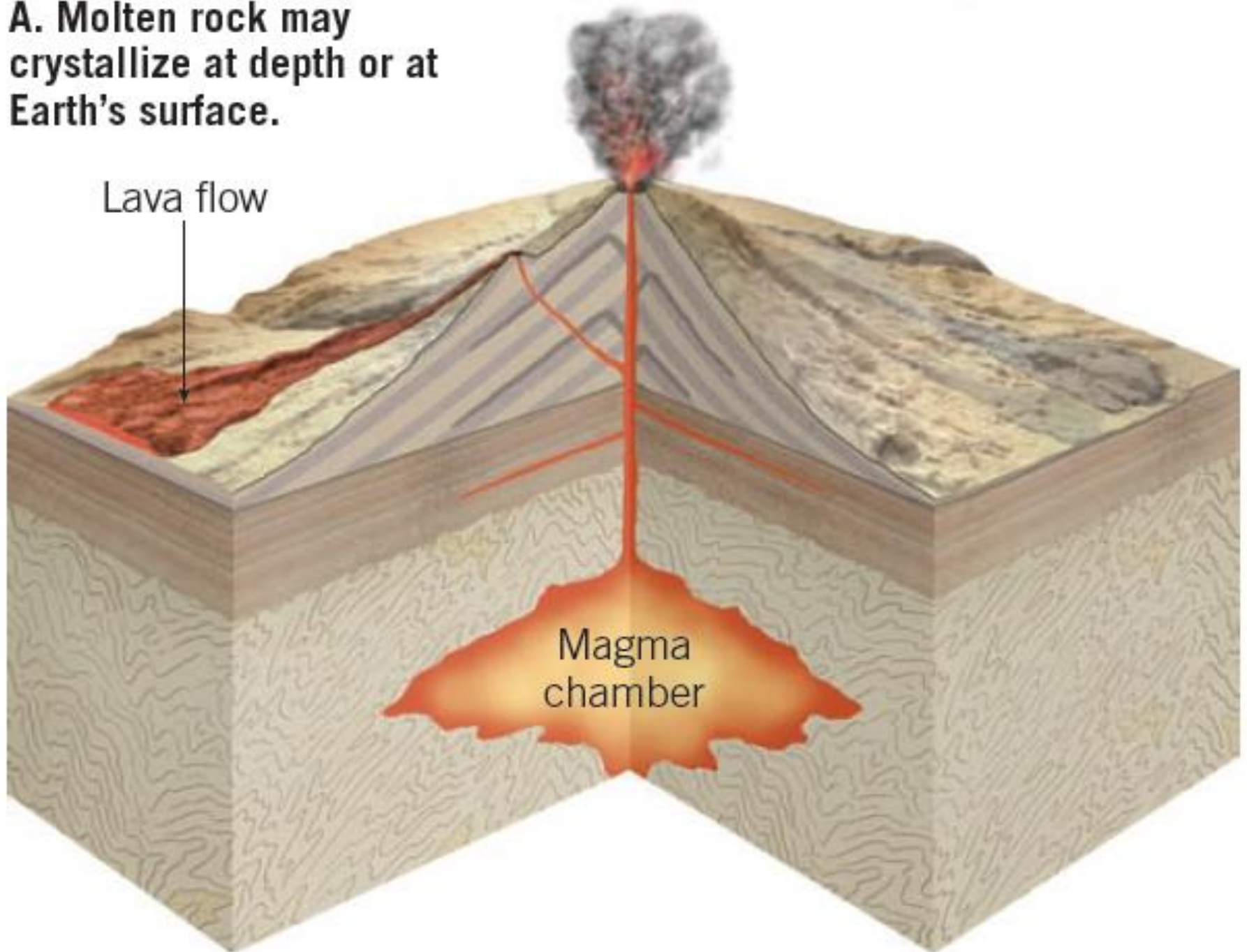


Dike

# Structures Associated with Extrusion

- Magma (formed by partial melting) = Parent Material of Igneous Rock.
- a magma body rises toward the surface because it is less dense than the surrounding rocks.
- Most magmas consist of three materials: a *liquid component*, a *solid component*, and a *gaseous component*
- *Magma : Explosive & Non Explosive.*
- Lava = Molten rock reaches Earth's surface.
- As shallow intrusions and extrusive flows cool, they contract.
- Because of their fine grain size, these bodies are susceptible to forming natural cracks, or joints, in response to the thermal stress associated with cooling.

**A. Molten rock may crystallize at depth or at Earth's surface.**





**A. Glassy texture**

Composed of unordered atoms and resembles dark manufactured glass. (Obsidian is a natural glass that usually forms when highly silica-rich magmas solidify.)



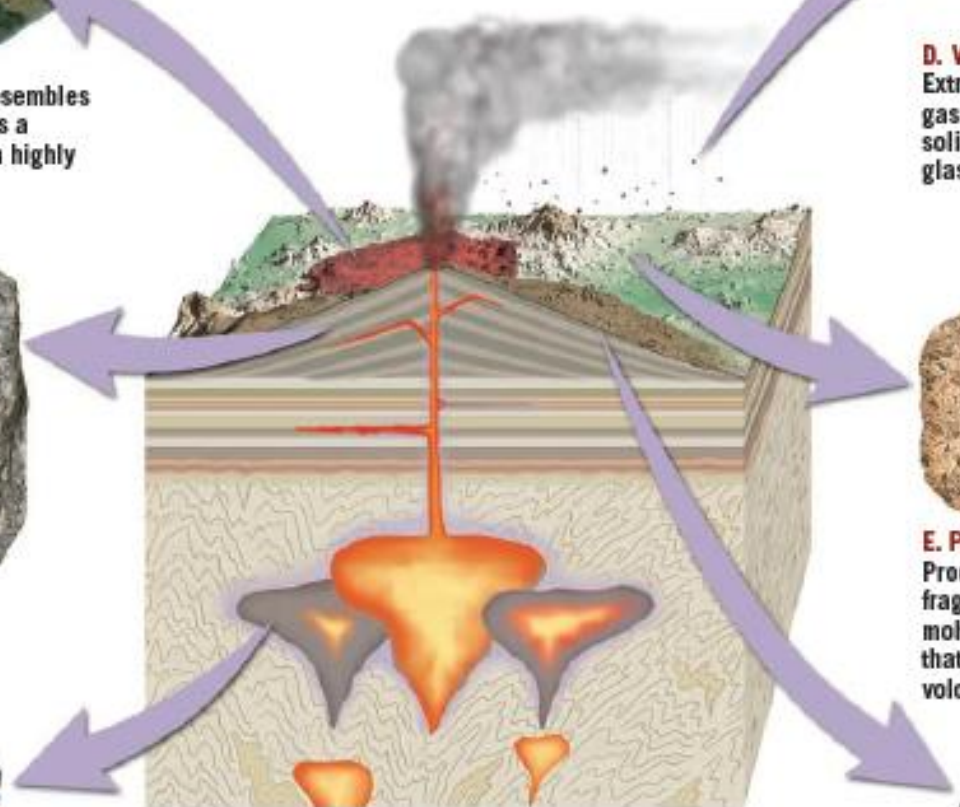
**B. Porphyritic texture**

Composed of two distinctly different crystal sizes.



**C. Phaneritic (coarse-grained) texture**

Composed of mineral grains that are large enough to be identified without a microscope.



**D. Vesicular texture**

Extrusive rock containing voids left by gas bubbles that escape as lava solidifies. (Pumice is a frothy volcanic glass that displays a vesicular texture.)



**E. Pyroclastic (fragmental) texture**

Produced by the consolidation of fragments that may include ash, once molten blobs, or large angular blocks that were ejected during an explosive volcanic eruption.



**F. Aphanitic (fine-grained) texture**

Composed of crystals that are too small for the individual minerals to be identified without a microscope.





Pillow lava



Aa lava



Aa lava



Vesicular Structure



Pahoehoe lava



Pahoehoe lava (Ropy lava)



**B. Hand sample of obsidian.**

Obsidian, a dark-colored, glassy rock formed from silica-rich lava



Igneous Dike





Igneous Dike



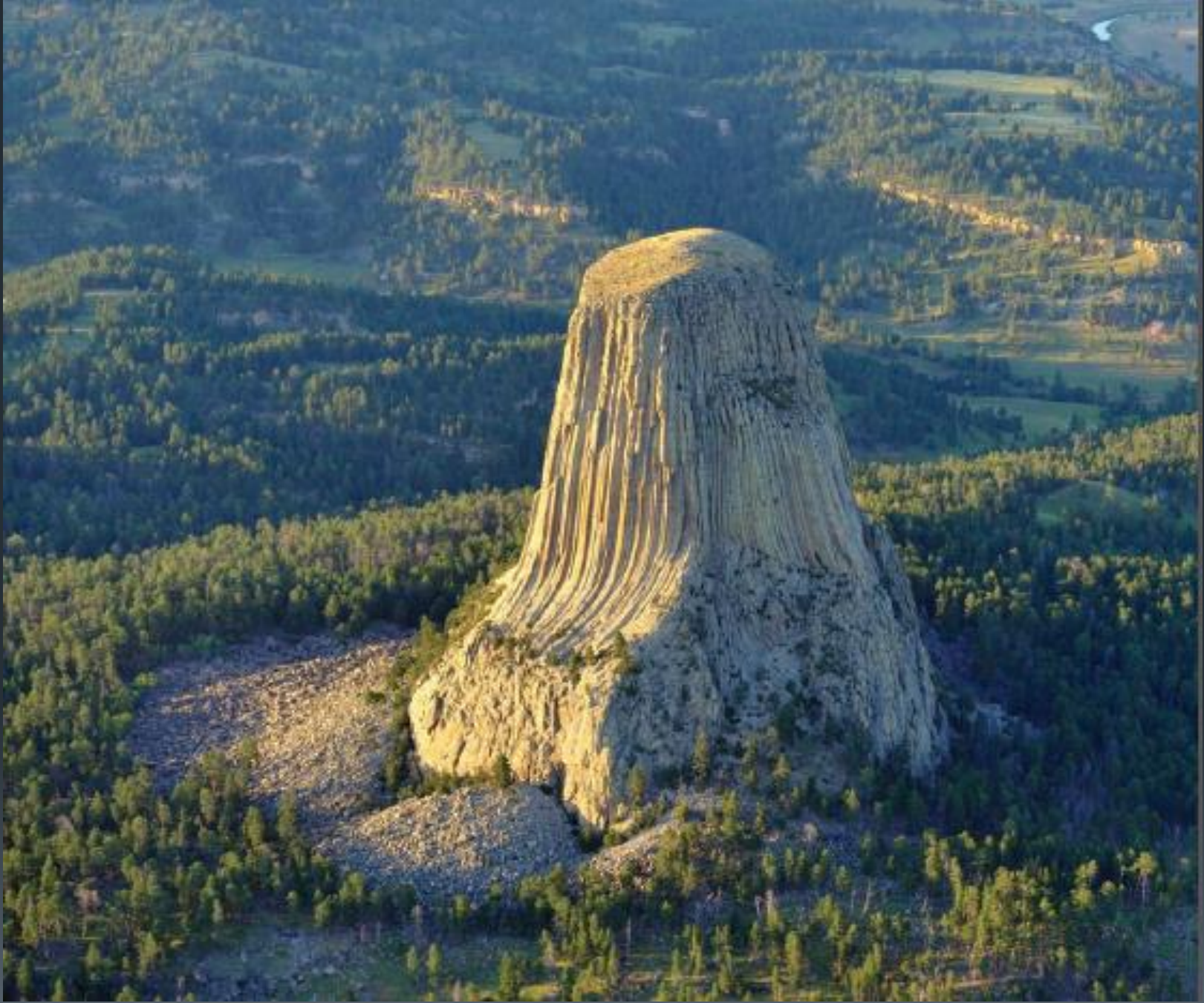
Fracture



Fracture



Columnar jointing occurs when igneous rocks cool and develop shrinkage fractures.



Columnar Joint

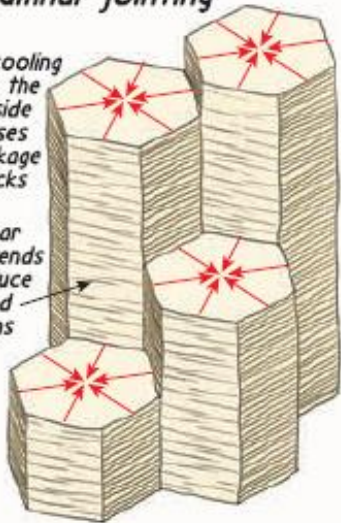


Columnar Joint

### Columnar jointing

Rapid cooling from the outside causes shrinkage cracks

Columnar jointing tends to produce 6-sided columns



Geologist's Sketch

Columnar Joint



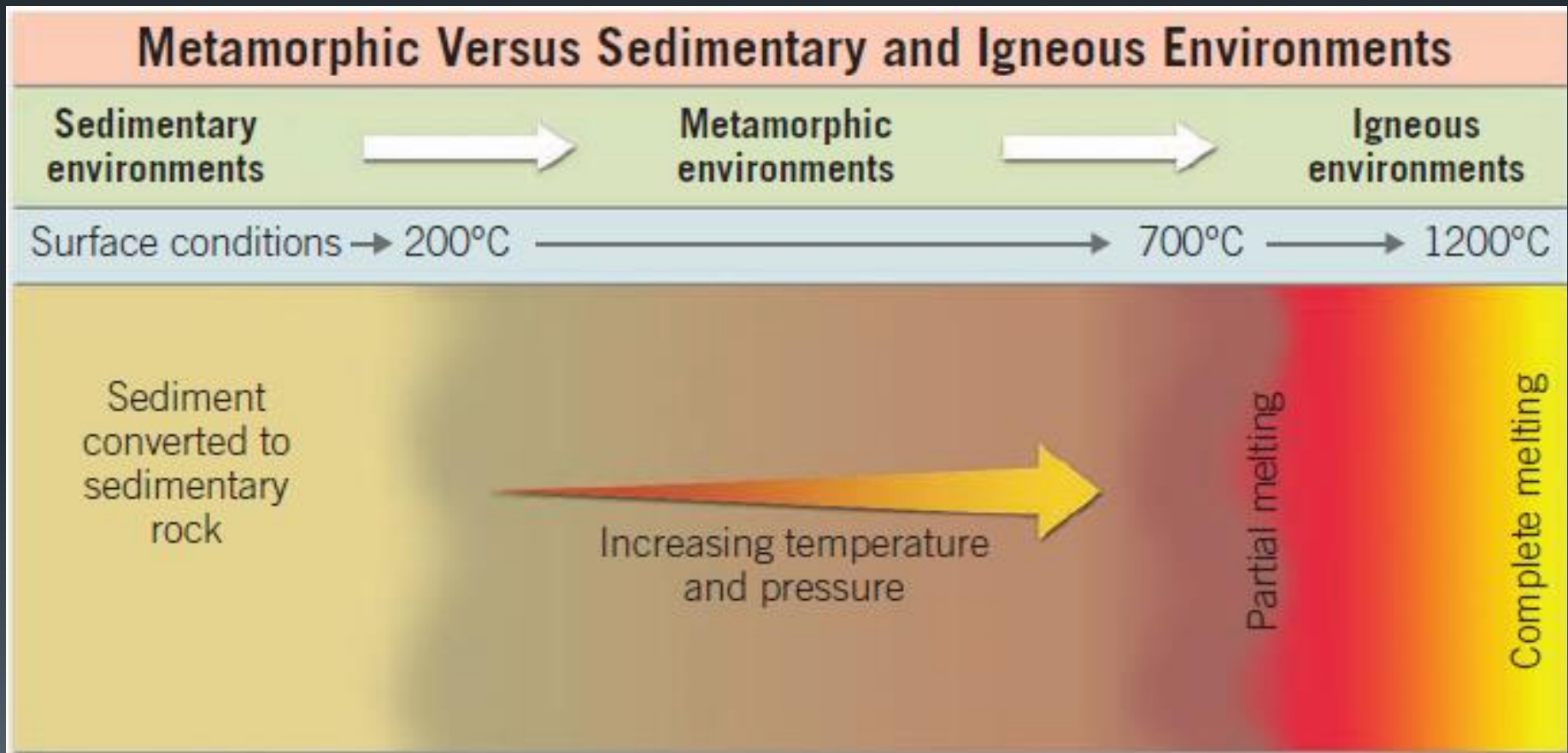
Sheet Joint





# **METAMORPHIC STRUCTURES**

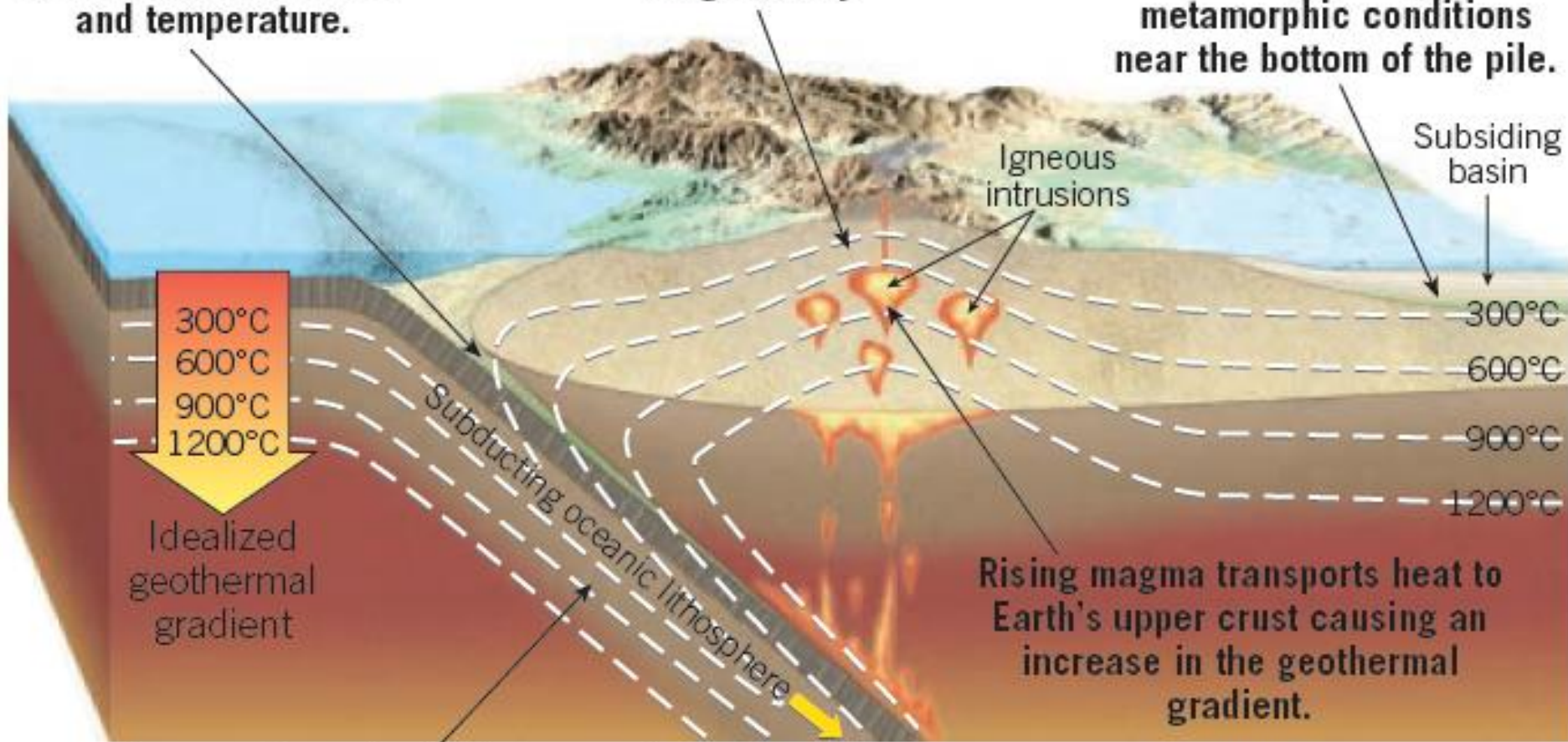
# Metamorphic Rock → Caused by Pressure and Temperature



Subducting sediments are metamorphosed due to increase in pressure and temperature.

Shallow crustal rocks are metamorphosed by heat emanating from a nearby magma body.

Rocks buried in a large sedimentary basin may encounter low-grade metamorphic conditions near the bottom of the pile.



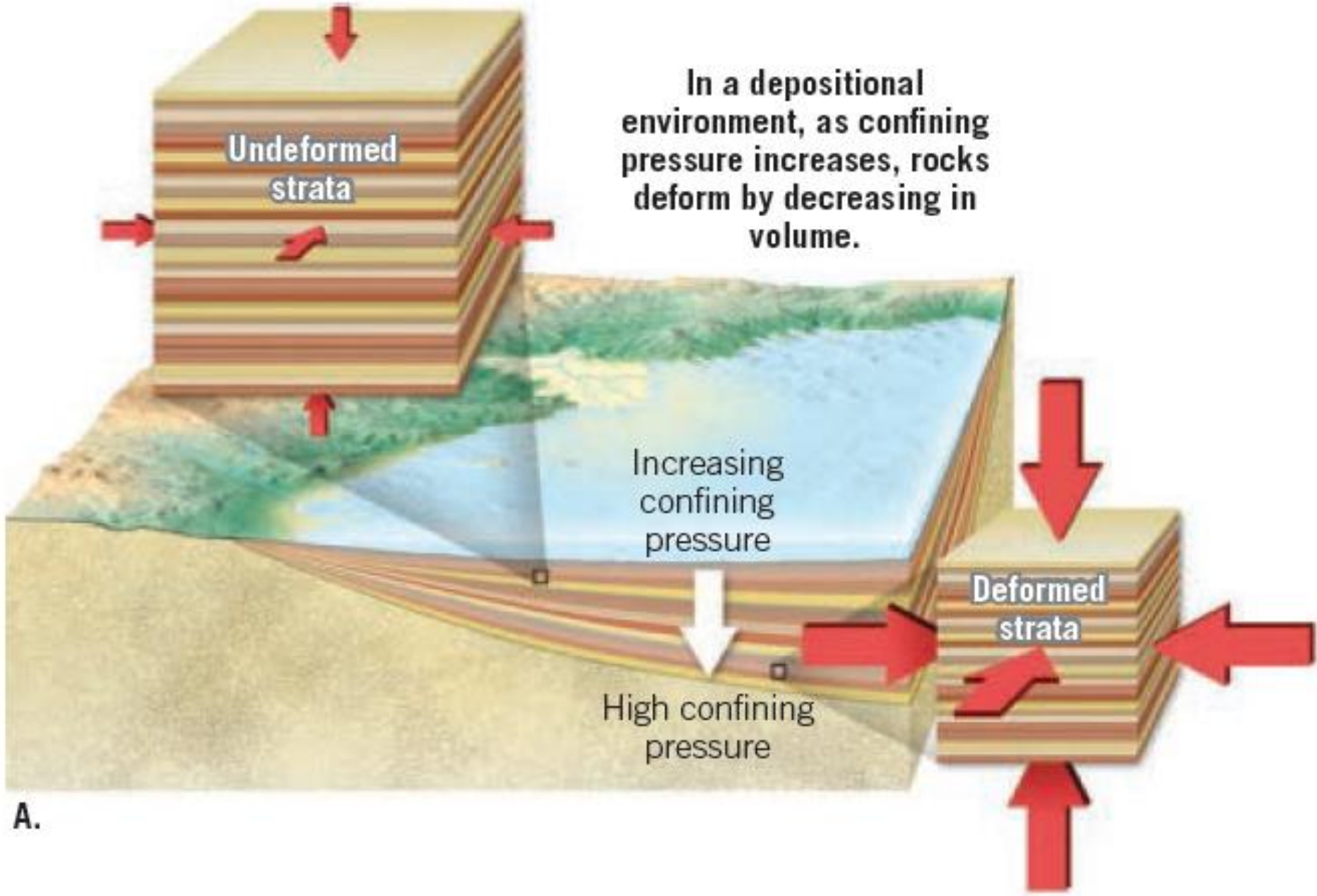
Low geothermal gradients are observed in subduction zones because cold oceanic crust and overlying sediments are descending into the mantle.

Sources of heat for metamorphism

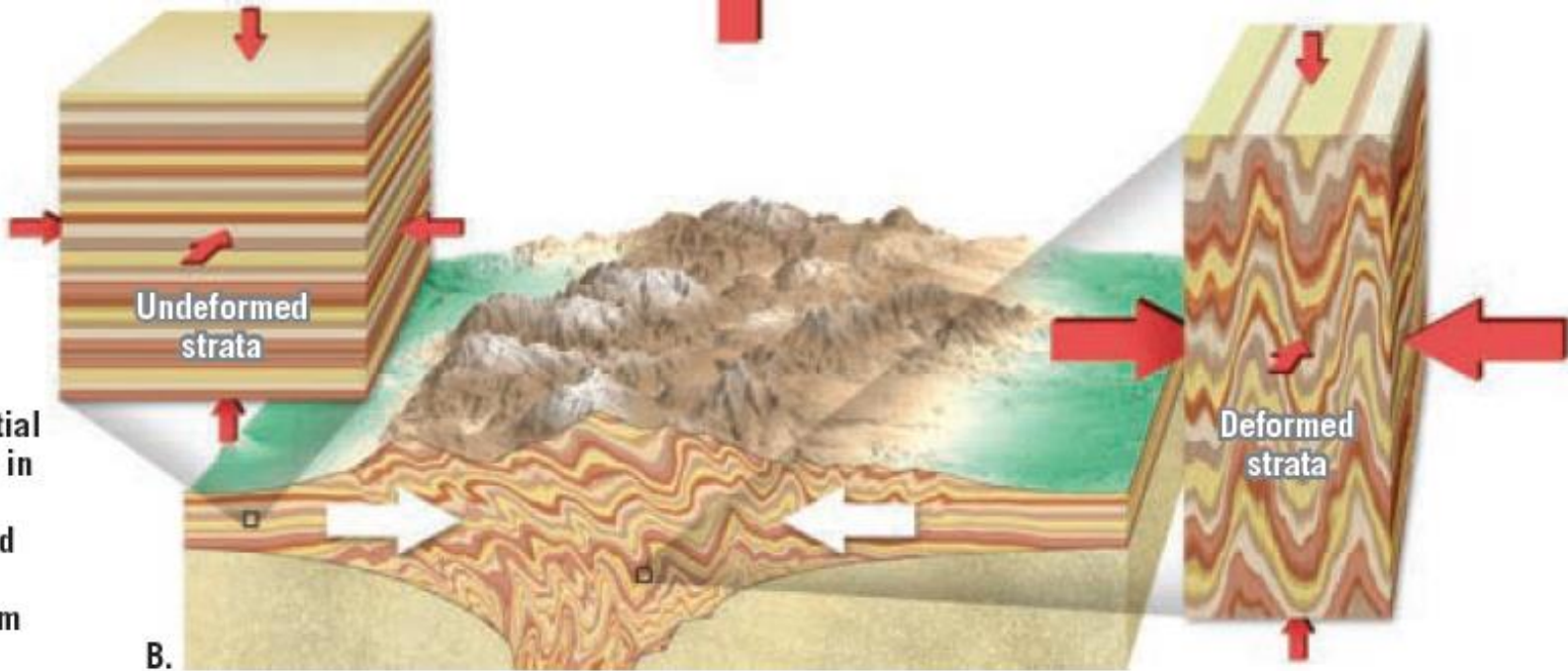


# Type of Stress / Pressure

- Confining Pressure
- Differential Stress



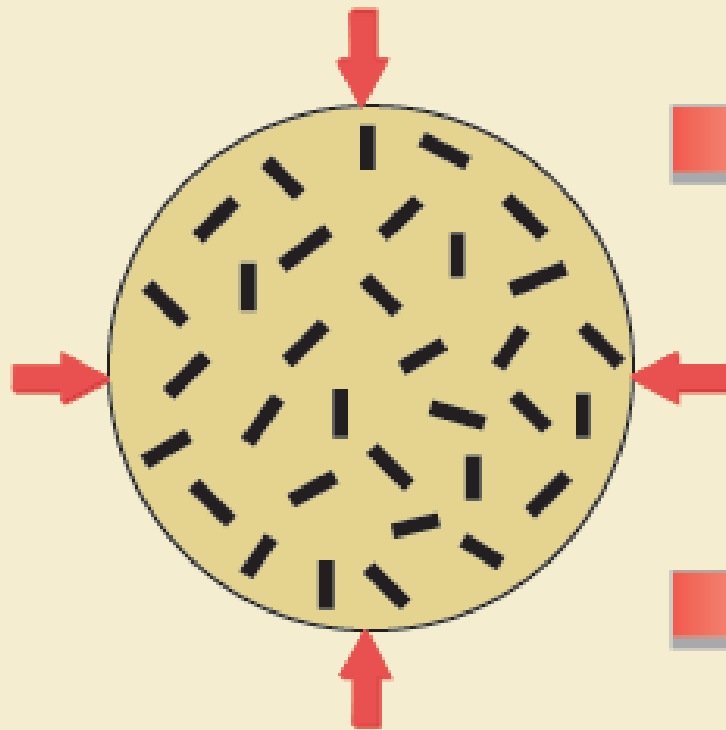
Confining Pressure



During mountain building, rocks subjected to differential stress are shortened in the direction of maximum stress and lengthened in the direction of minimum stress.

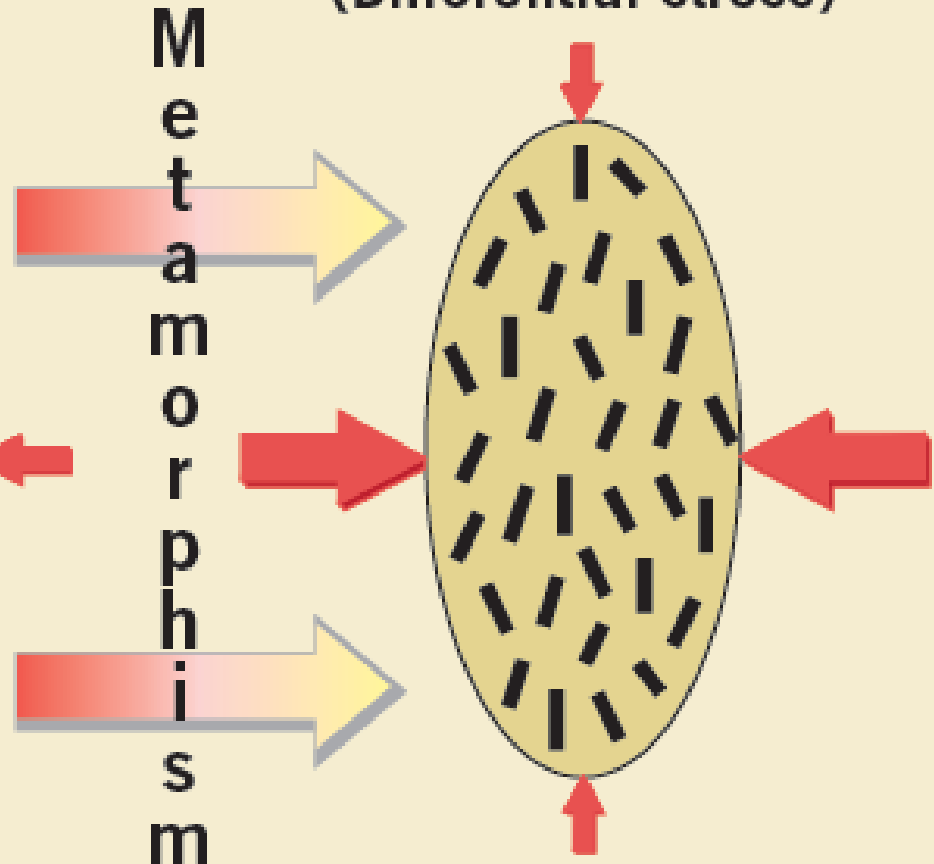
### Differential Stress

Before metamorphism  
(Confining pressure)



Platy mineral grains having random orientation.

After metamorphism  
(Differential stress)



When differential stress causes rocks to flatten, the mineral grains rotate and align roughly perpendicular to the direction of maximum differential stress.

shale

slate

phyllite

schist

gneiss

increasing metamorphism

Metamorphic Rocks







# Structure of Metamorphic Rock

- Foliation, Lineation
- Non Foliation

# Fabric, Foliation and Lineation

- Fabric is built of minerals and mineral aggregates with a preferred orientation that penetrate the rock at the microscopic to centimeter spacing scale.
- Fabric : Linear Fabric (Lineation) and Planar Fabric (Foliation).
- Lineation is characterized by elongate elements with a preferred orientation.
- Lineation : Result of elongation.
- Foliation contains tabular or platy minerals or other “flat” objects with a common orientation.
- Foliation : Result of flattening.

**Parent rock  
(Shale)**



Low-grade  
metamorphism  
Low temperatures  
and pressures

**Metamorphic rock  
(Slate)**



**A.**

Loosely  
packed  
clay  
minerals



Tightly  
packed  
chlorite and  
mica grains



**Parent rock  
(Granodiorite)**

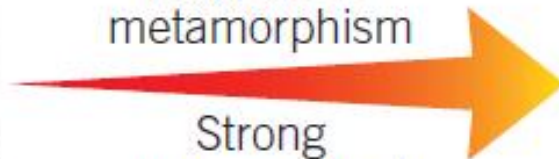


**B.**

Randomly oriented mineral grain



High-grade metamorphism

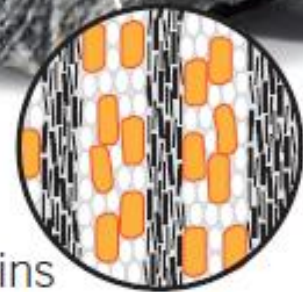


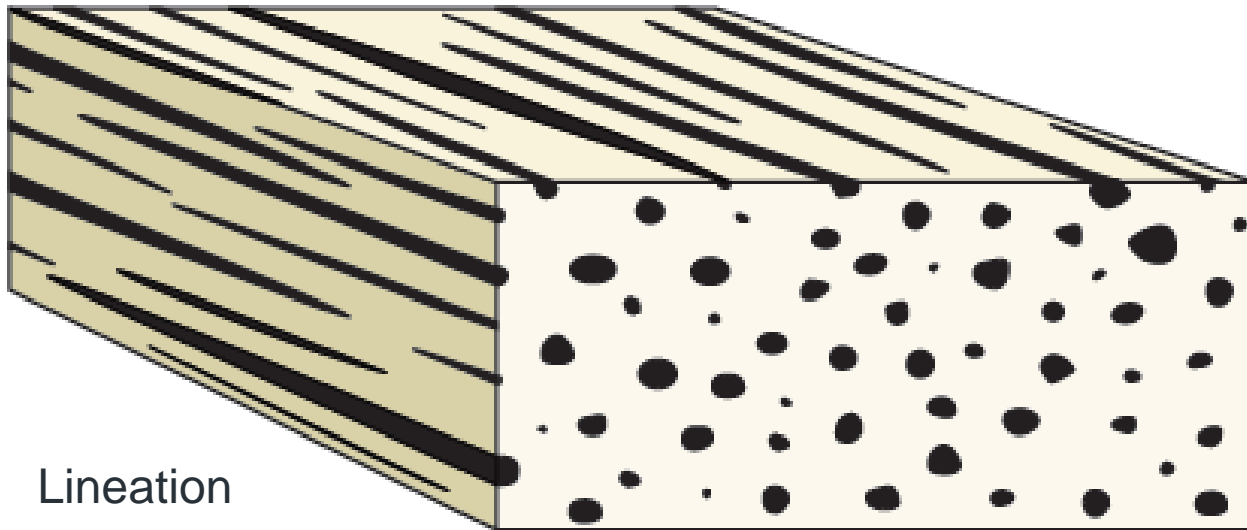
Strong compressional forces, high temperatures and pressures

**Metamorphic rock  
(Folded gneiss)**

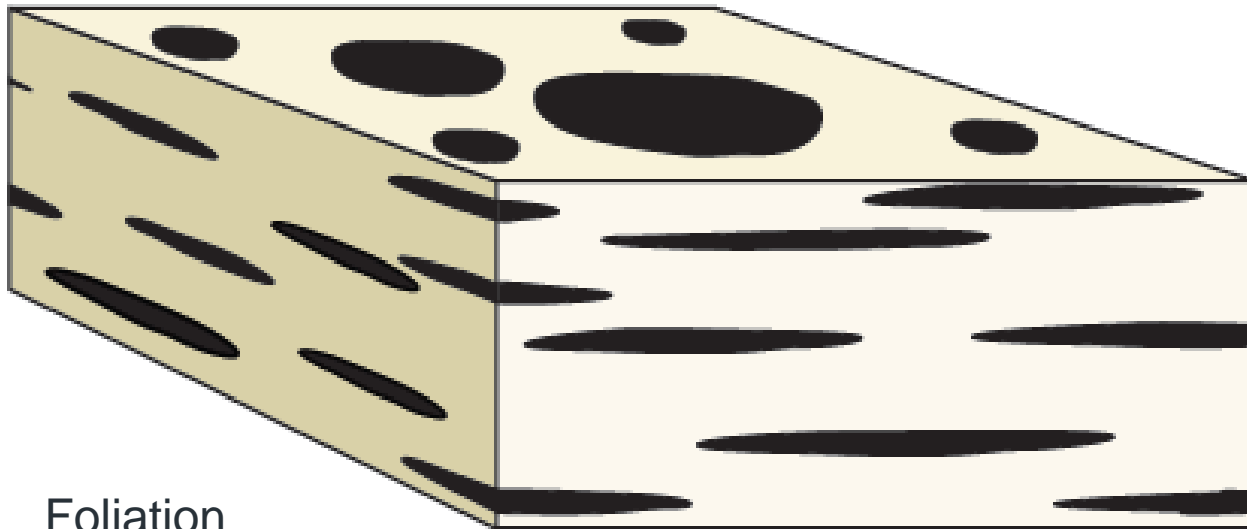


Deformed layers of segregated grains





Lamination



Foliation

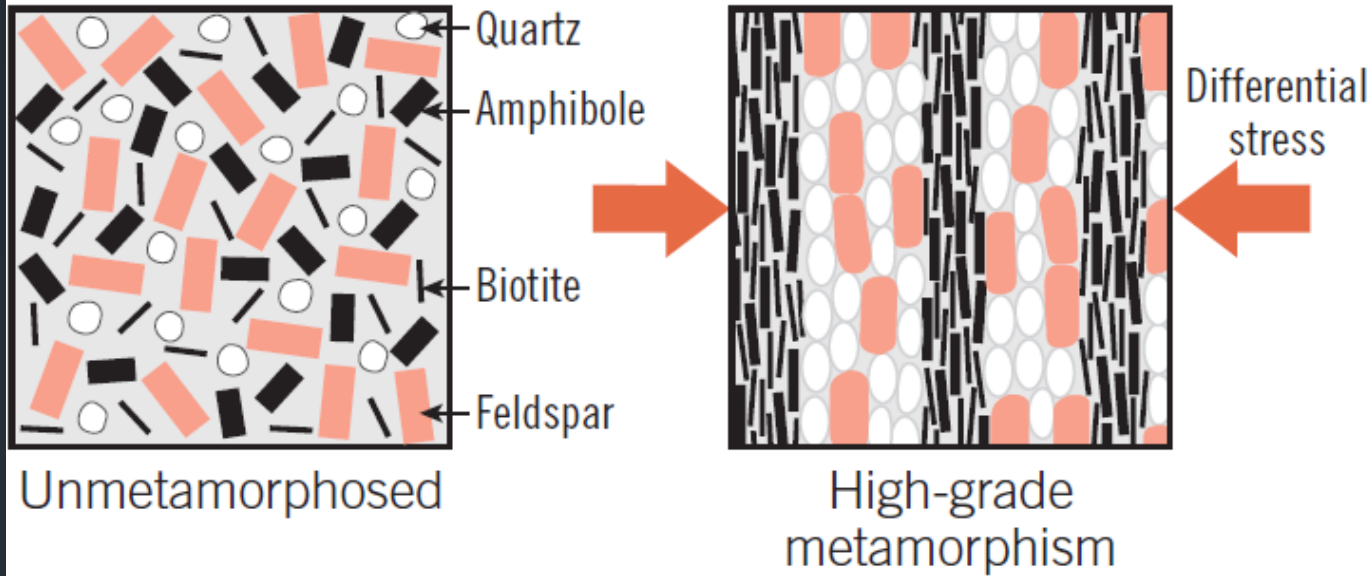
Fabric is a configuration of objects penetrating the rock.



Lineation in Gneiss

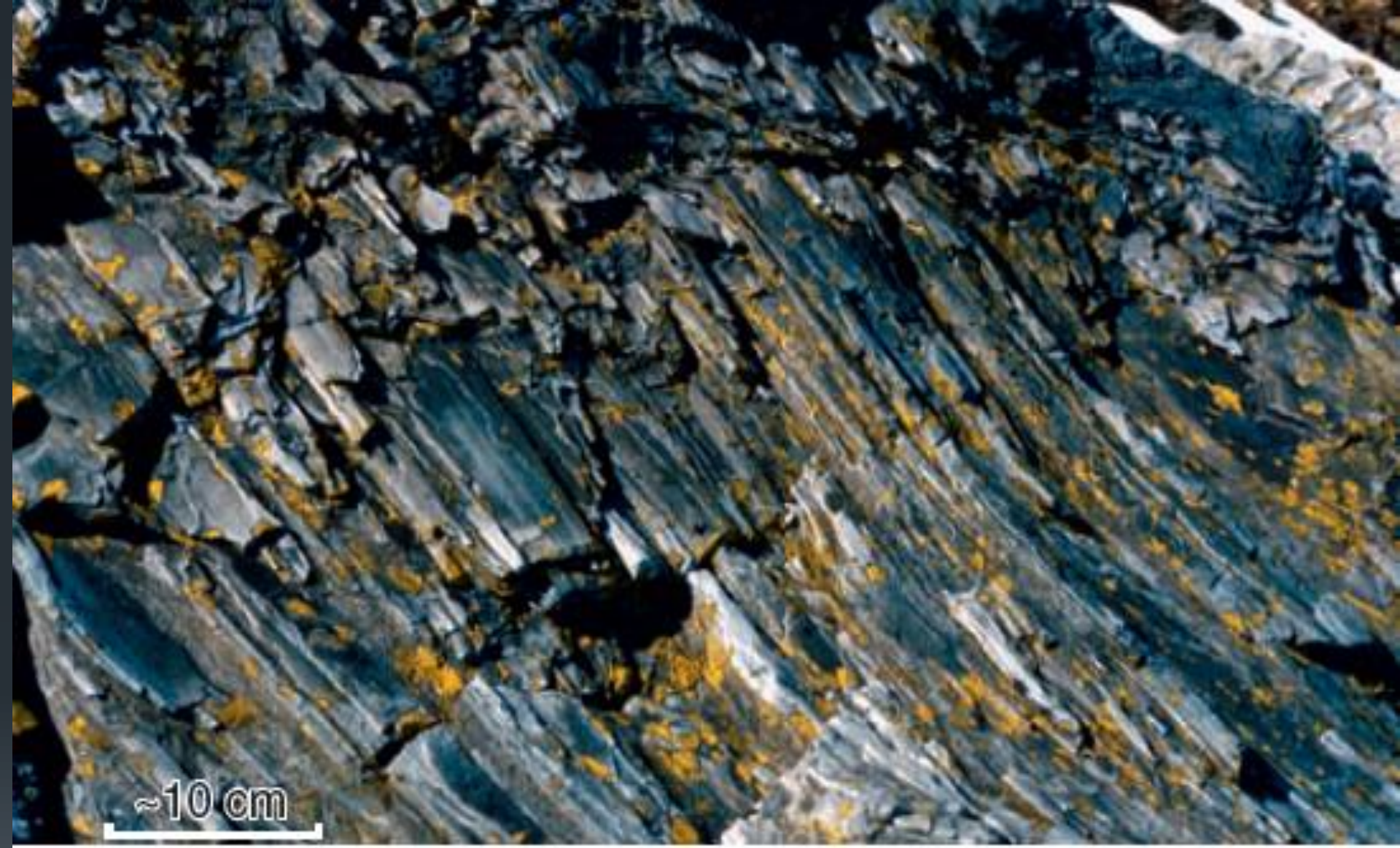
Parent rock with randomly oriented mineral grains.

Ion migration causes light and dark minerals to separate.



Foliation in Gneiss



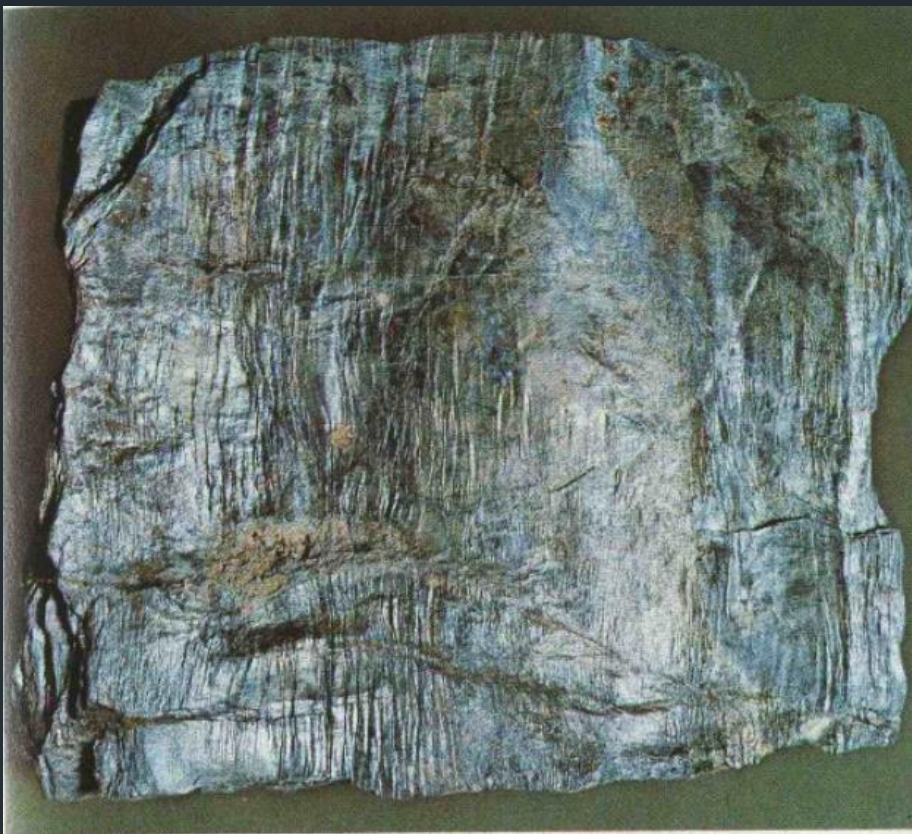


Lineation in Quartzite Conglomerate

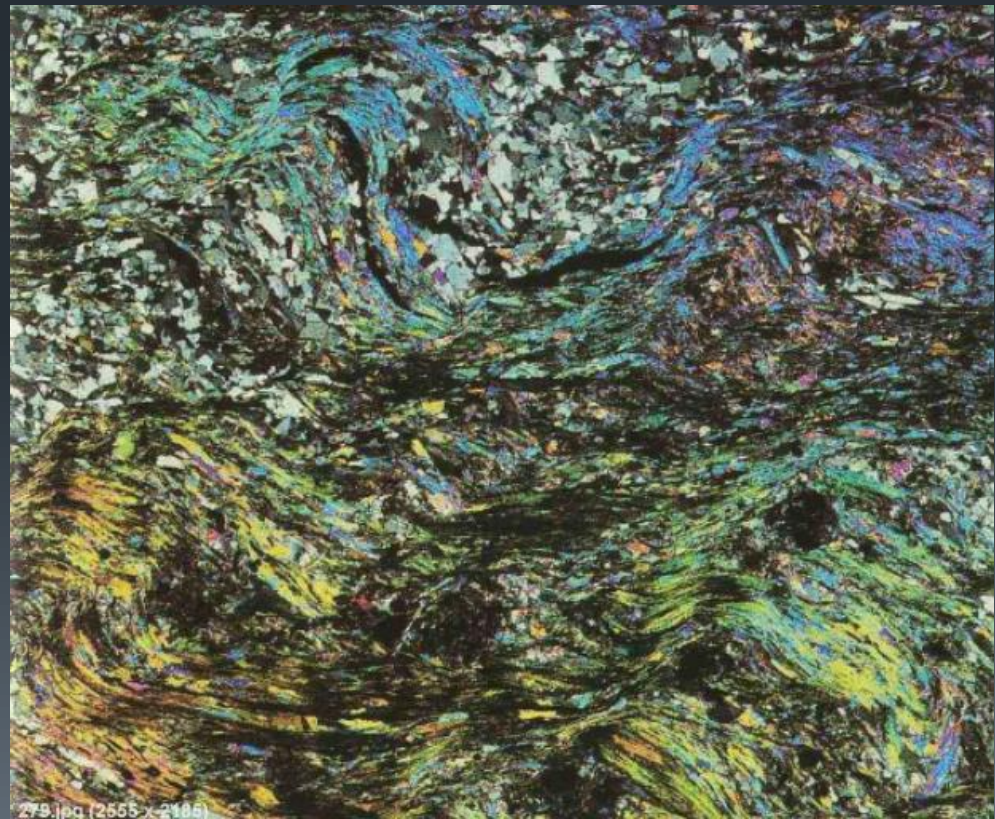




Foliation in a granitic rock



Phyllite



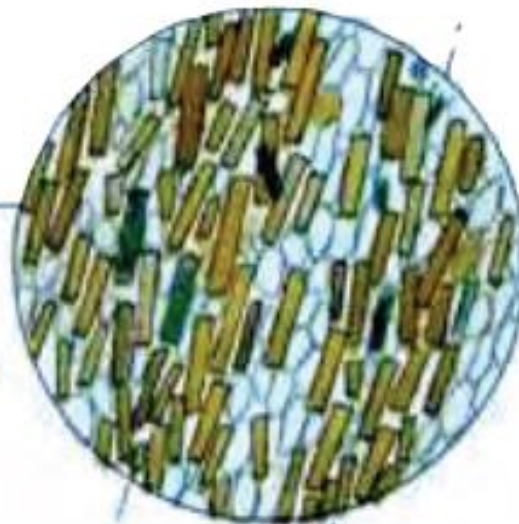
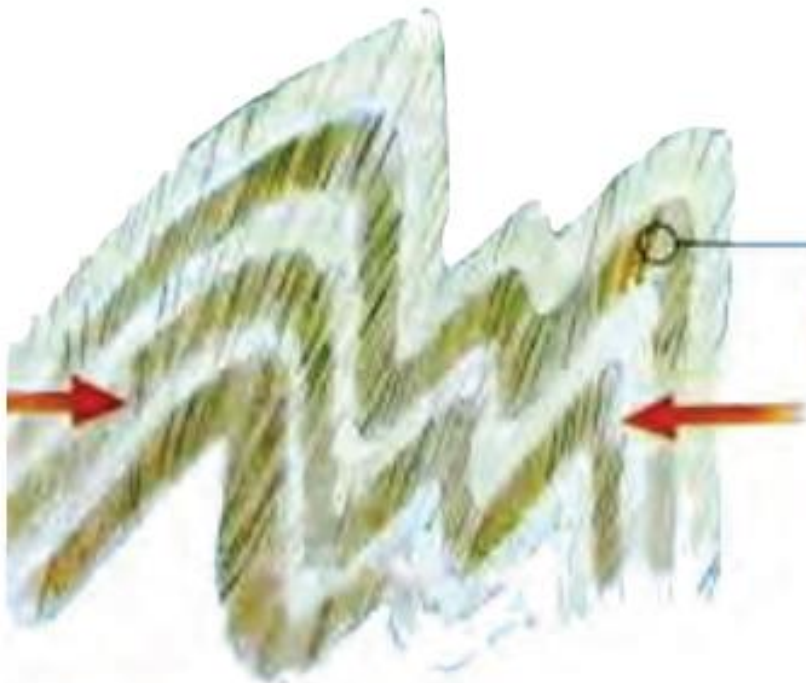
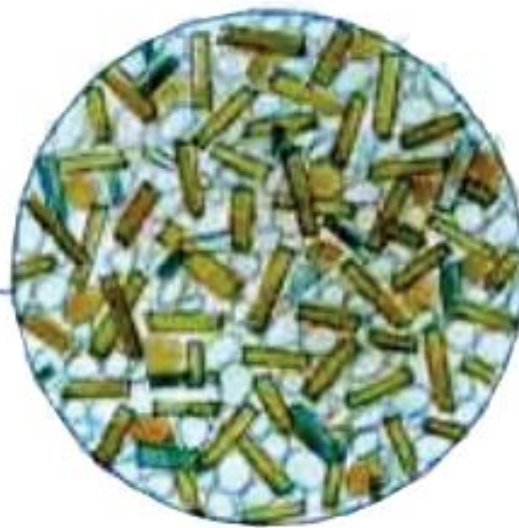
279.jpg (2555 x 2100)

# Foliation and Lineation Forming Processes

1. **Folding.** During folding, grains and minerals are re-oriented and flattened into a planar fabric.
2. **Shearing.** Shearing leads to the flattening and stretching of rock's forming grains and minerals.
3. **Flow of magma.** Results in the rotation of minerals into magmatic foliations and lineations.

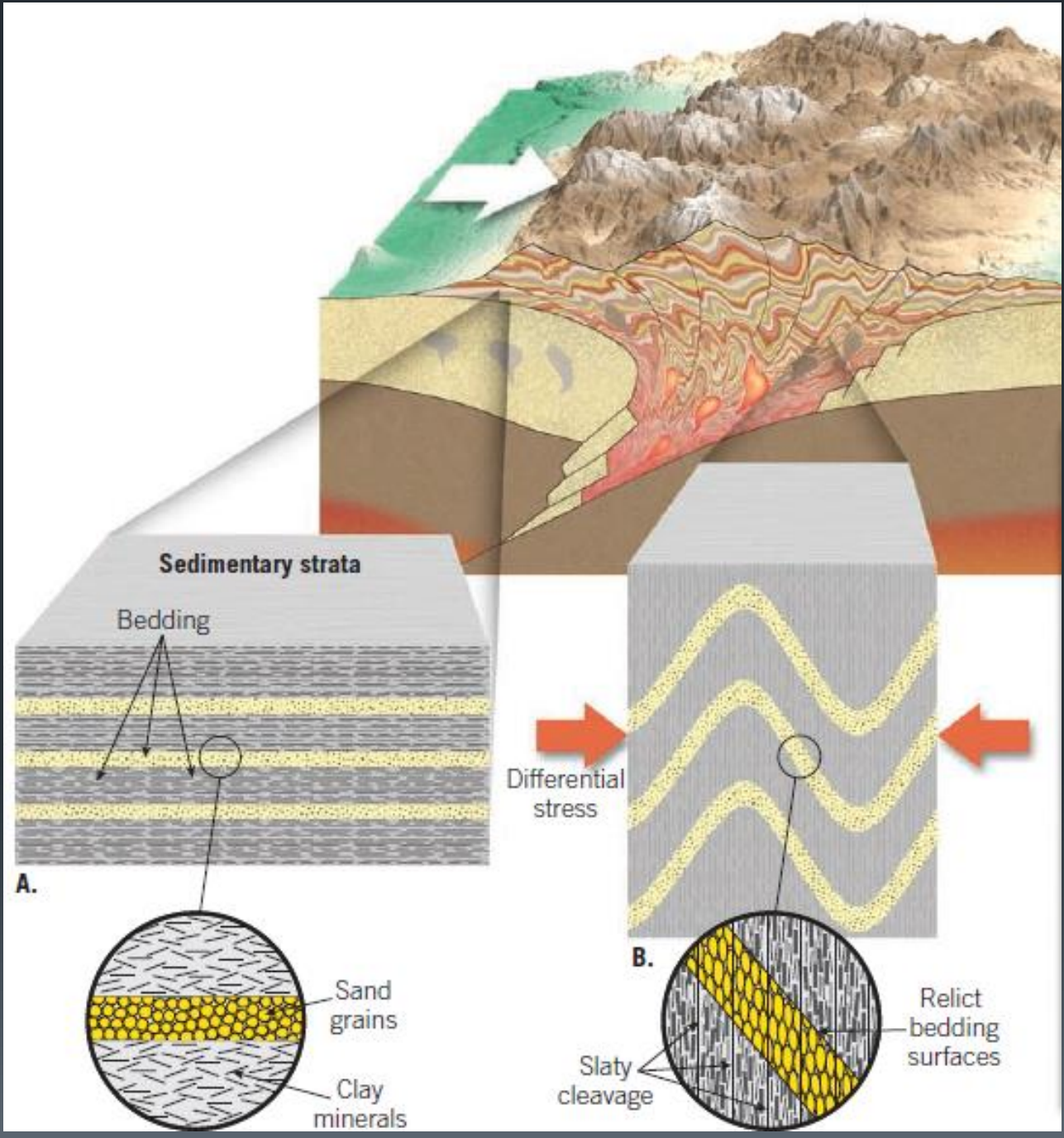
During deformation, rock forming grains and minerals change their orientation and shape, giving deformed rocks organized planar and linear structures.

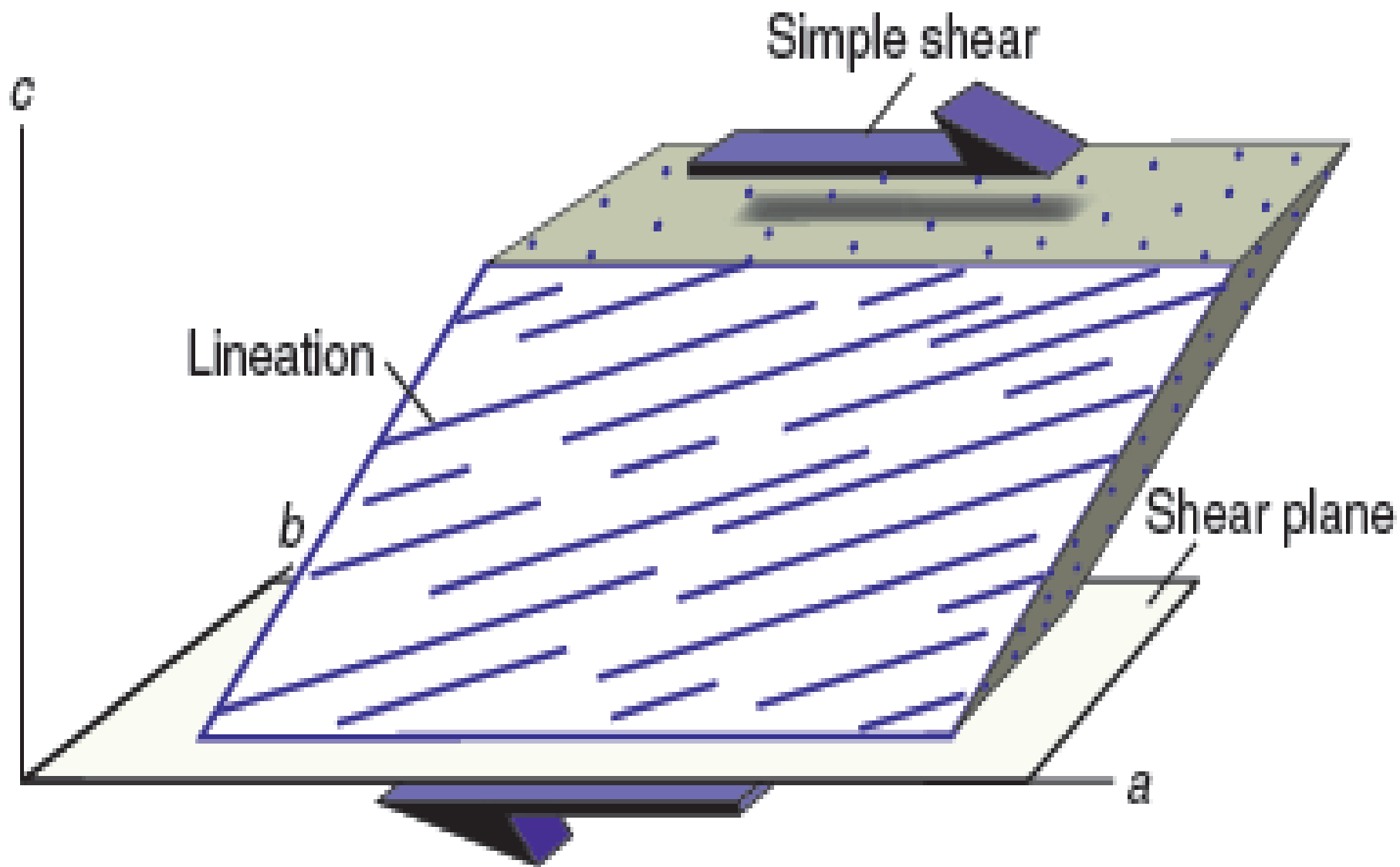
Before foliation  
(random mineral grains)



After foliation  
(parallel mineral grains)

Foliation by Folding

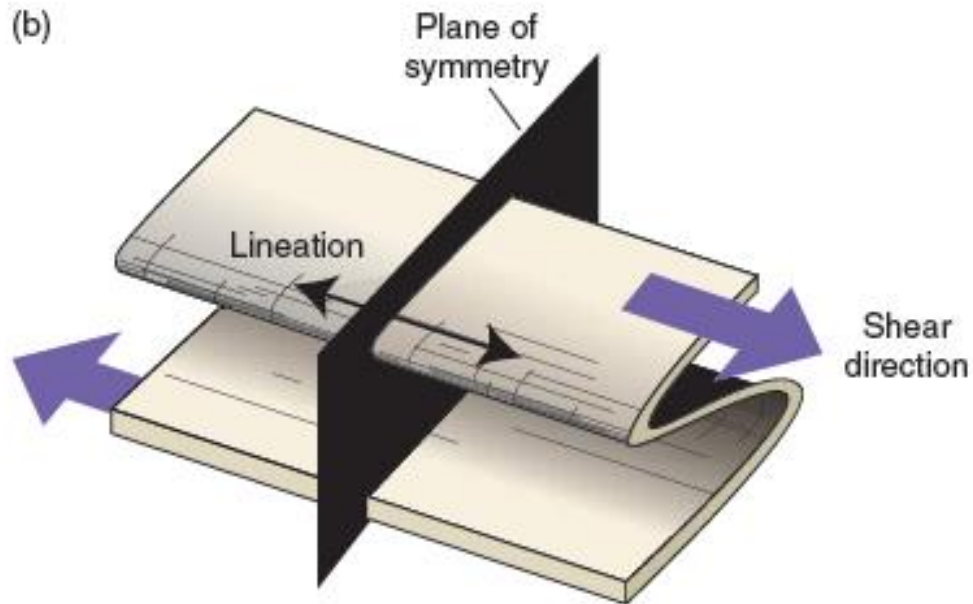
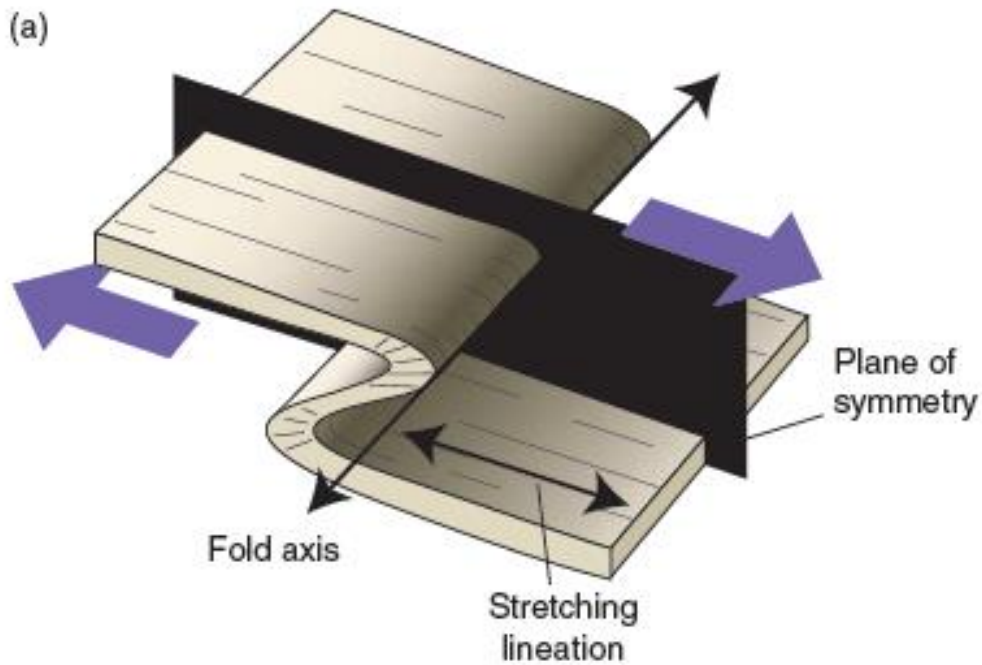




The stretching lination

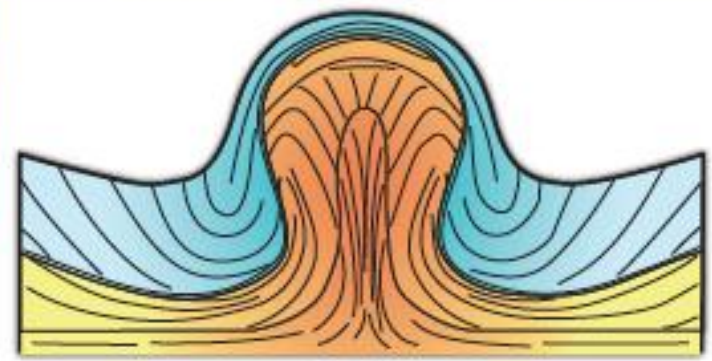
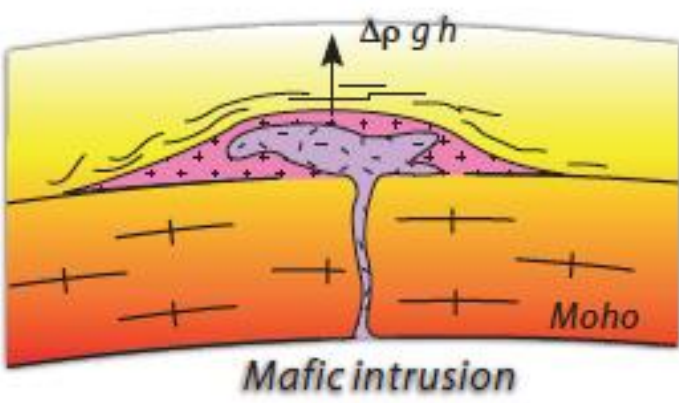
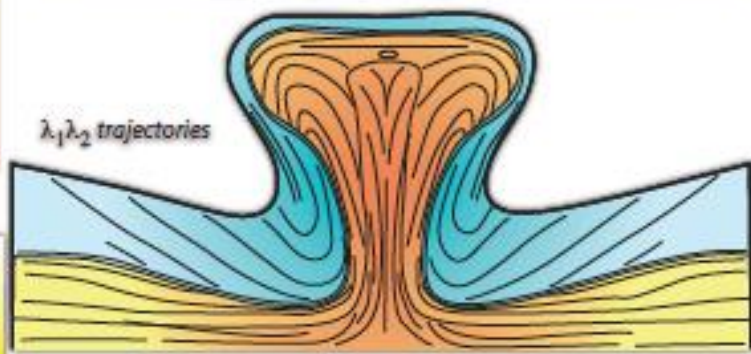
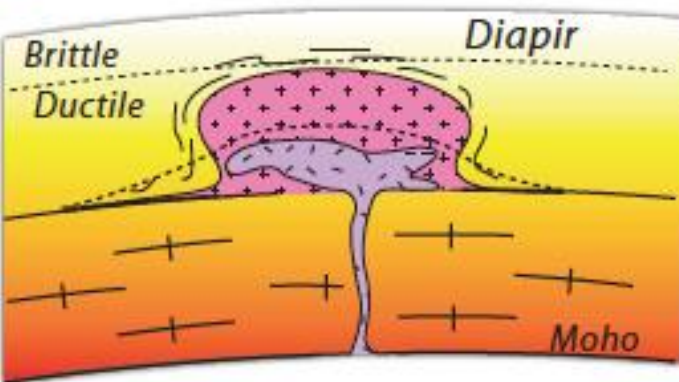
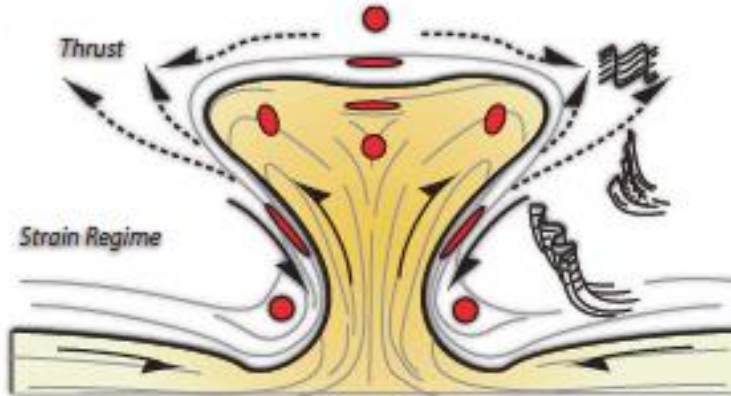
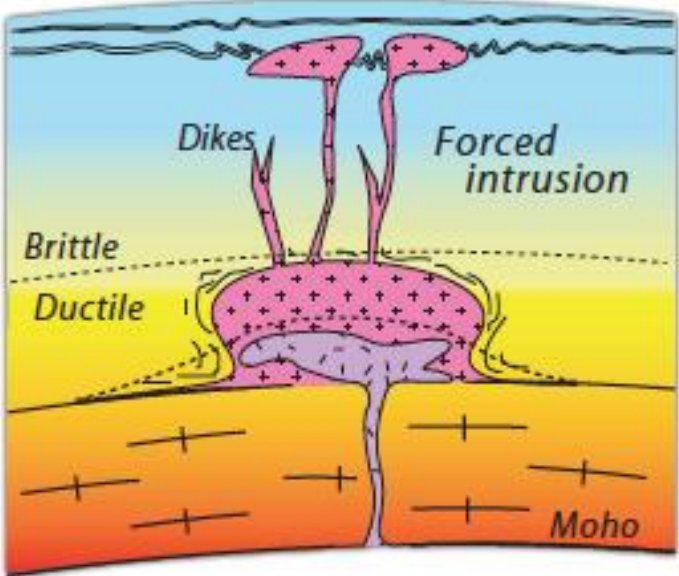


Stretching lineation



Folds may have axes that are parallel as well as perpendicular to the stretching lineation.





Flowing of Magma



**Slate**



**Phyllite**



**Schist**



**Gneiss**

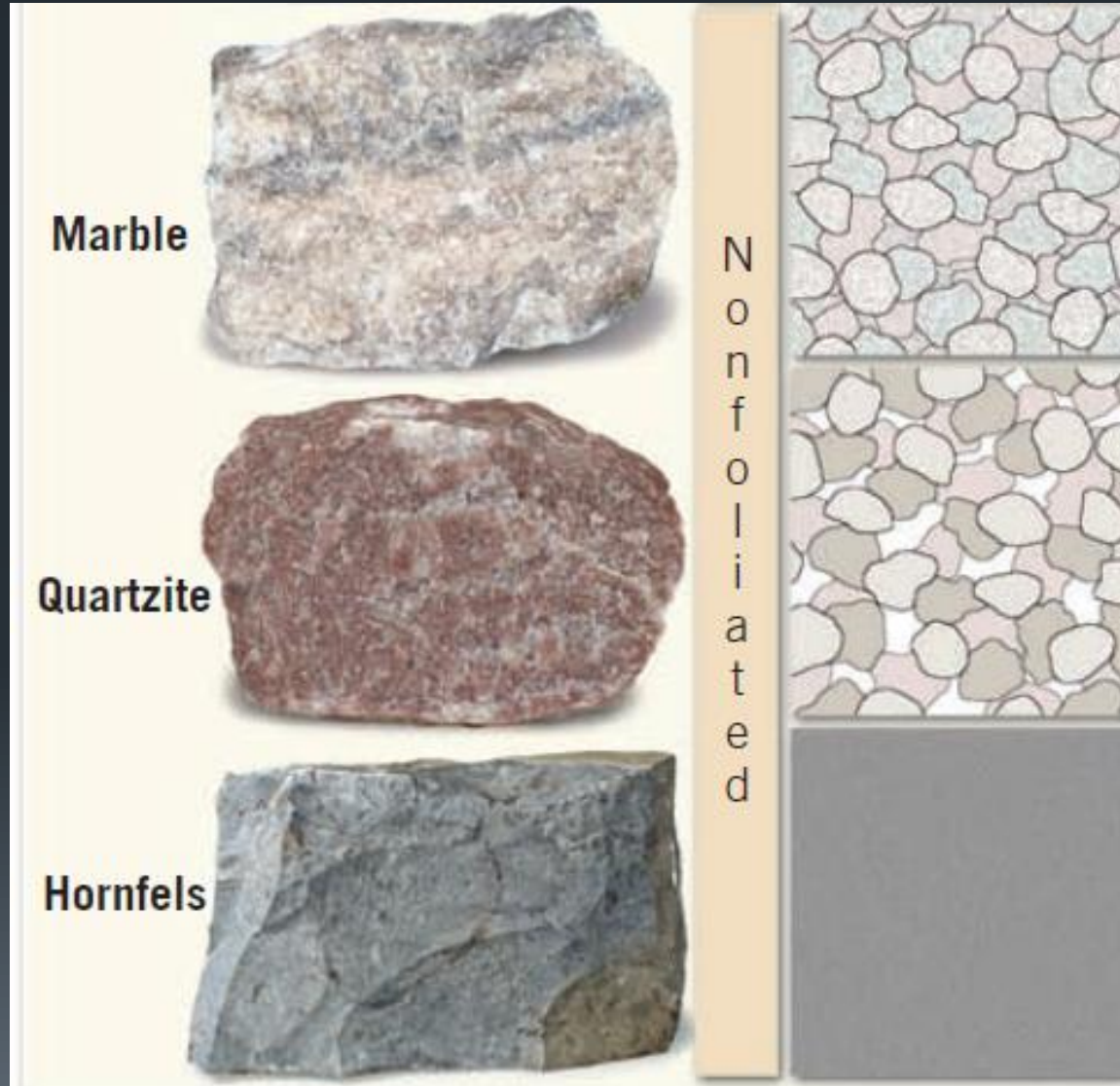


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**Foliated Metamorphic Rock**

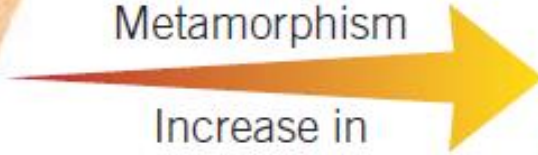
# Non Foliated



Quartz sandstone



Metamorphism



Increase in temperature and pressure

Quartzite



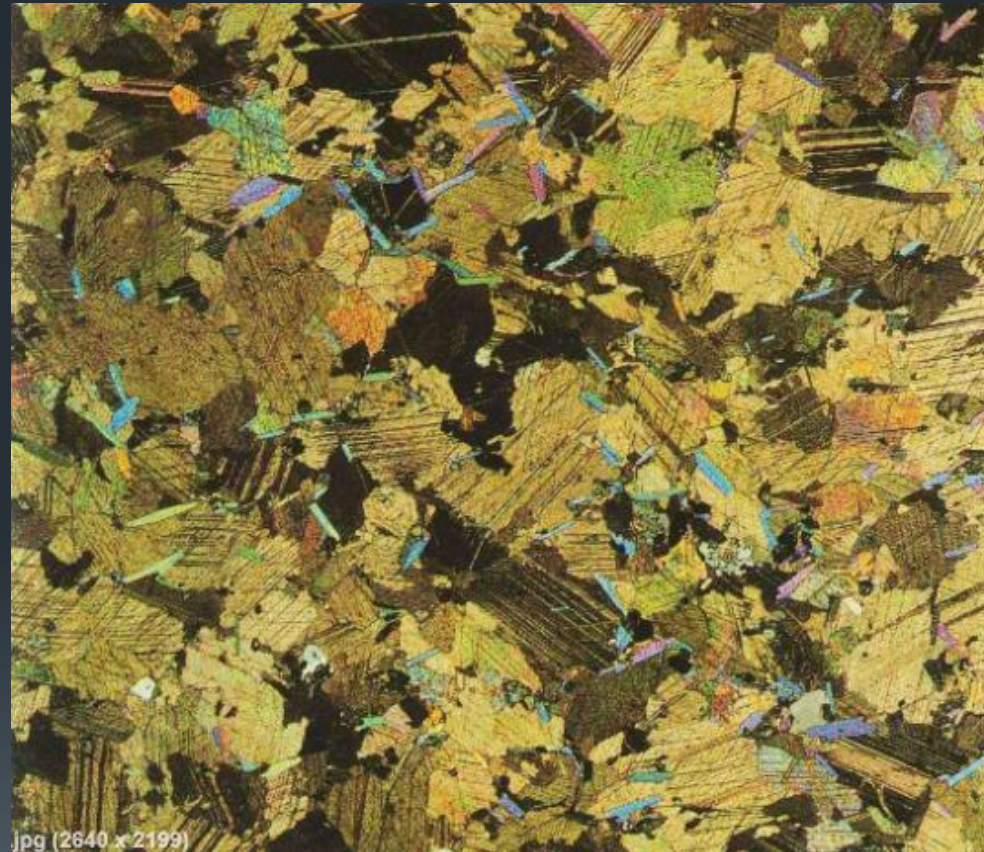
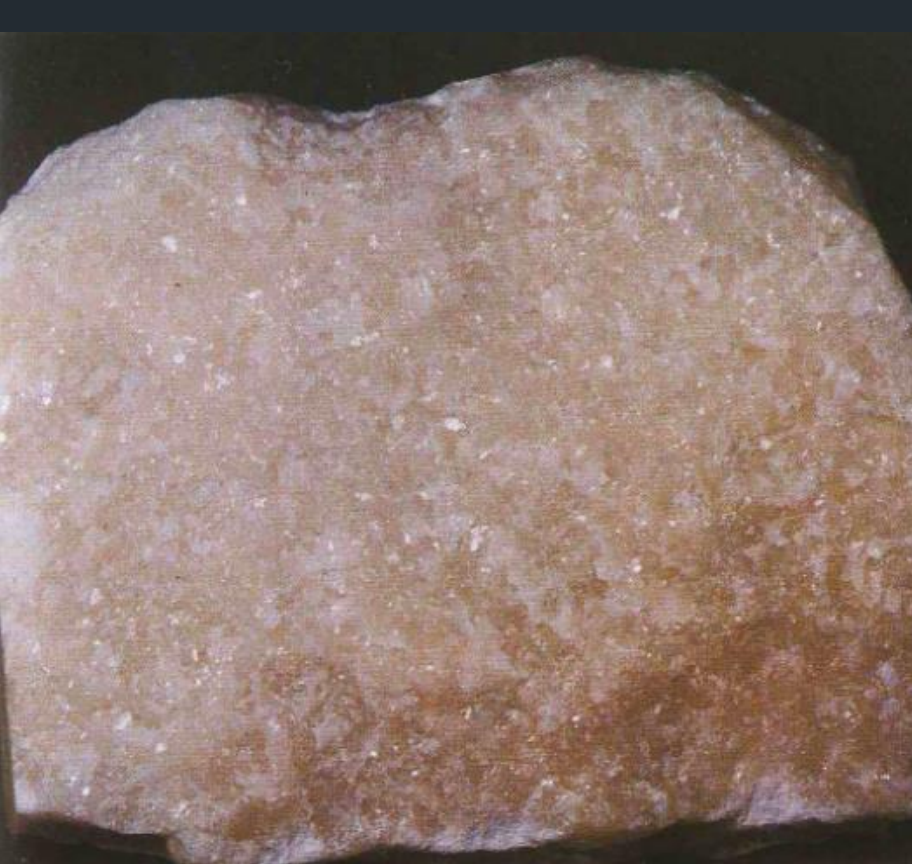
Close up



Close up



Quartzite. Non-Foliated Metamorphic Rock



Marble



# SUMMARY

# Summary

- Geologic structure is a geometric feature in rock whose shape, form, and distribution can be described.
- Geologic Structure: Primary Structure, Secondary Structure.
- Primary Structure : Sedimentary Structure, Igneous Structure, Metamorphic Structure.
- Primary Sedimentary Structures : Bedding, Ripples, Tool Mark, Mudcrack, Bioturbation, etc.
- Primary Igneous Structures : Sill, Dyke, Batolith, Laccolith, Lava, Magma, Joint, Vesikuler, Amigdaloidal, etc.
- Primary Metamorphic Structures : Foliation, Non-Foliation, Lineation.