PRIMARY STRUCTURES

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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.

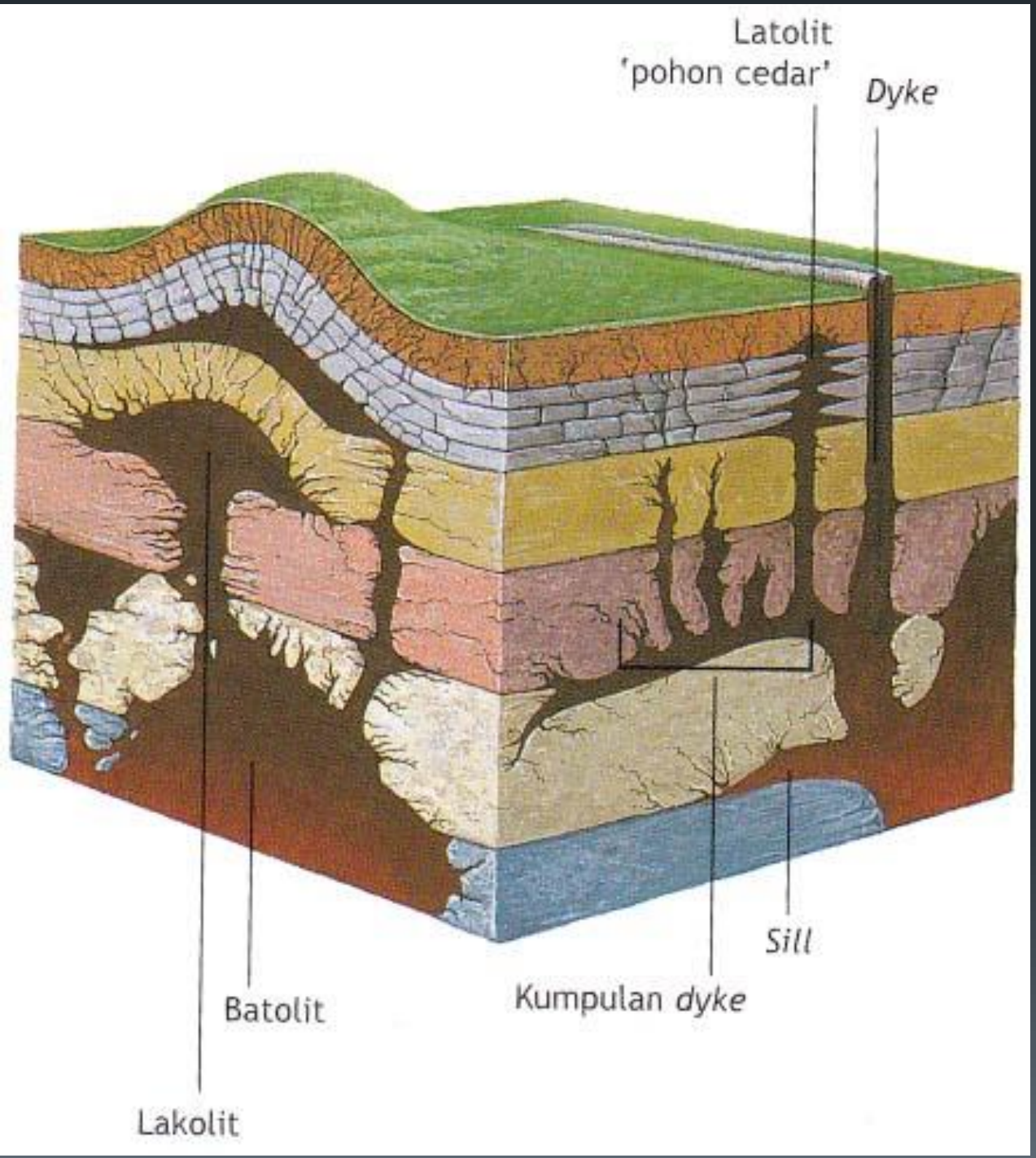
Igneous Structures

Structures Associated with Intrusions:

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

Structures Associated with Extrusion:

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



Structures Associated with Intrusions:

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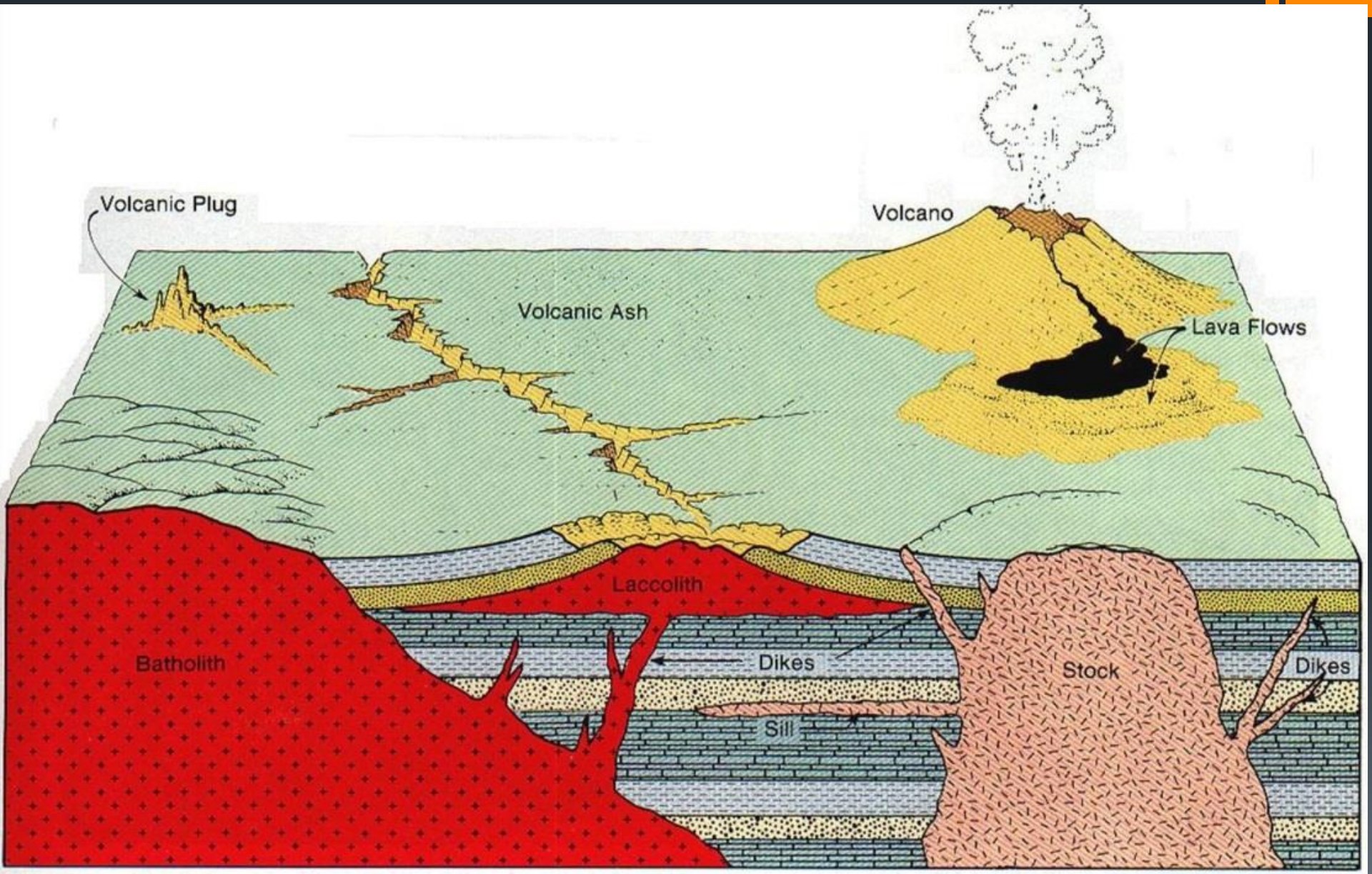
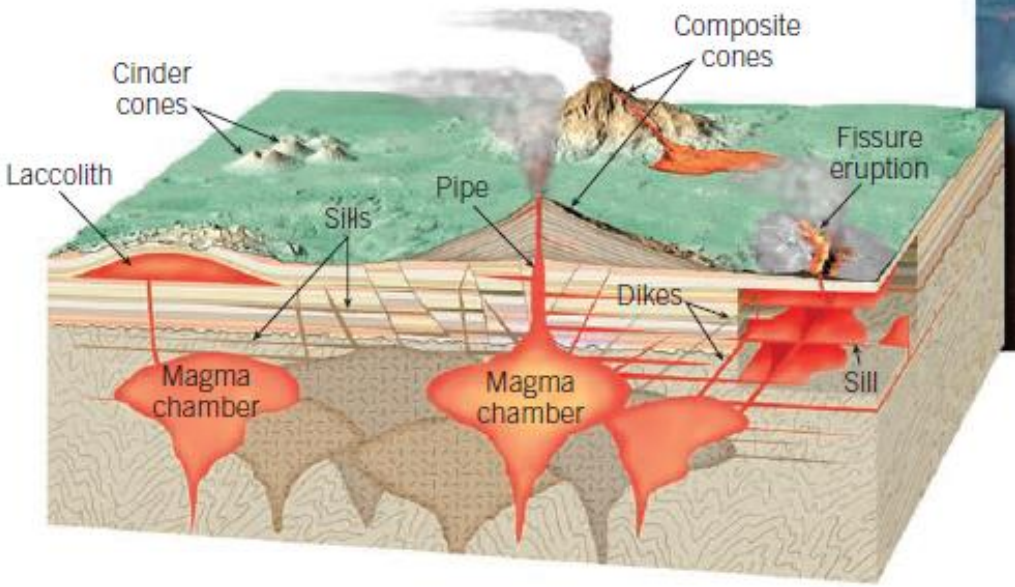
- Discordant : Dyke, Batolith, Stock.

Structures Associated with Intrusions

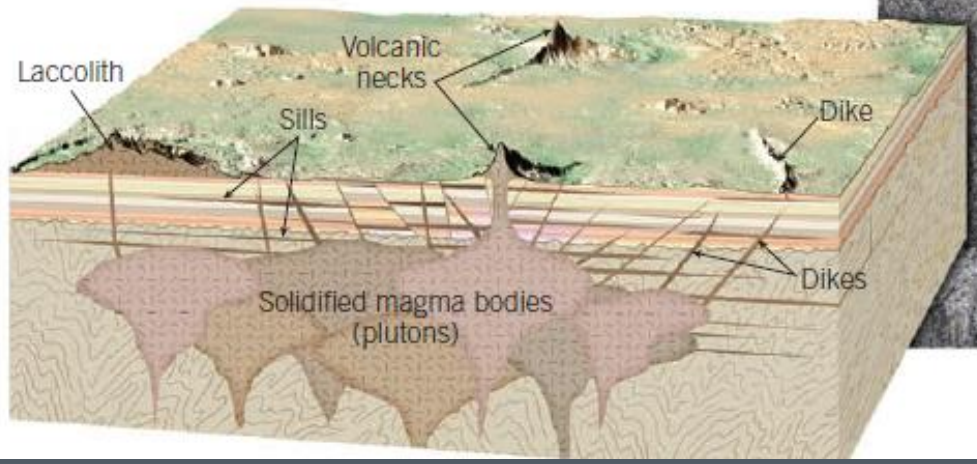


A. Interrelationship between volcanism and intrusive igneous activity.

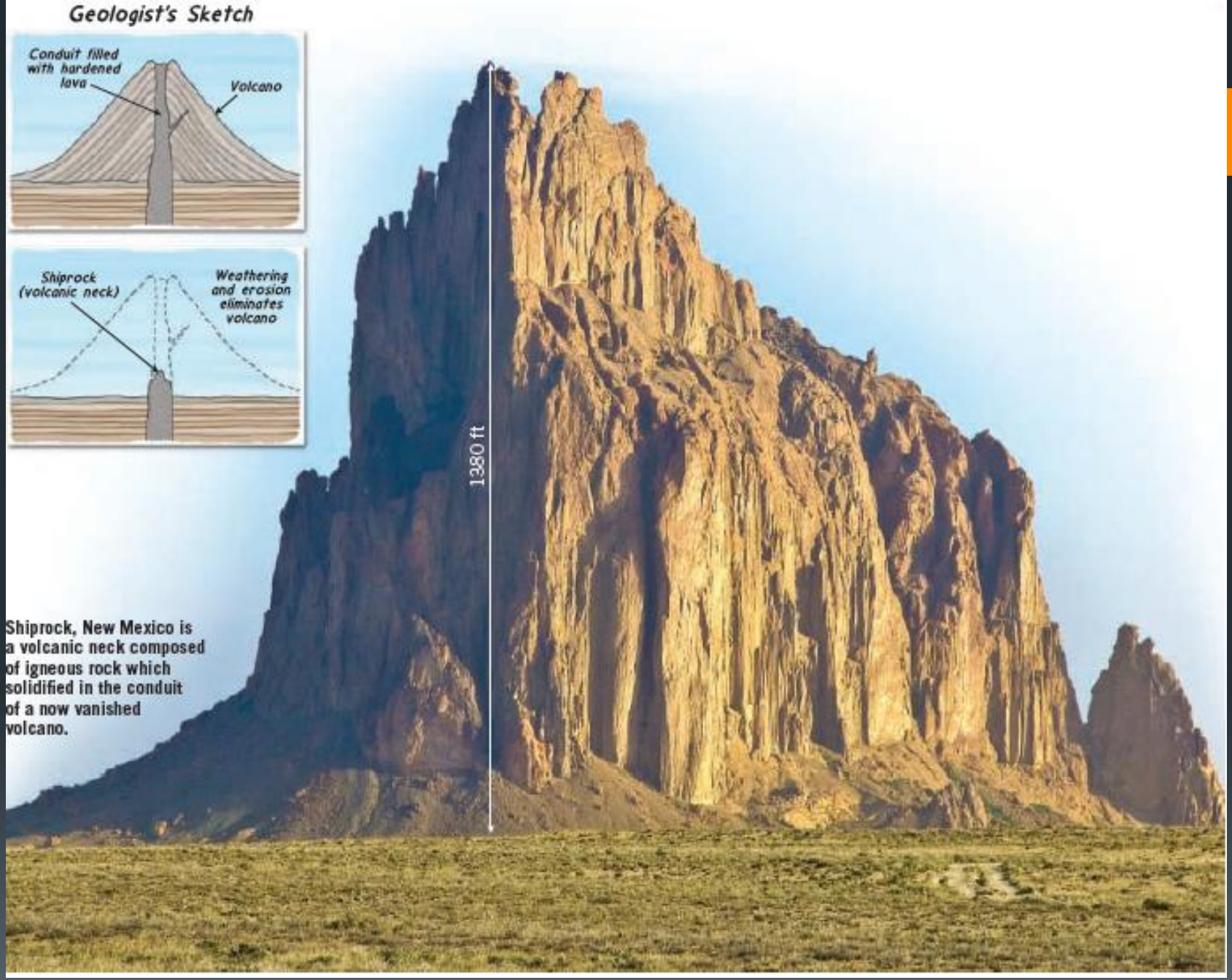


USGS

Marli Miller

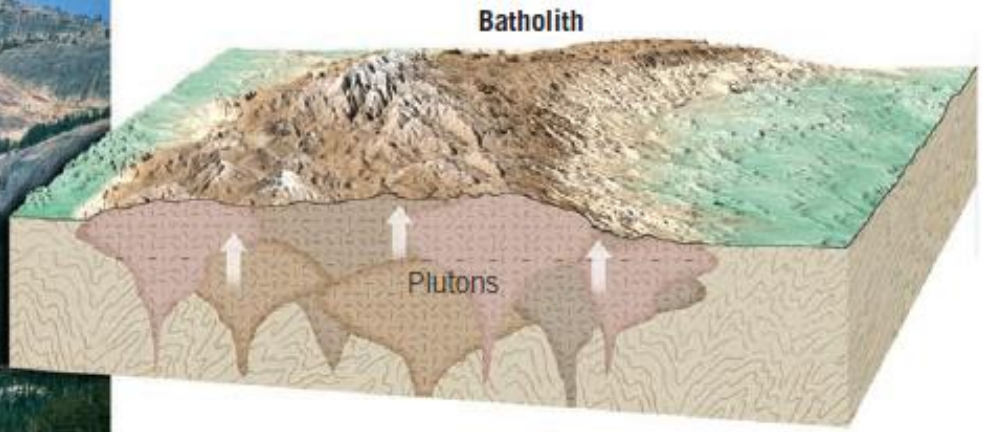


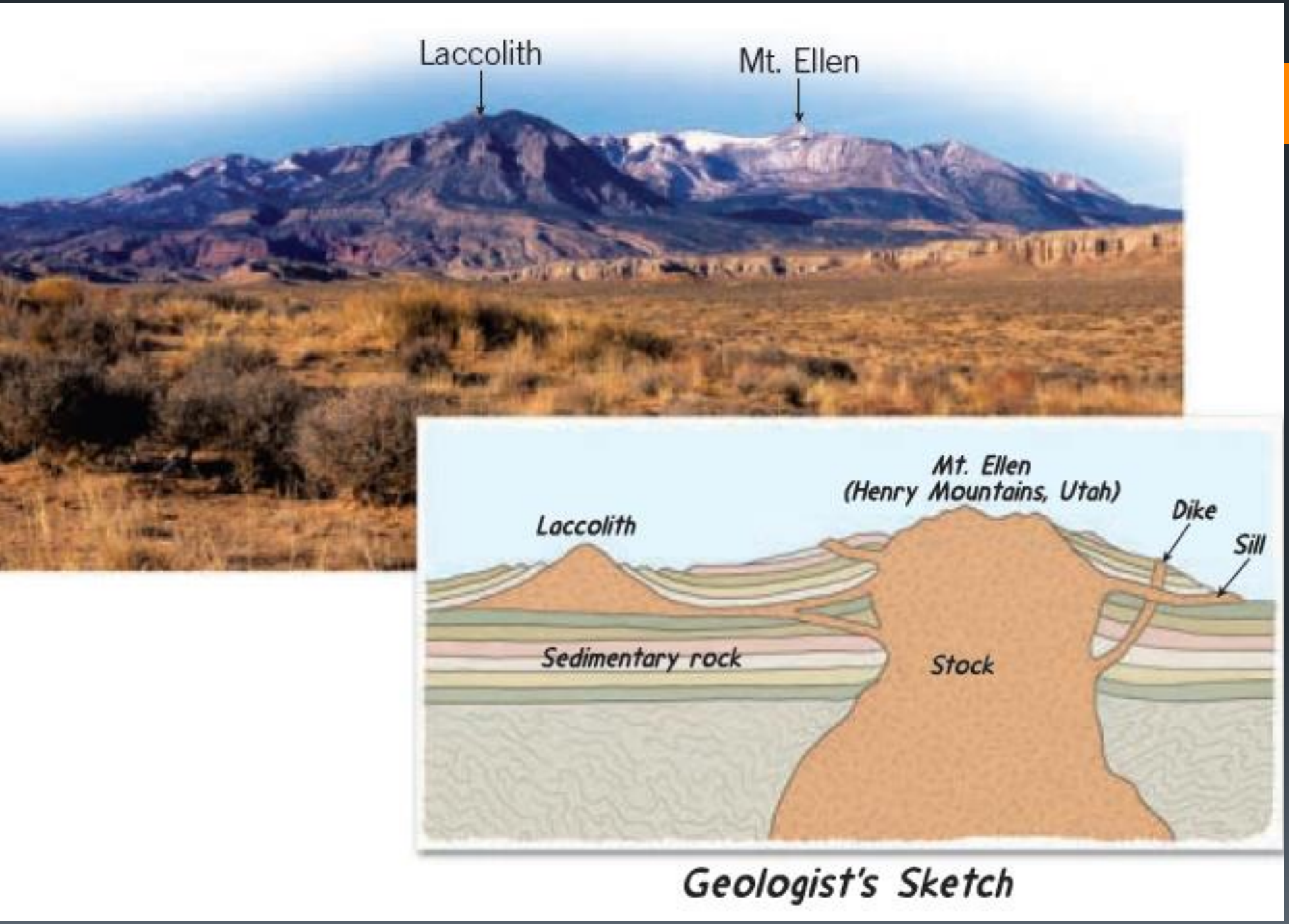
B. Basic intrusive structures, some of which have been exposed by erosion.



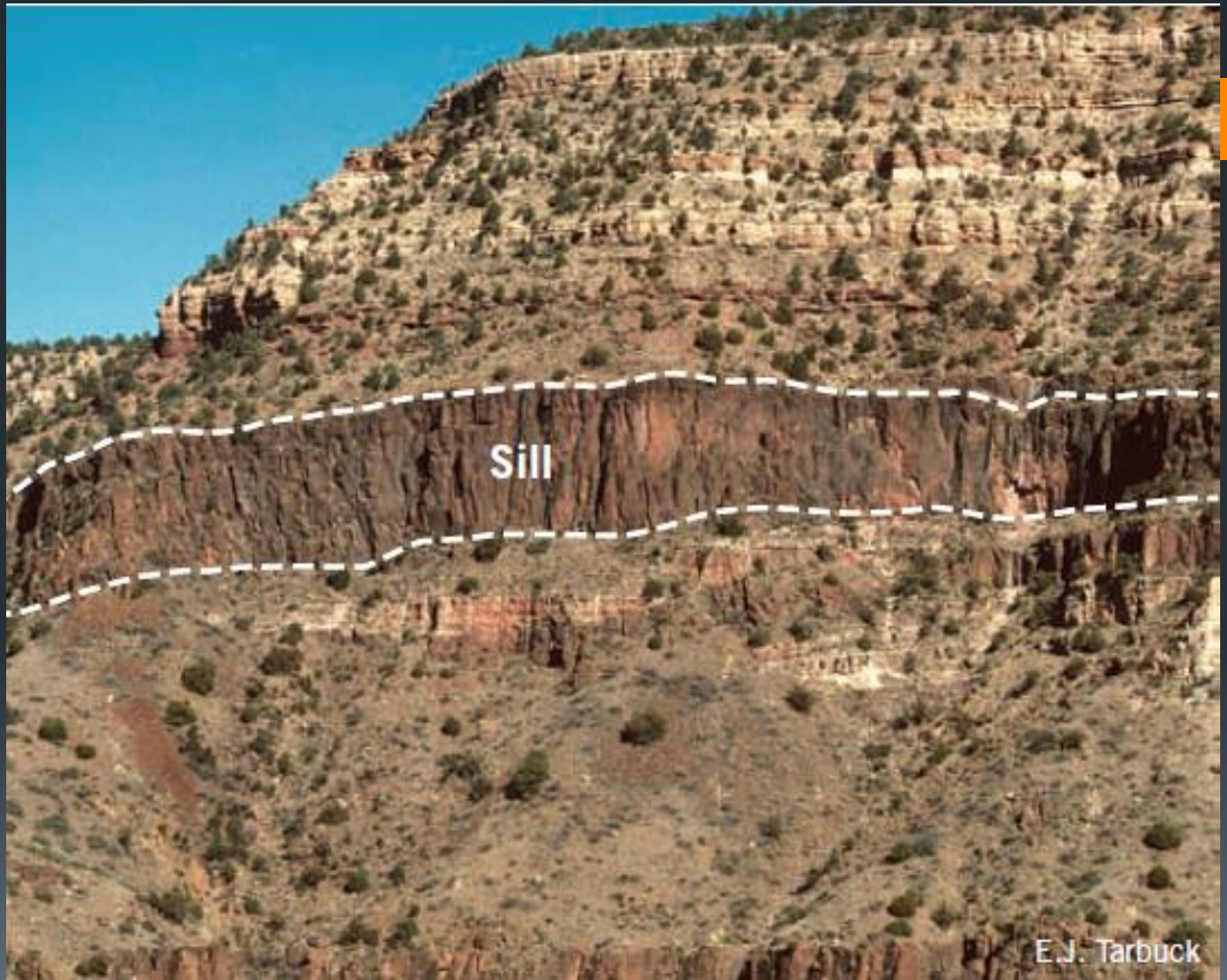
Volcanic neck

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





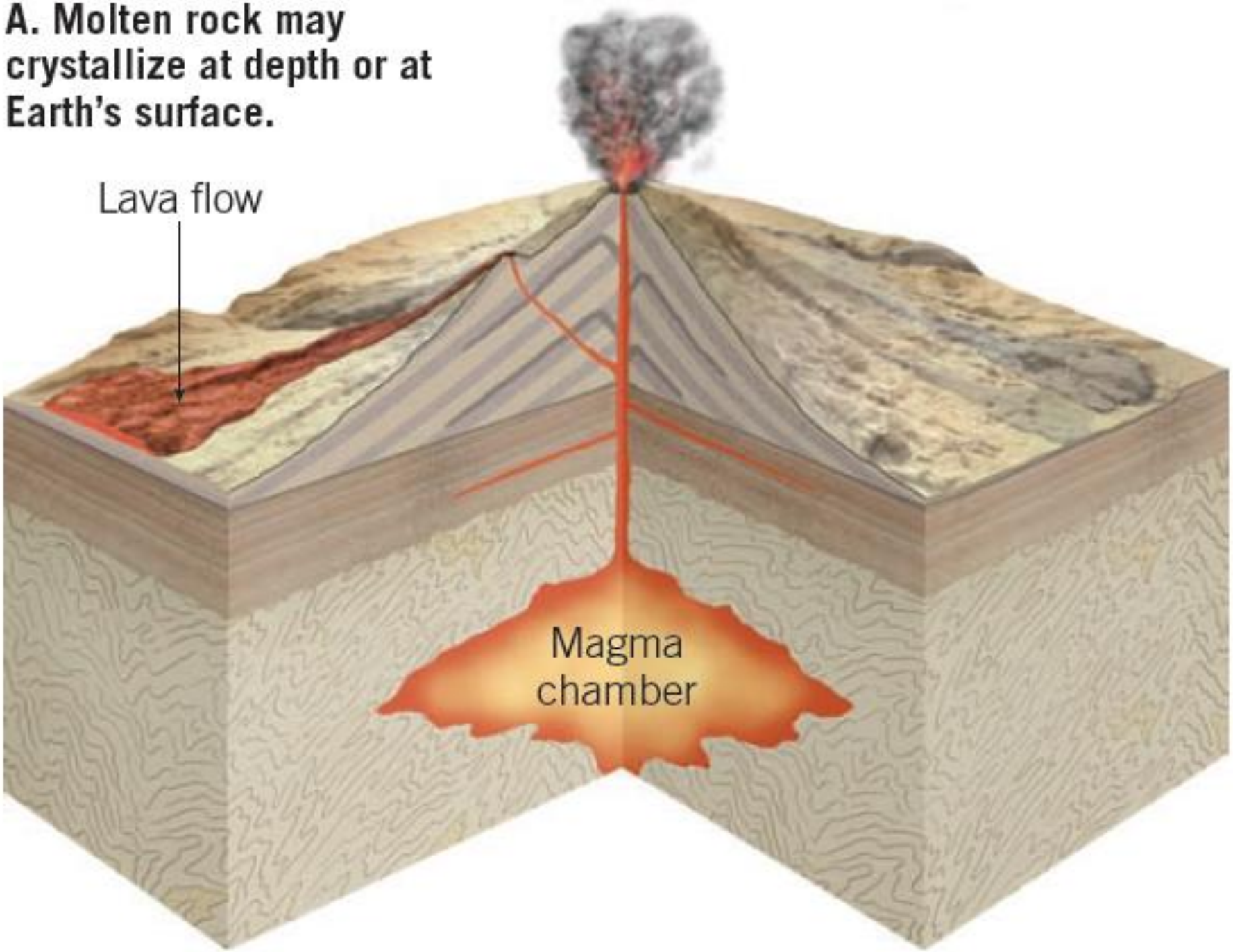
Geologist's Sketch

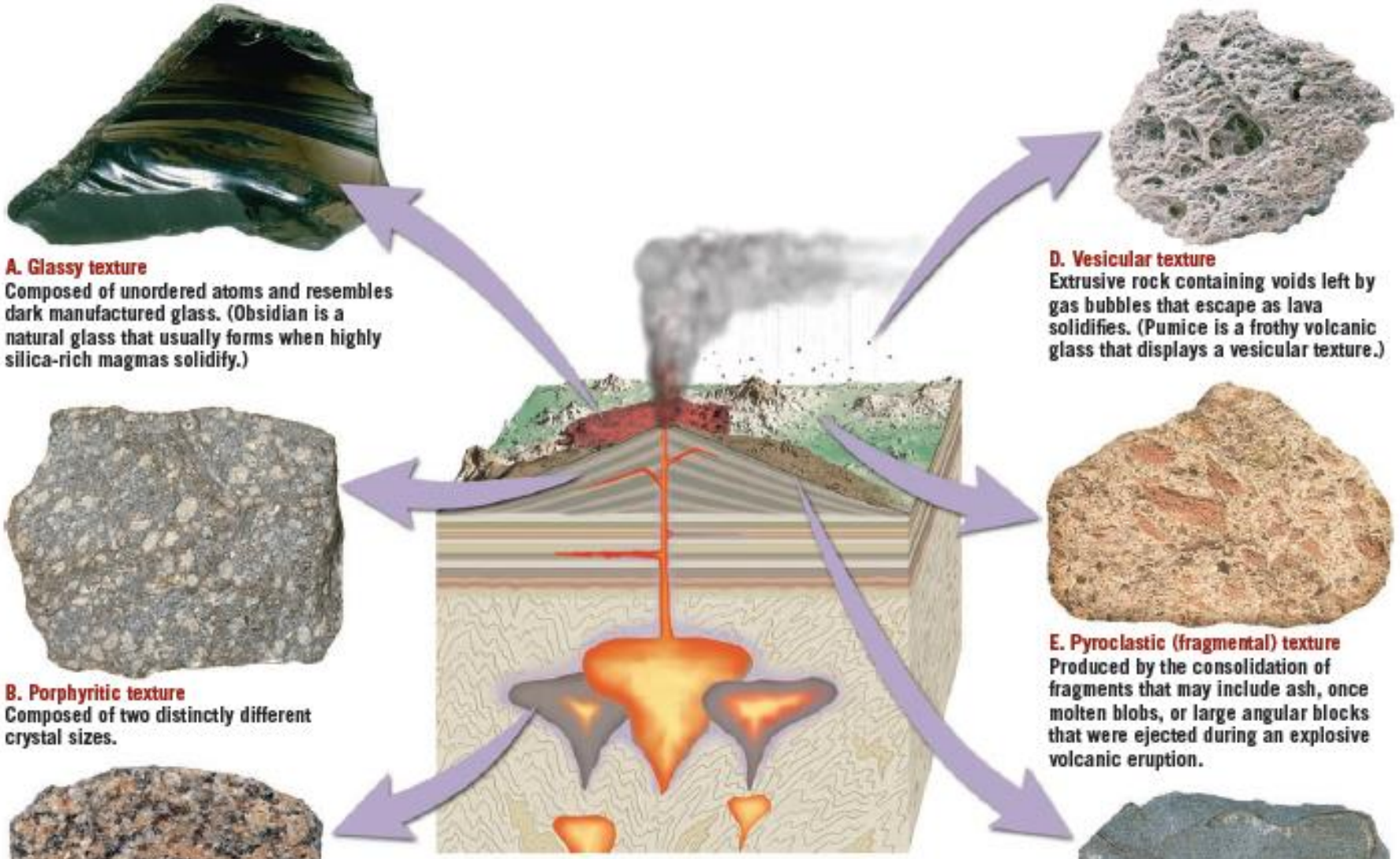

Sill
E.J. Tarbuck


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.
Lava flow
Magma chamber



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.

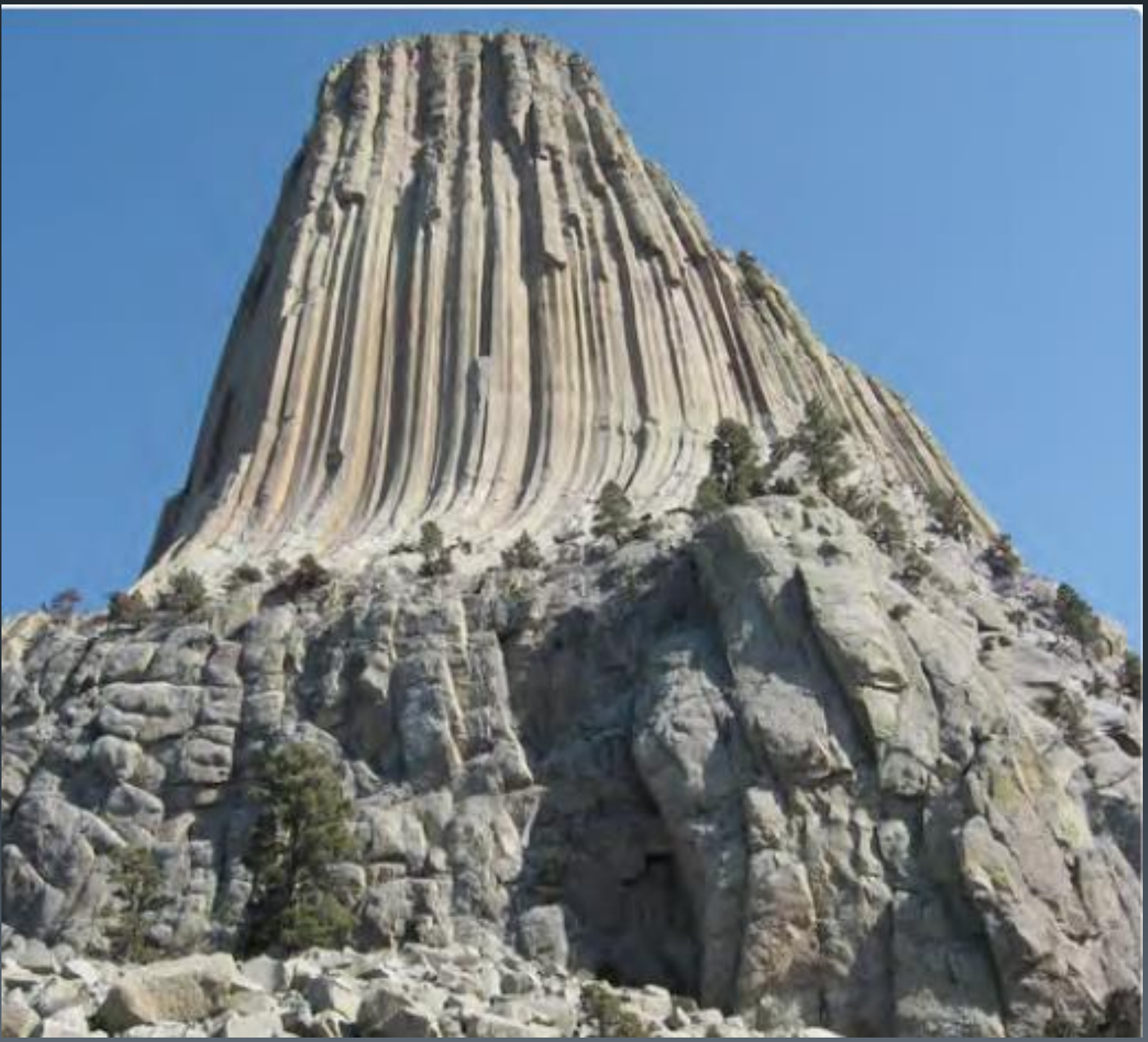
Obsidian, a dark-colored, glassy rock formed from silica-rich lava

Igneous Dike

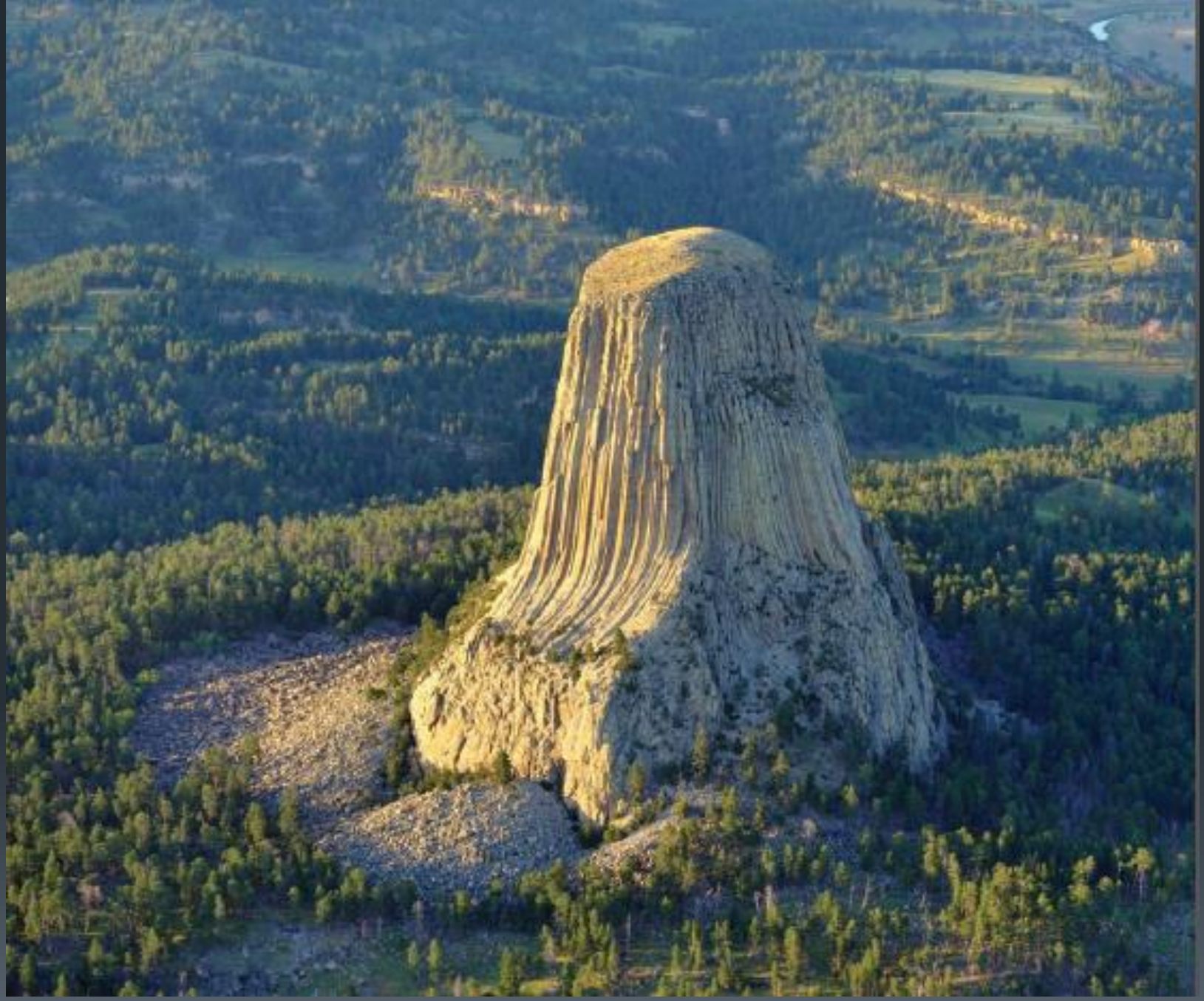
Igneous Dike

Fracture

Fracture



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



Columnar Joint

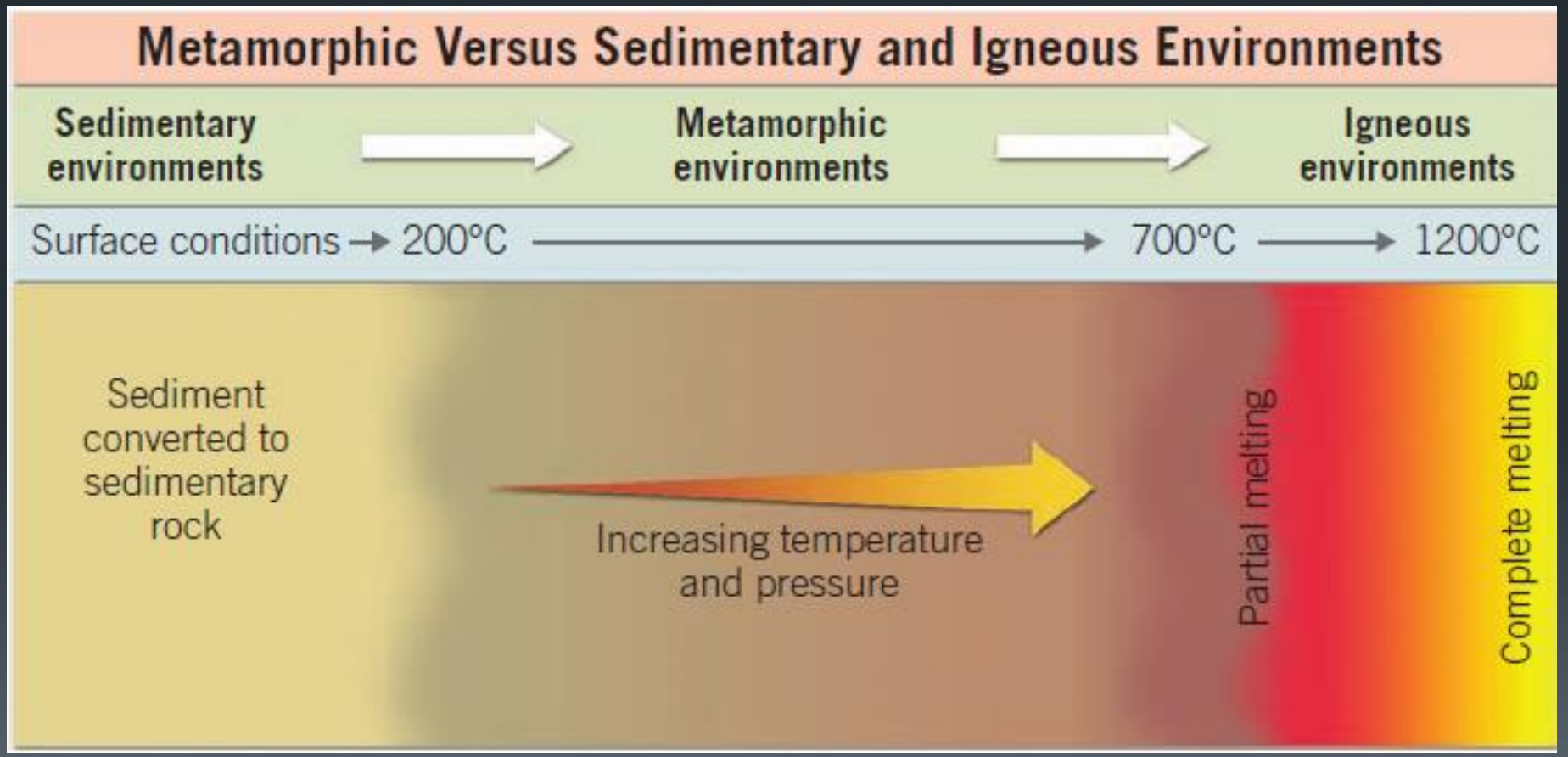
Columnar Joint

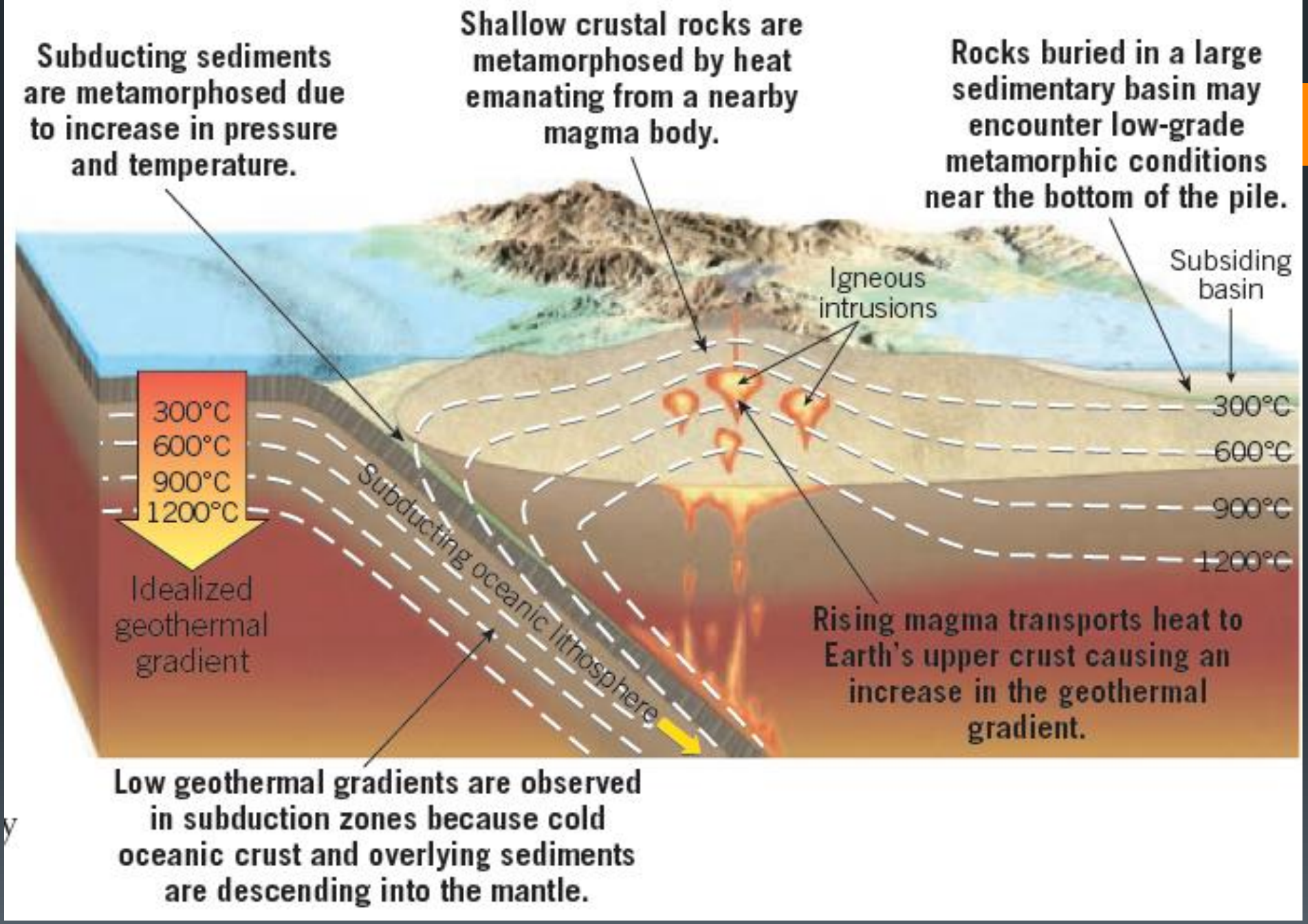
Columnar Joint

Sheet Joint

METAMORPHIC STRUCTURES

Metamorphic Rock → Caused by Pressure and Temperature

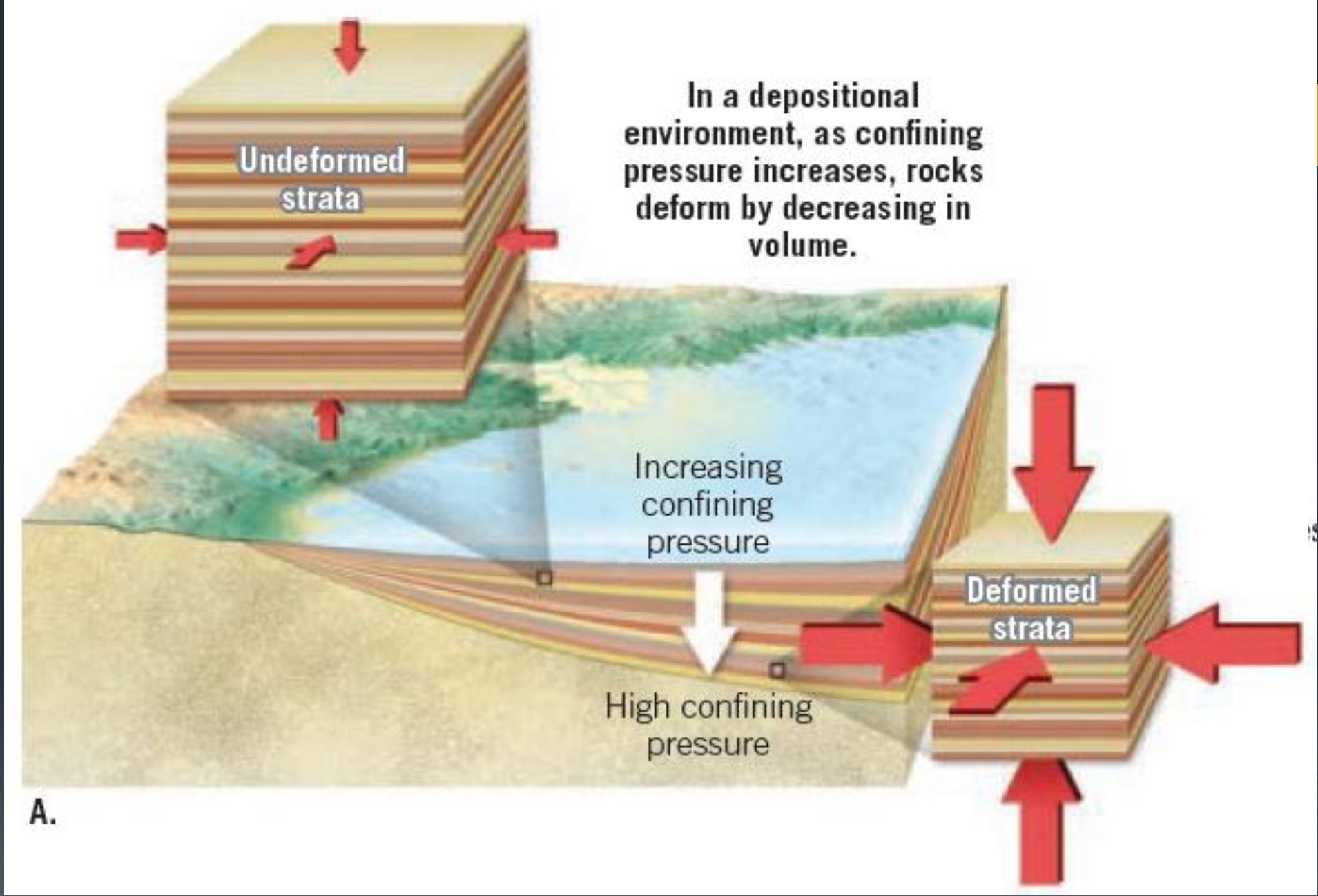




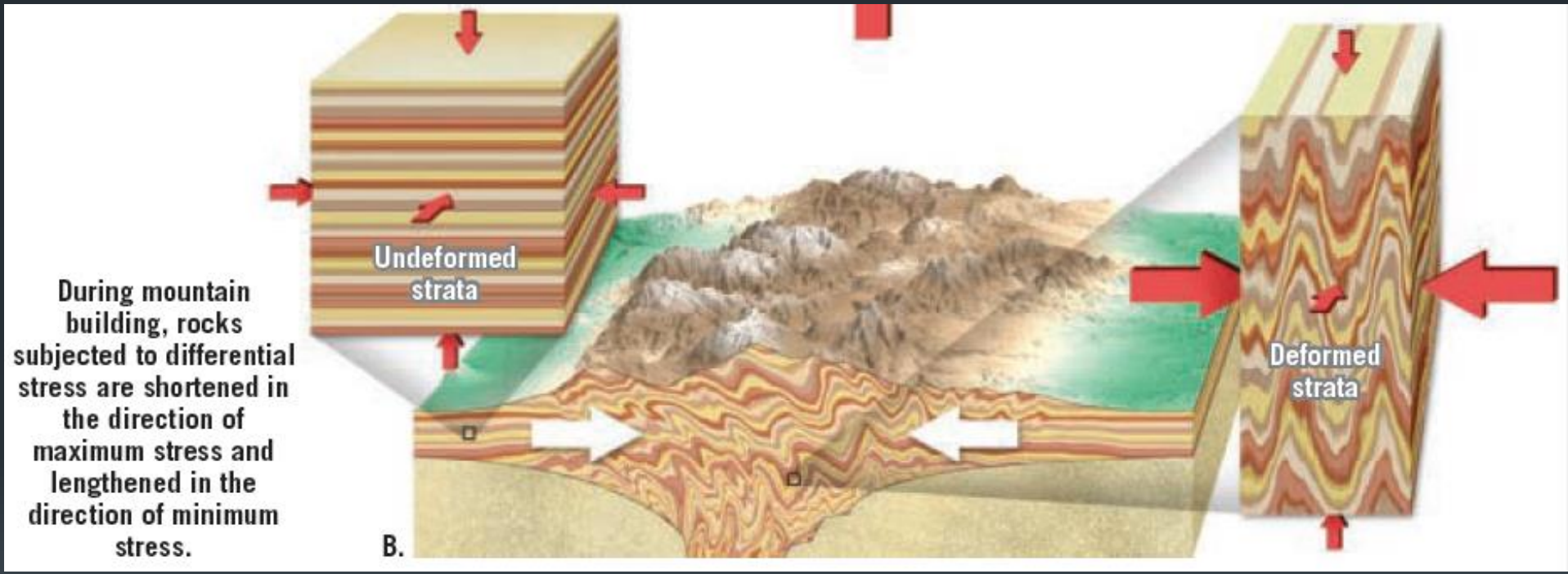
Sources of heat for metamorphism

Type of Stress / Pressure

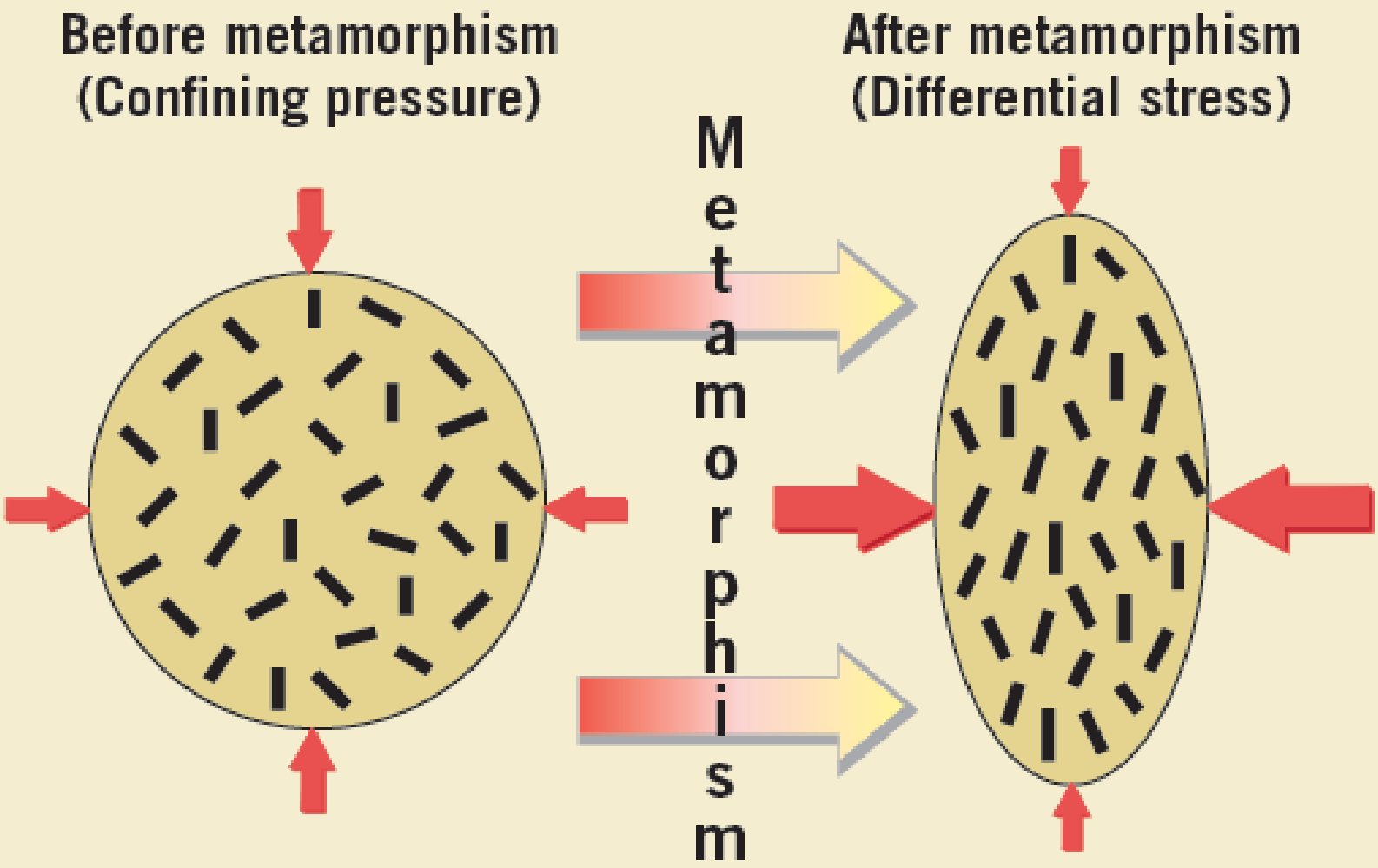
- Confining Pressure
- Differential Stress



Confining Pressure

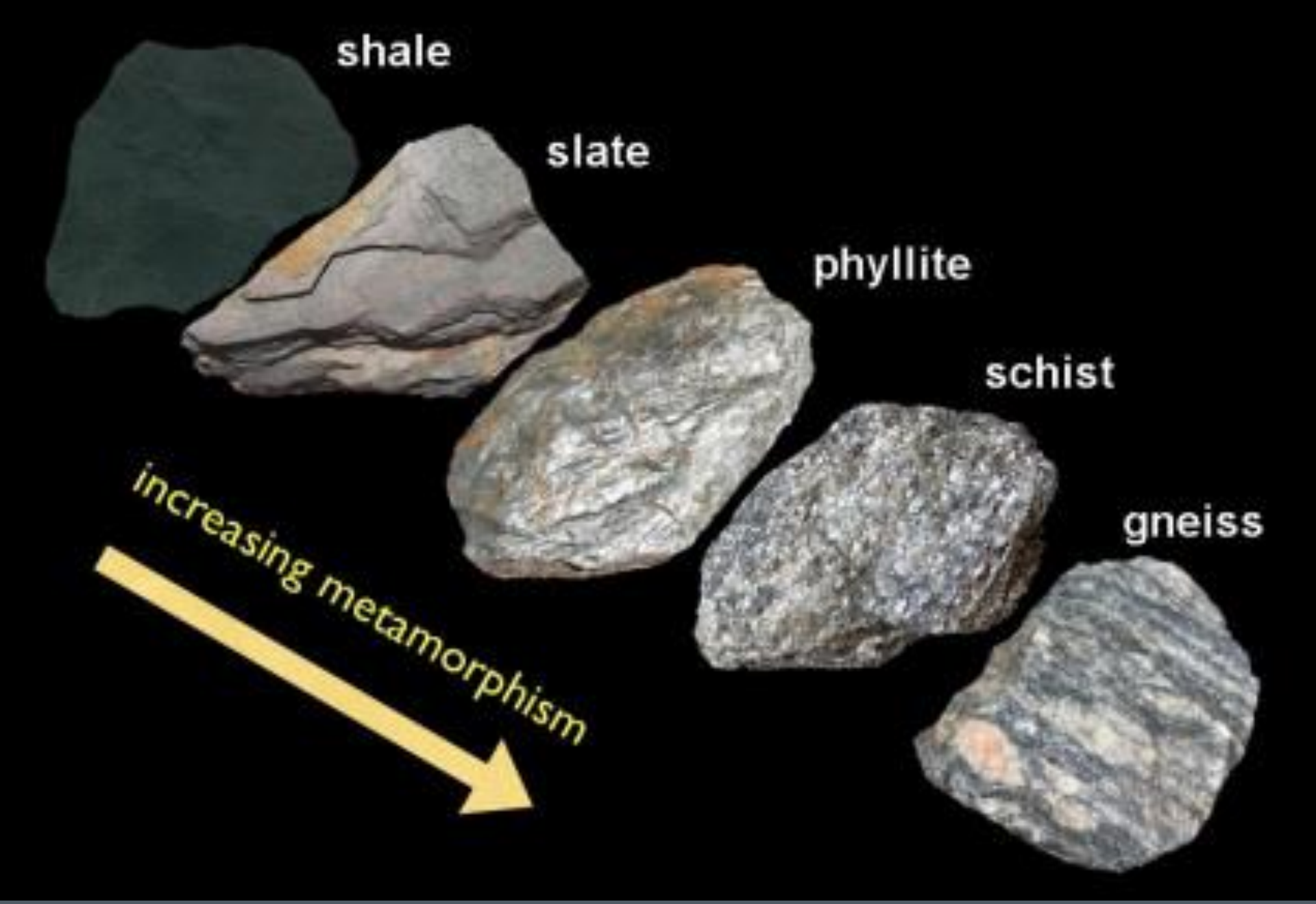


Differential Stress



Platy mineral grains having random orientation.

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



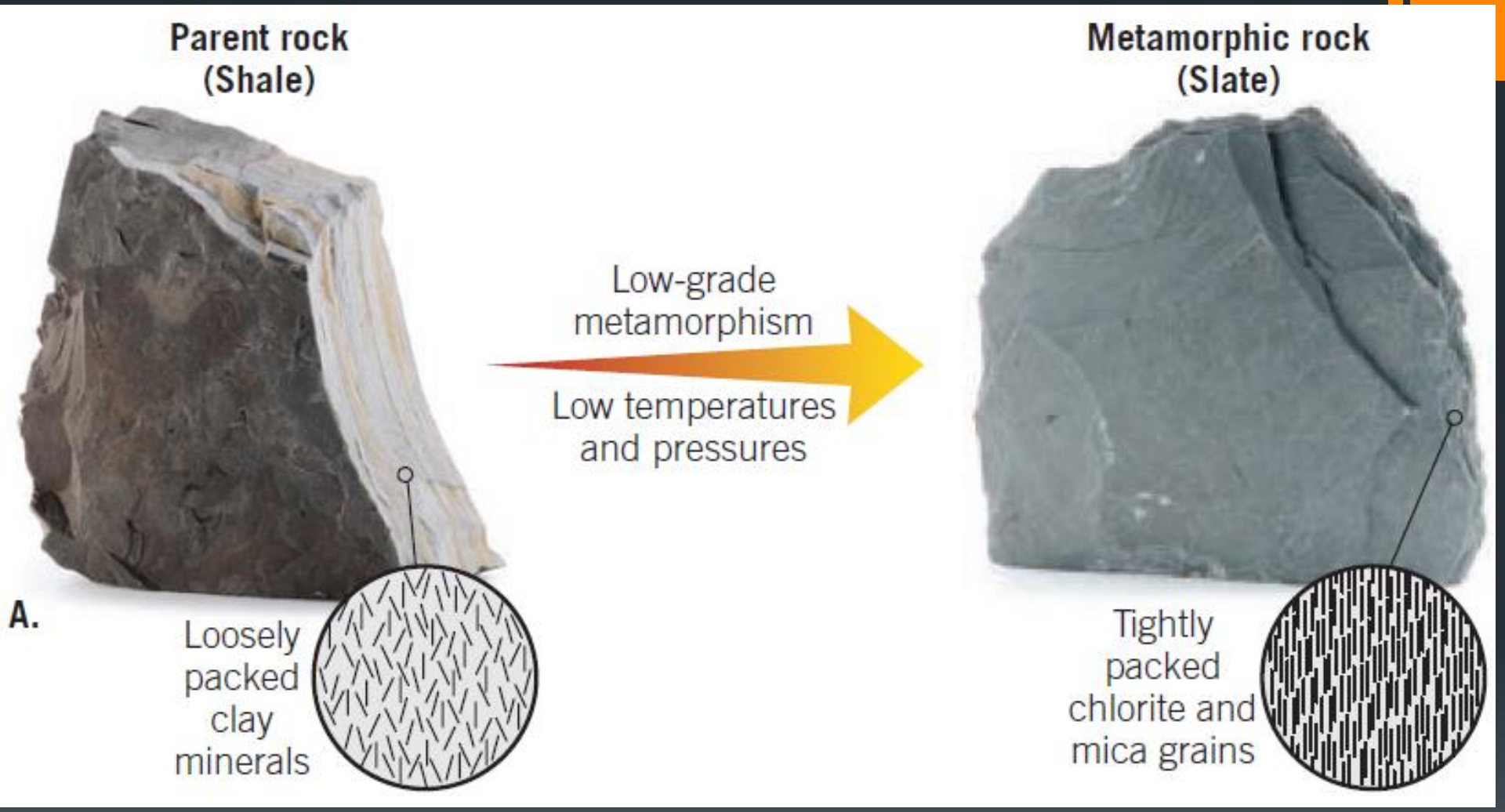
Metamorphic Rocks

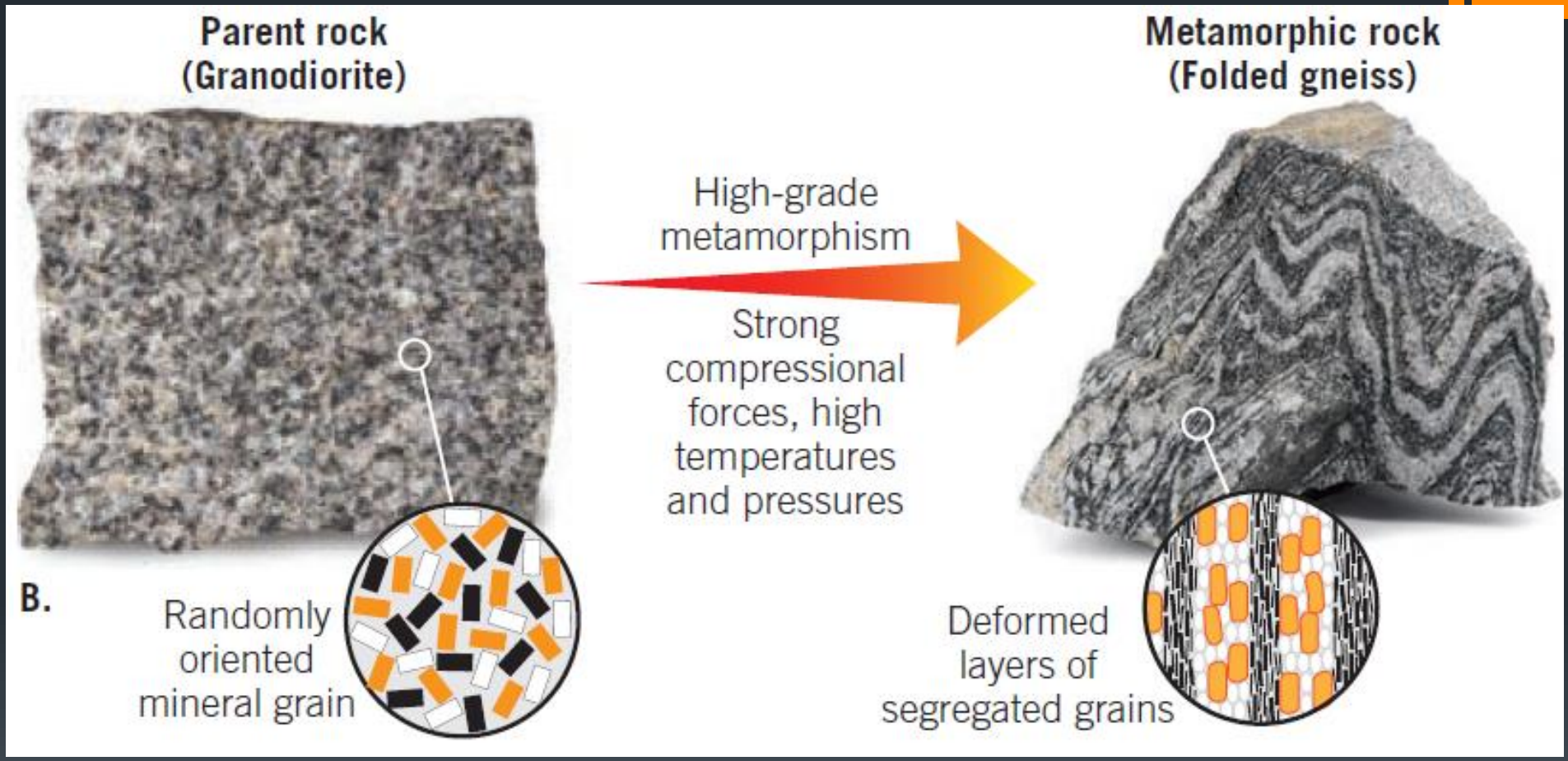
Structure of Metamorphic Rock

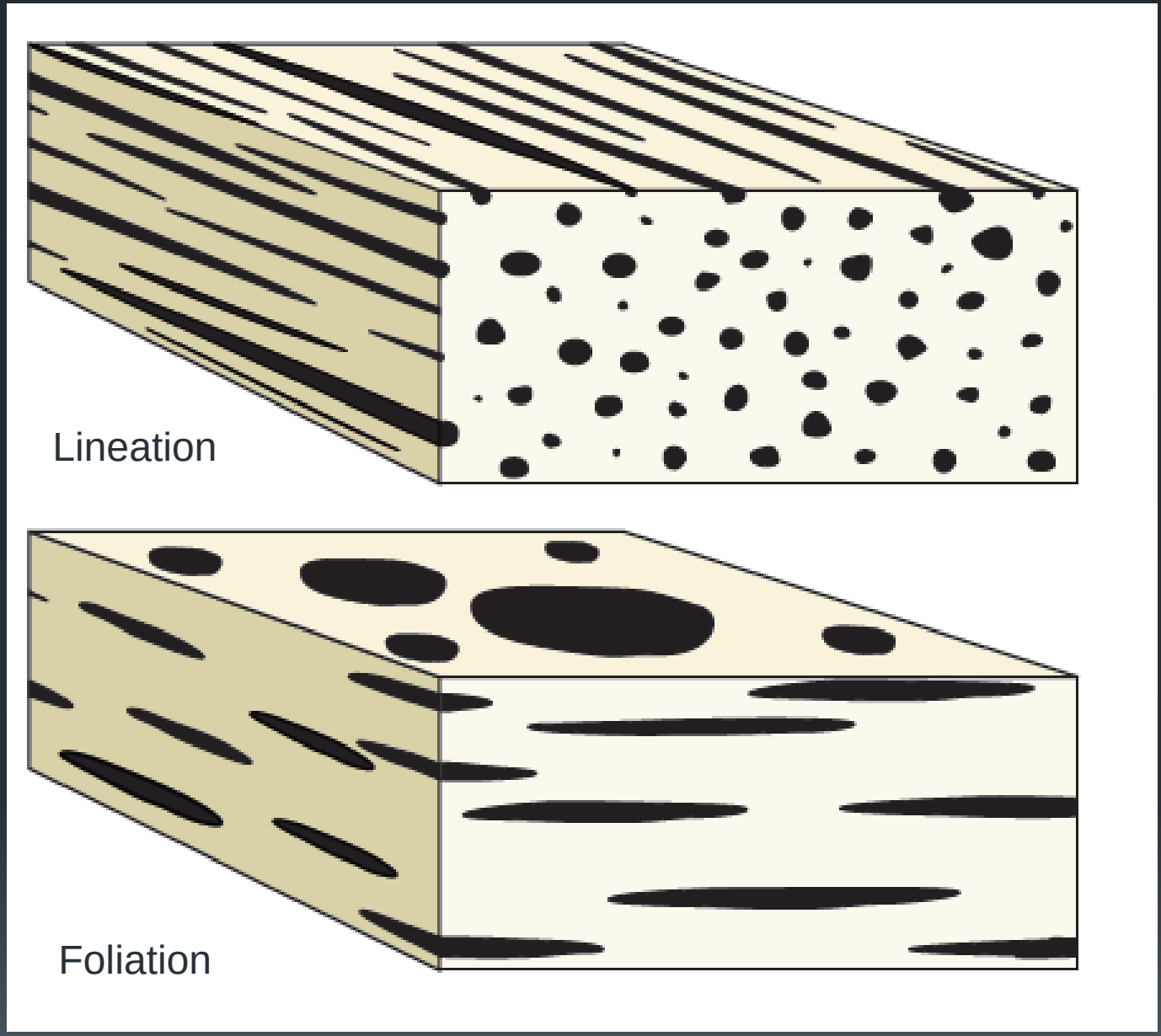
- Foliation, Lineation
- Non Foliation

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.

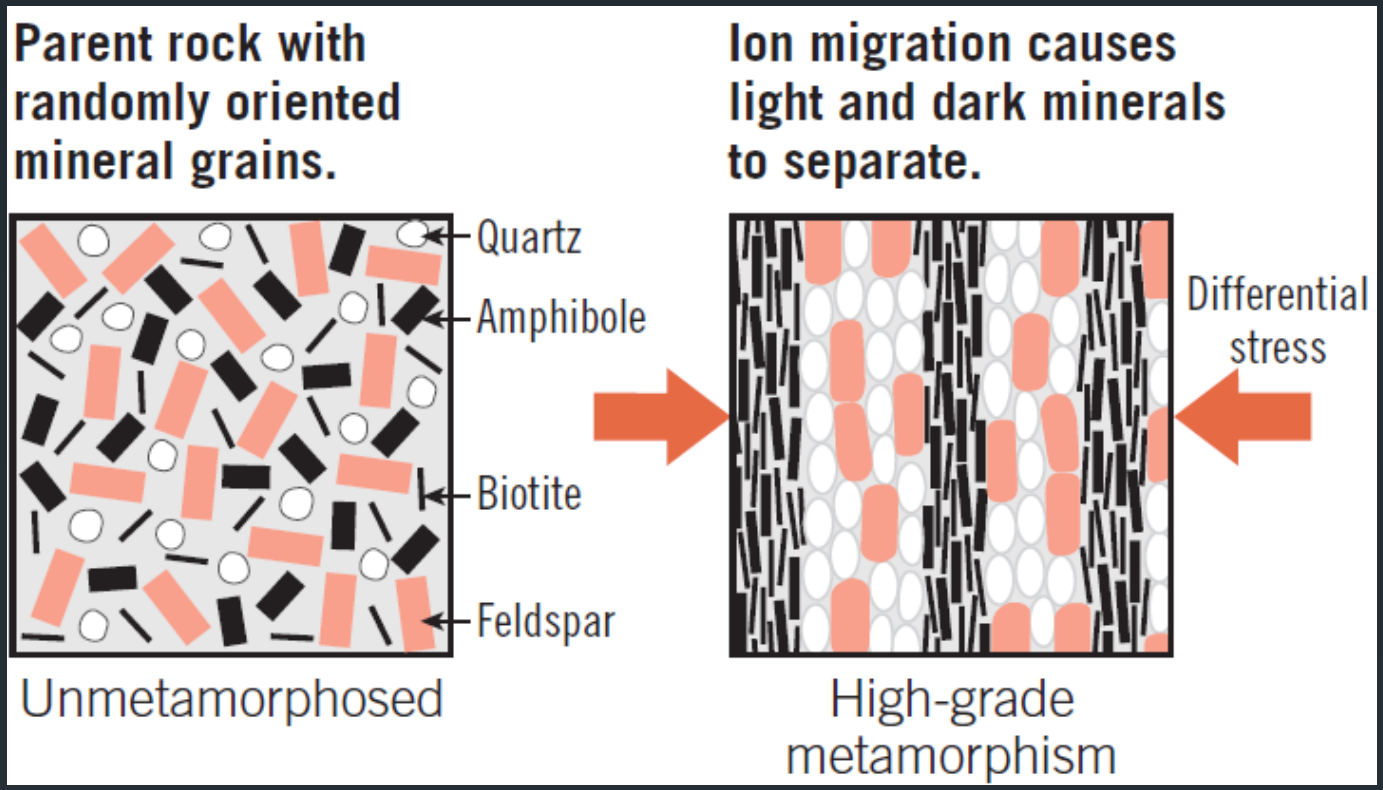

Parent rock
(Shale)
Metamorphic rock
(Slate)
Low-grade
metamorphism
Low temperatures
and pressures
A.
Loosely
packed
clay
minerals
Tightly
packed
chlorite and
mica grains


Parent rock
(Granodiorite)
High-grade
metamorphism
Strong
compressional
forces, high
temperatures
and pressures
Metamorphic rock
(Folded gneiss)
B.
Randomly
oriented
mineral grain
Deformed
layers of
segregated grains

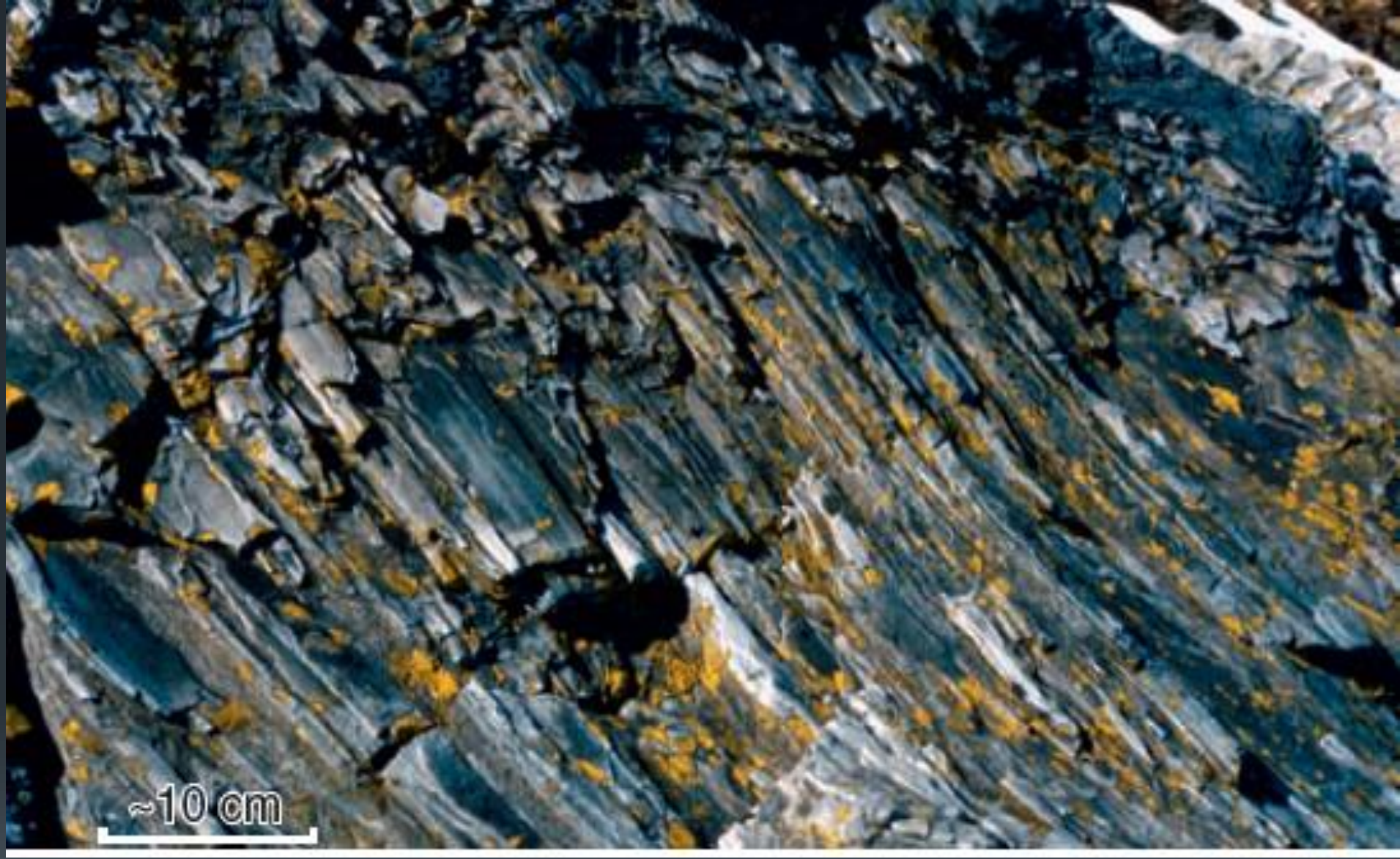


Fabric is a configuration of objects penetrating the rock.

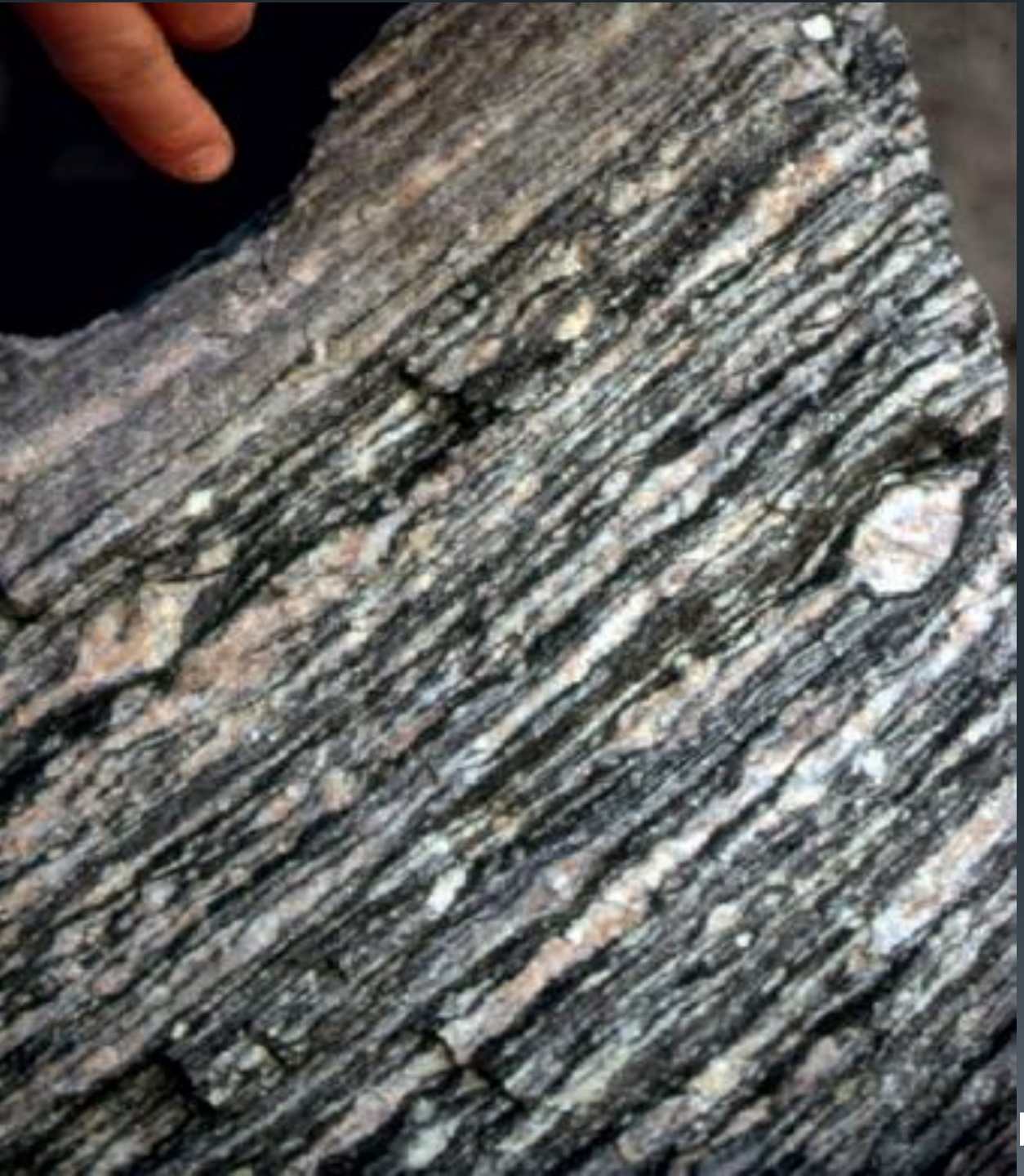
Lineation in Gneiss



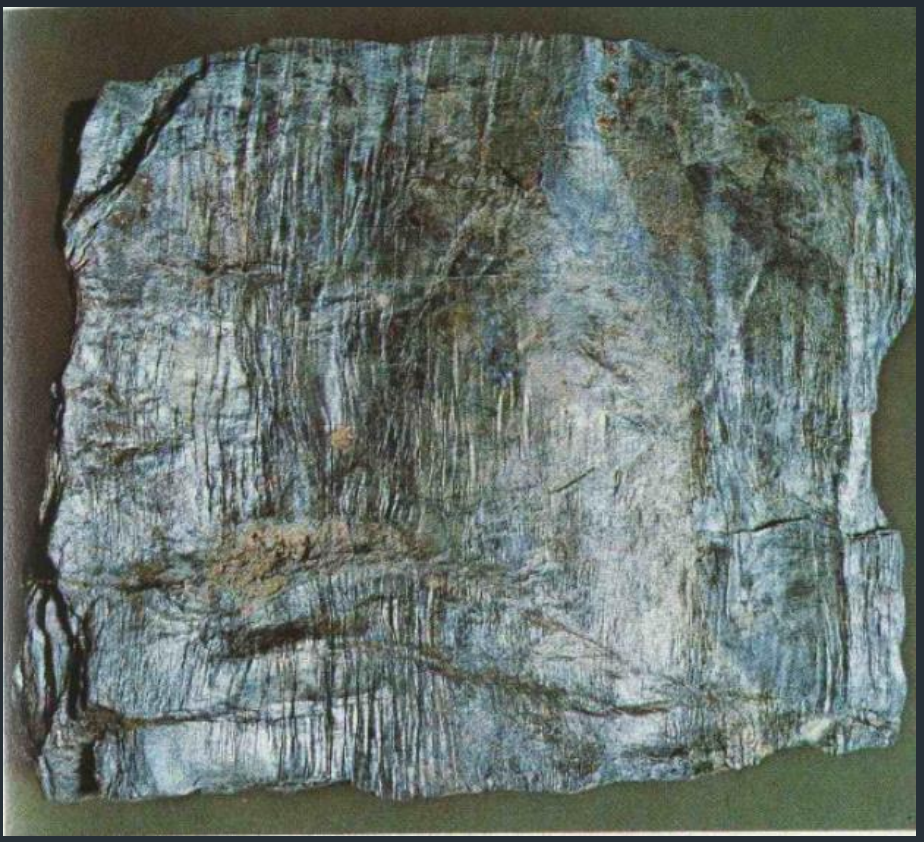
Foliation in Gneiss

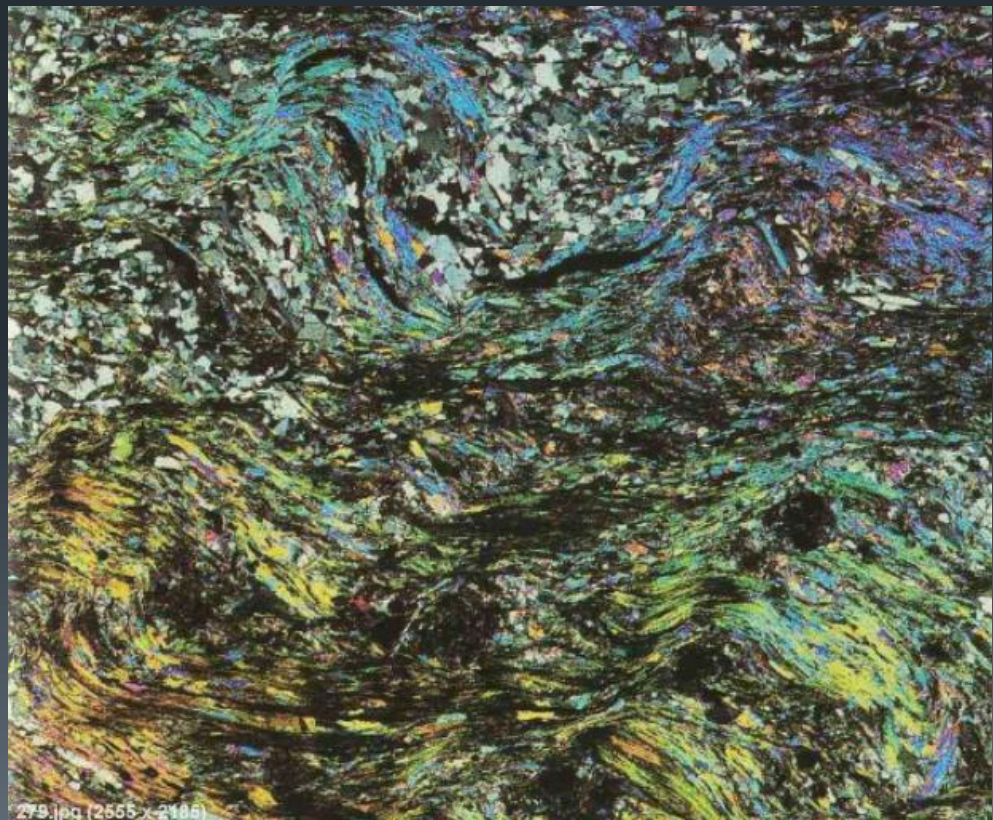


Lineation in Quartzite Conglomerate



Foliation in a granitic rock



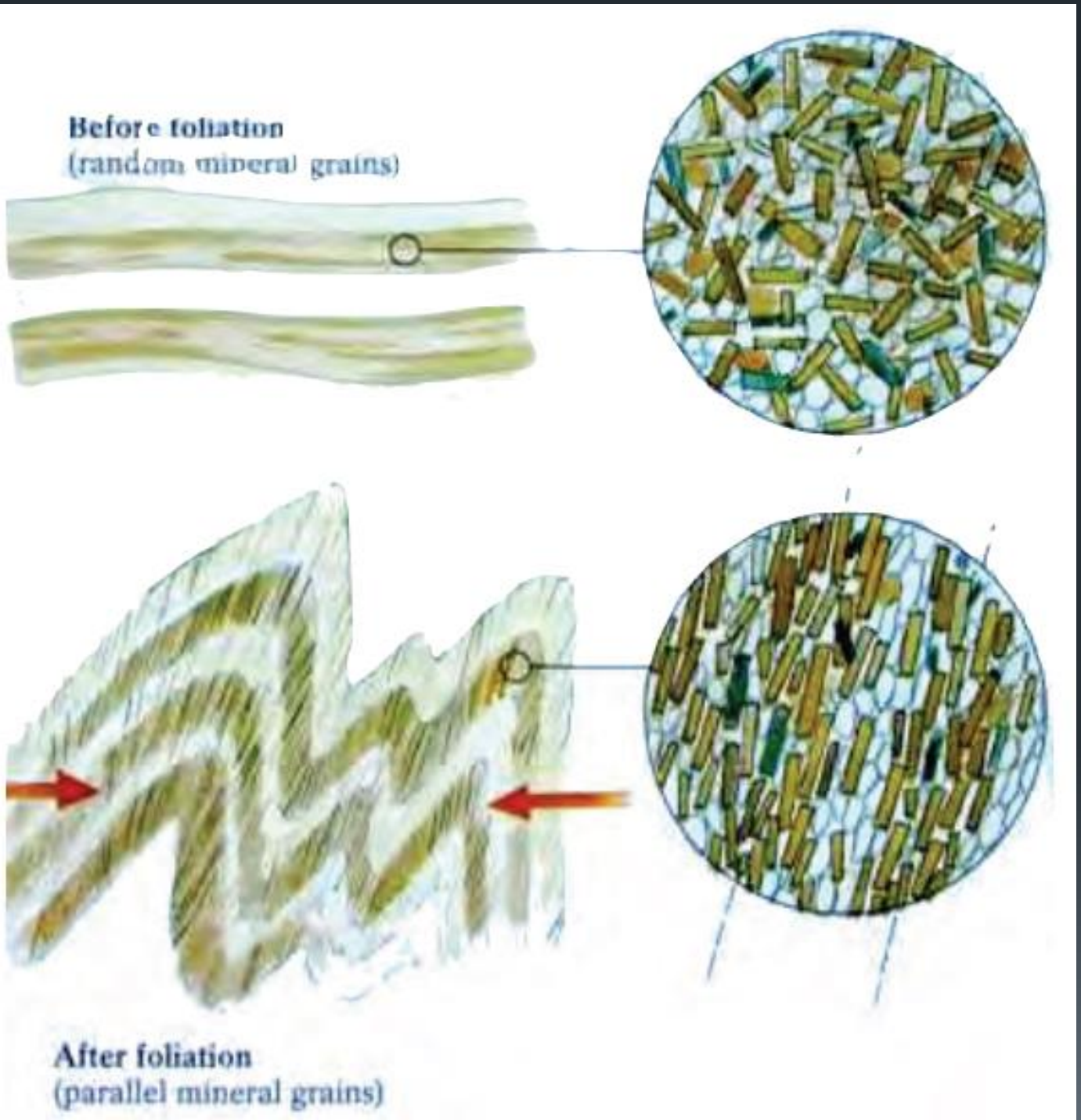


Phyllite

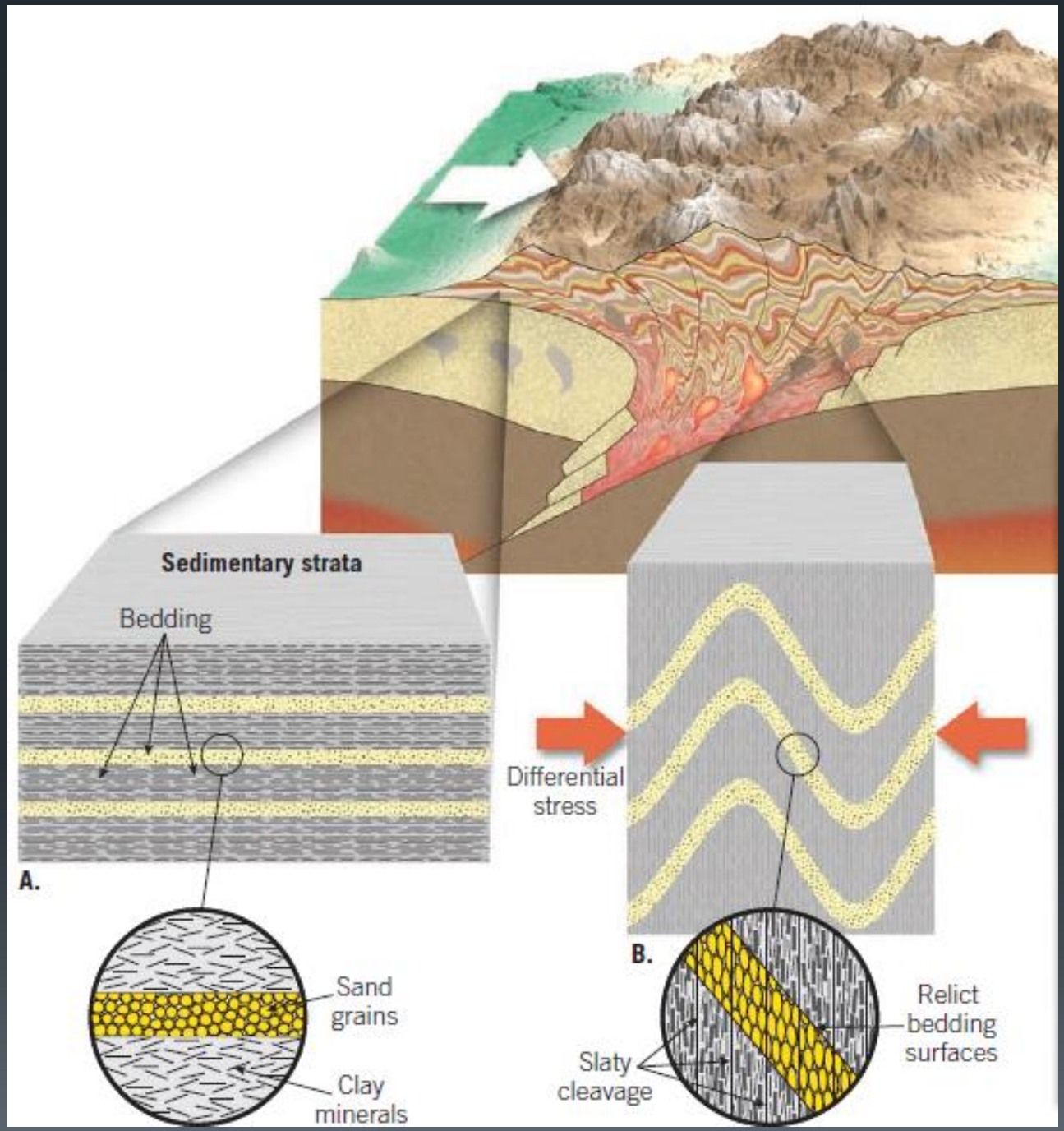
Foliation and Lineation Forming Processes

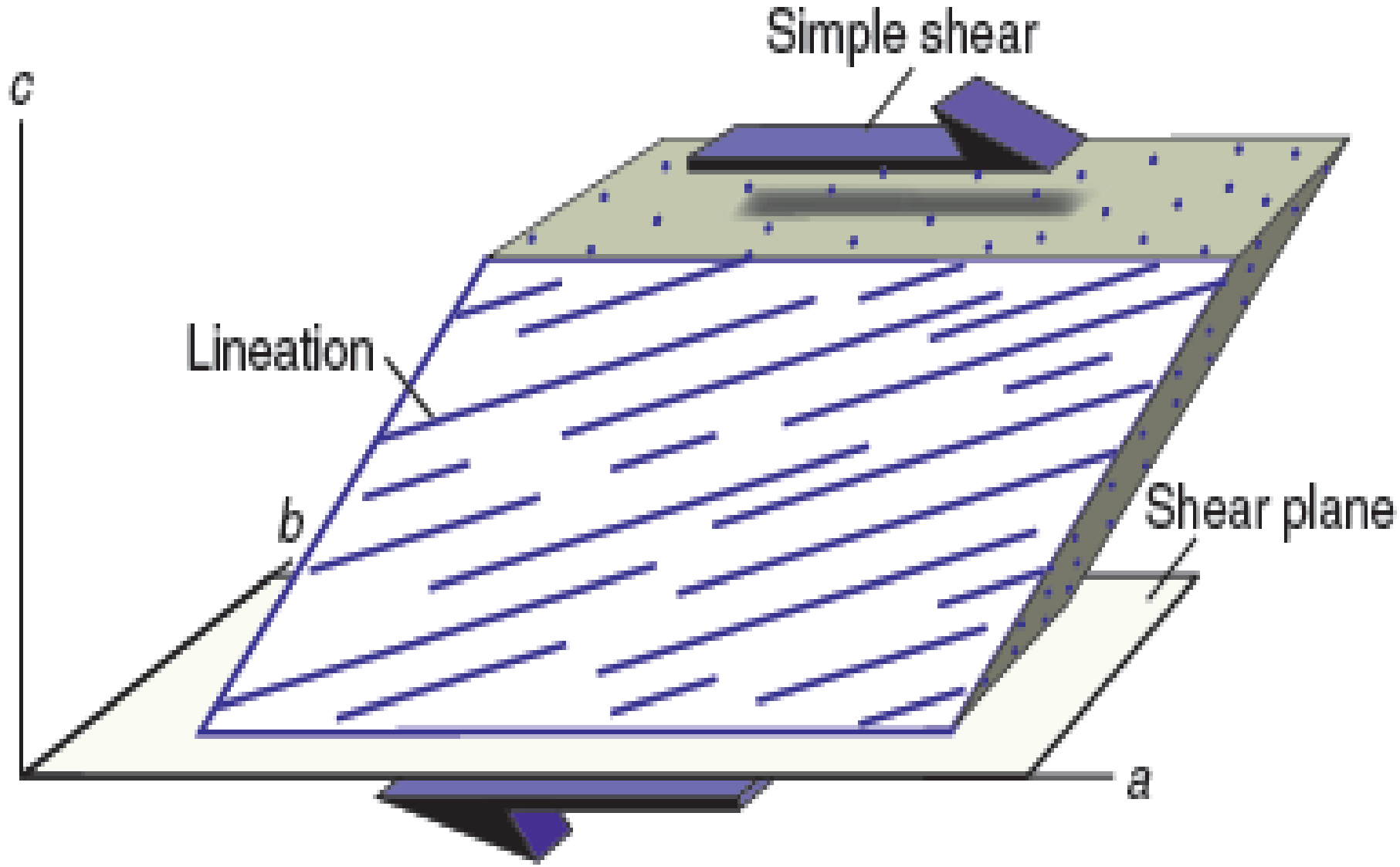
1. Folding. During folding, grains and minerals are re-oriented and flattened into a planar fabric.
2. Shearing. Shearing leads to the flattening and stretching of rock's forming grains and minerals.
3. Flow of magma. Results in the rotation of minerals into magmatic foliations and lineations.

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



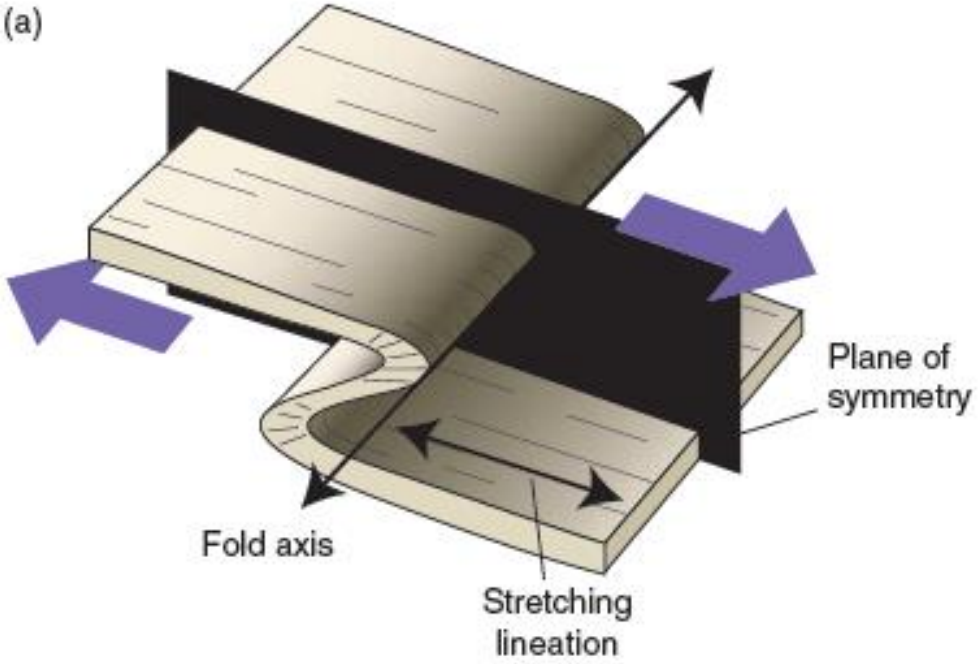
Foliation by Folding

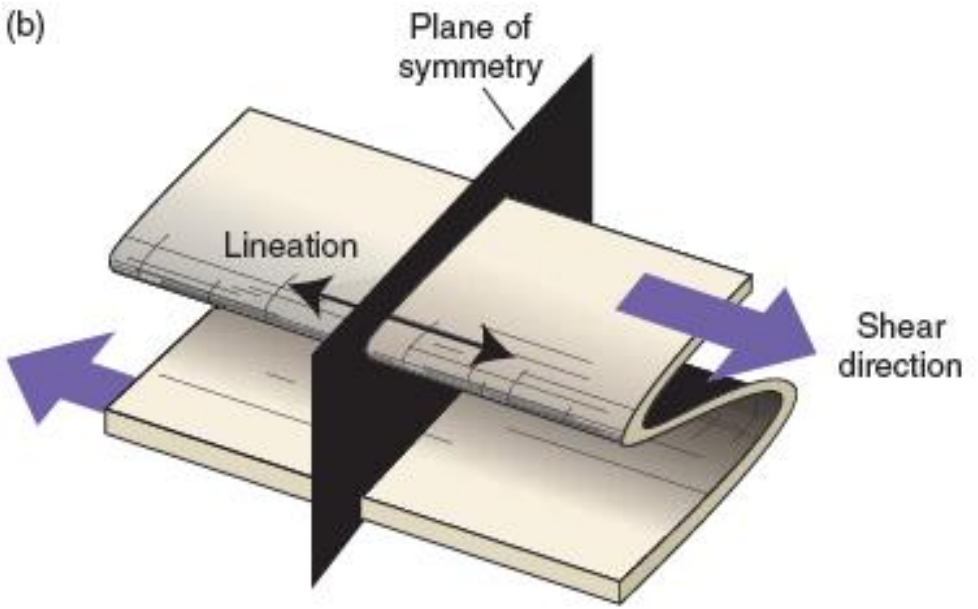

Sedimentary strata
Bedding
A.
Sand grains
Clay minerals
Differential stress
B.
Relict bedding surfaces
Slaty cleavage



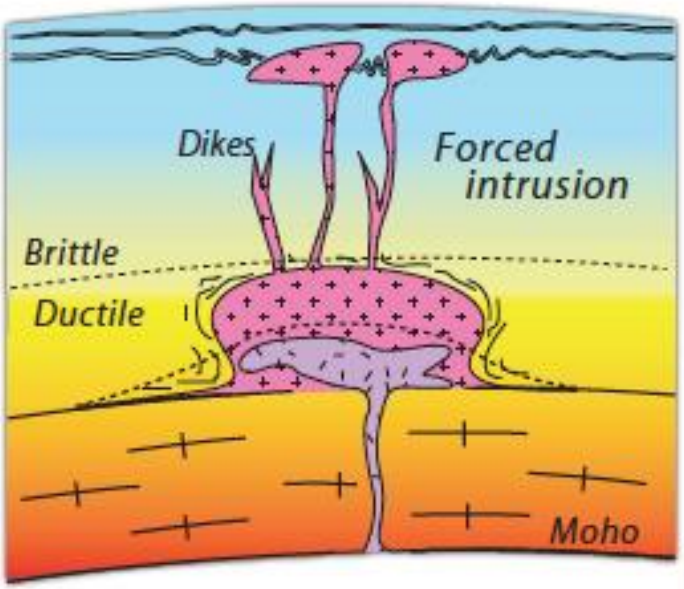
The stretching lineation

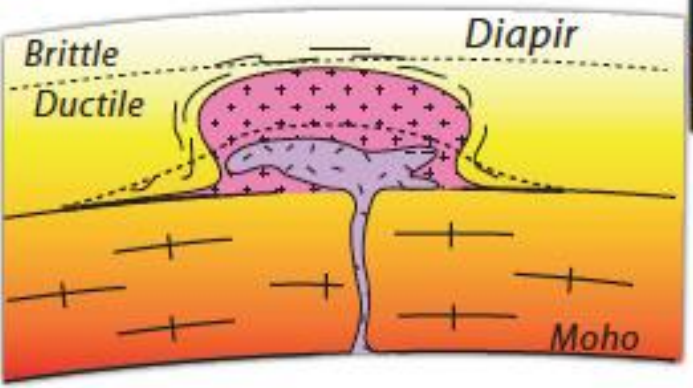
Stretching lineation

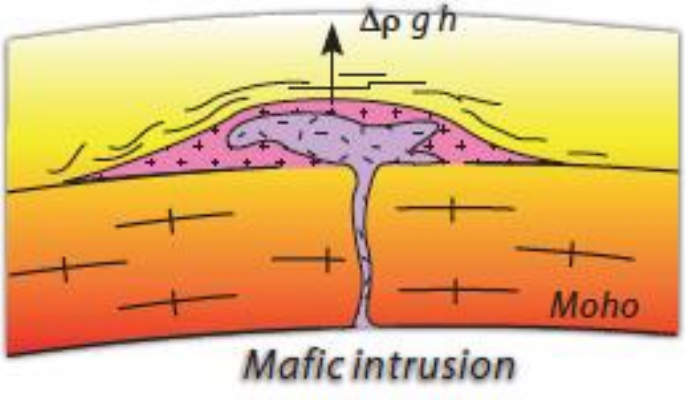


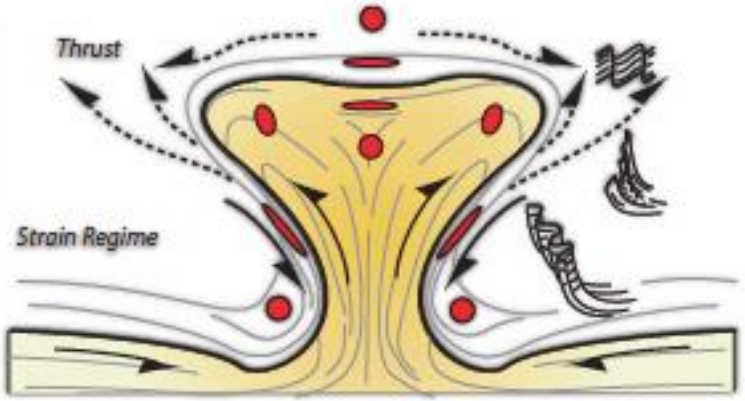


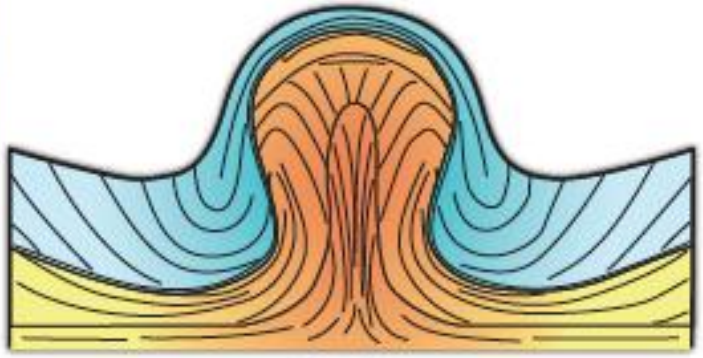
Folds may have axes that are parallel as well as perpendicular to the stretching lineation.



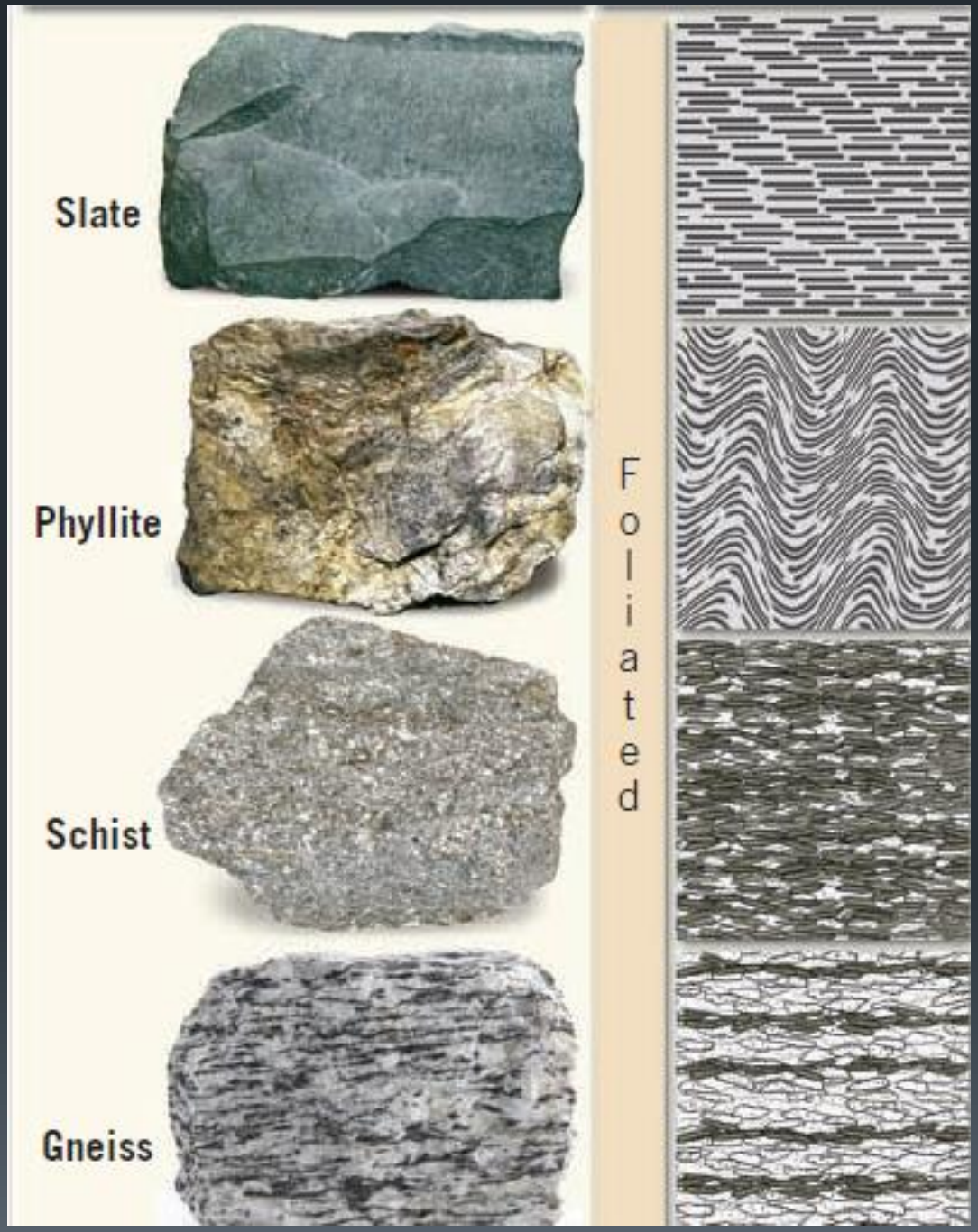






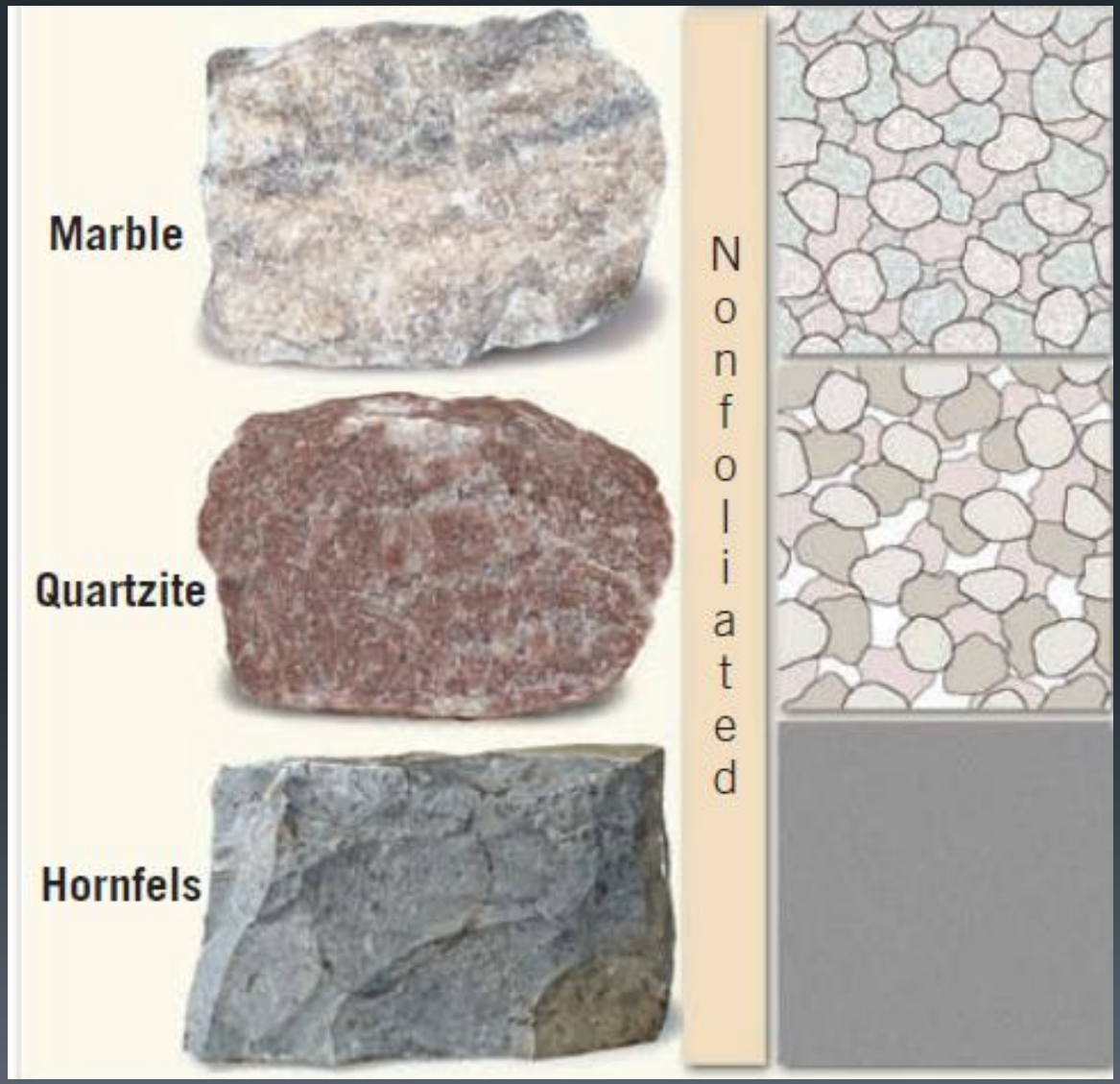


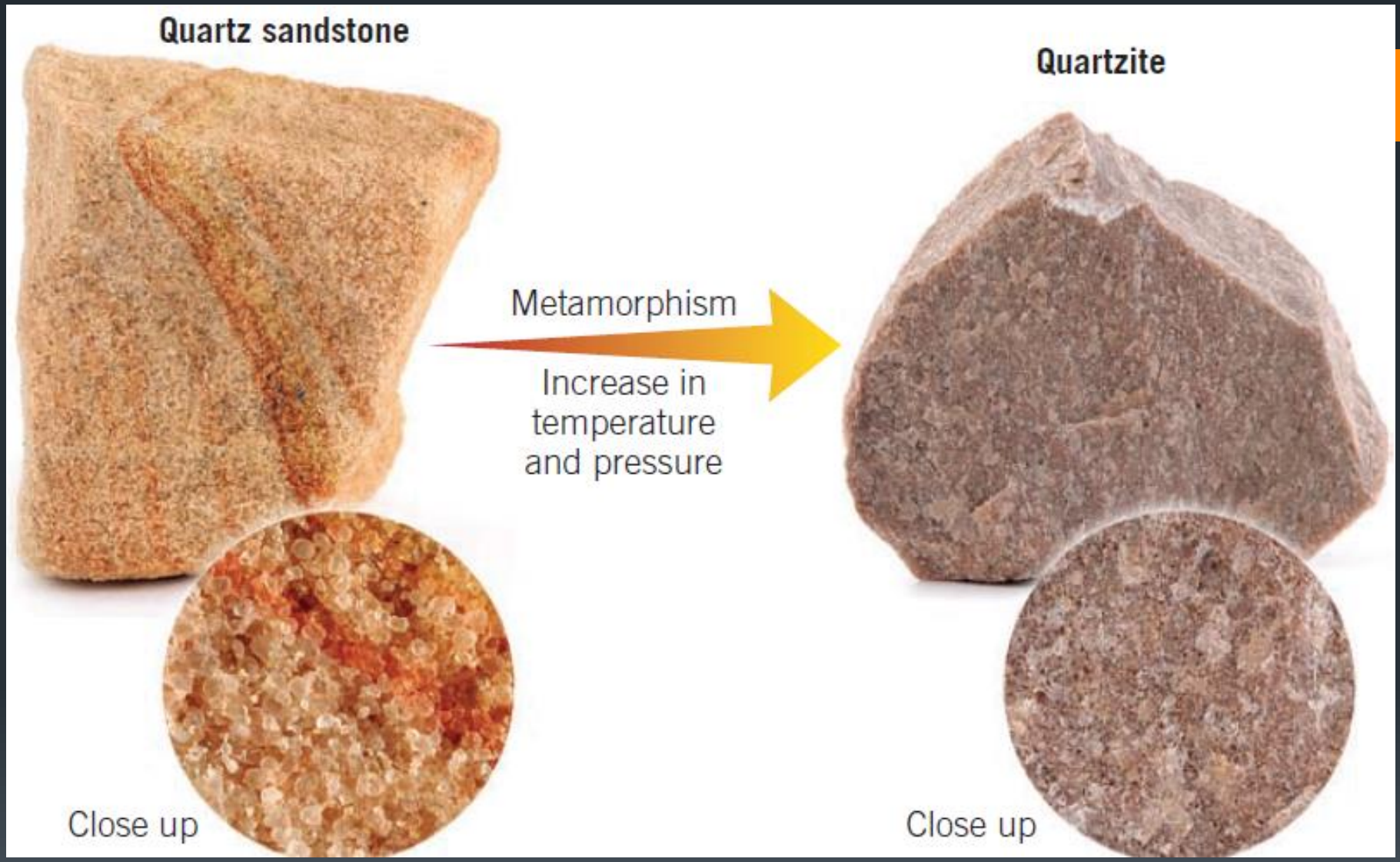
Flowing of Magma



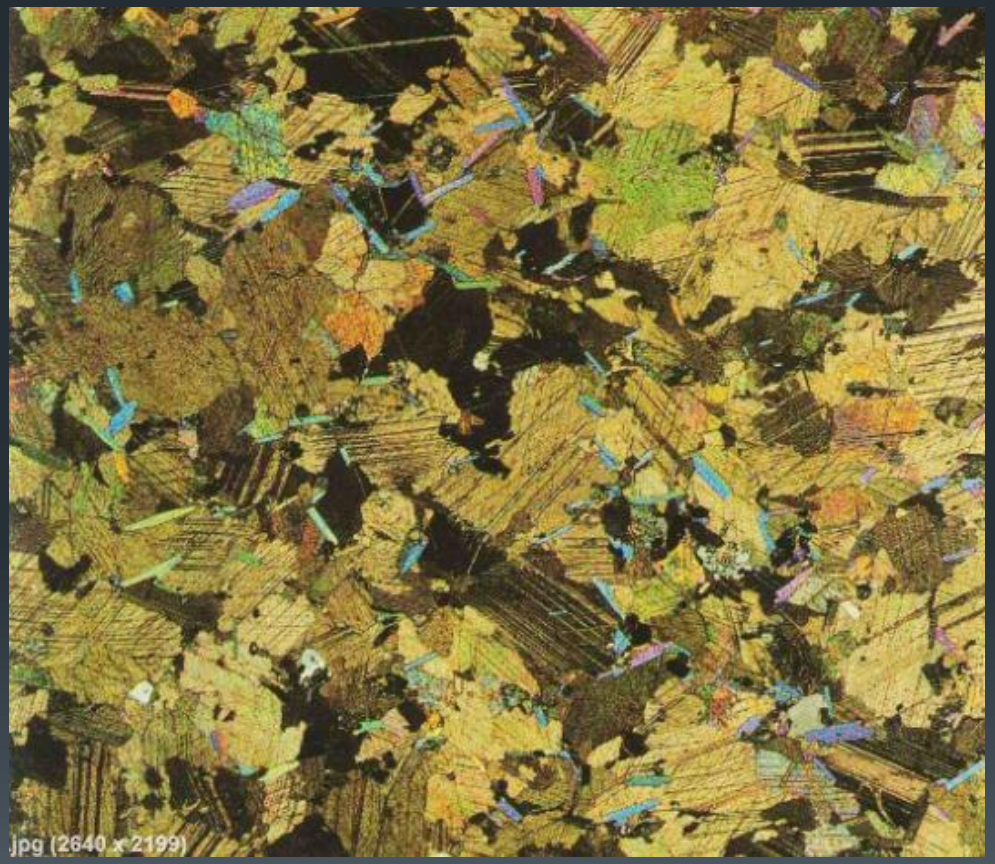
Foliated Metamorphic Rock

Non Foliated





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 Stucture, 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.