EWCE 203

Geology and Geomorphology

Geology

Metamorphic Rocks

To be discussed:

- Metamorphic Rocks
- Metamorphism
- Agents of Metamorphism
- Types of Metamorphism (contact and regional)
- Texture of Metamorphic Rocks (Non-foliated & Foliated)
- Types of Metamorphic Rocks (slate, schist, gneiss & marble)
- **Is Glacier Ice a type metamorphic rock?**

Metamorphic Rocks:

- Changed Rocks.
- Result from the **alteration of pre-existing rocks** in response to changing environmental conditions

Environmental Conditions:

- May be **variations in temperature, pressure,** and **mechanical stress**, and the **addition or subtraction of chemical components**.

Pre-existing rocks may be igneous, sedimentary, or other metamorphic rocks.

What are Metamorphic Rocks?

Rocks have been **modified** **by:**

-heat,

-pressure, and

-chemical processes,

- Usually while **buried deep below Earth's surface**.

Exposure to these extreme conditions has **altered:**

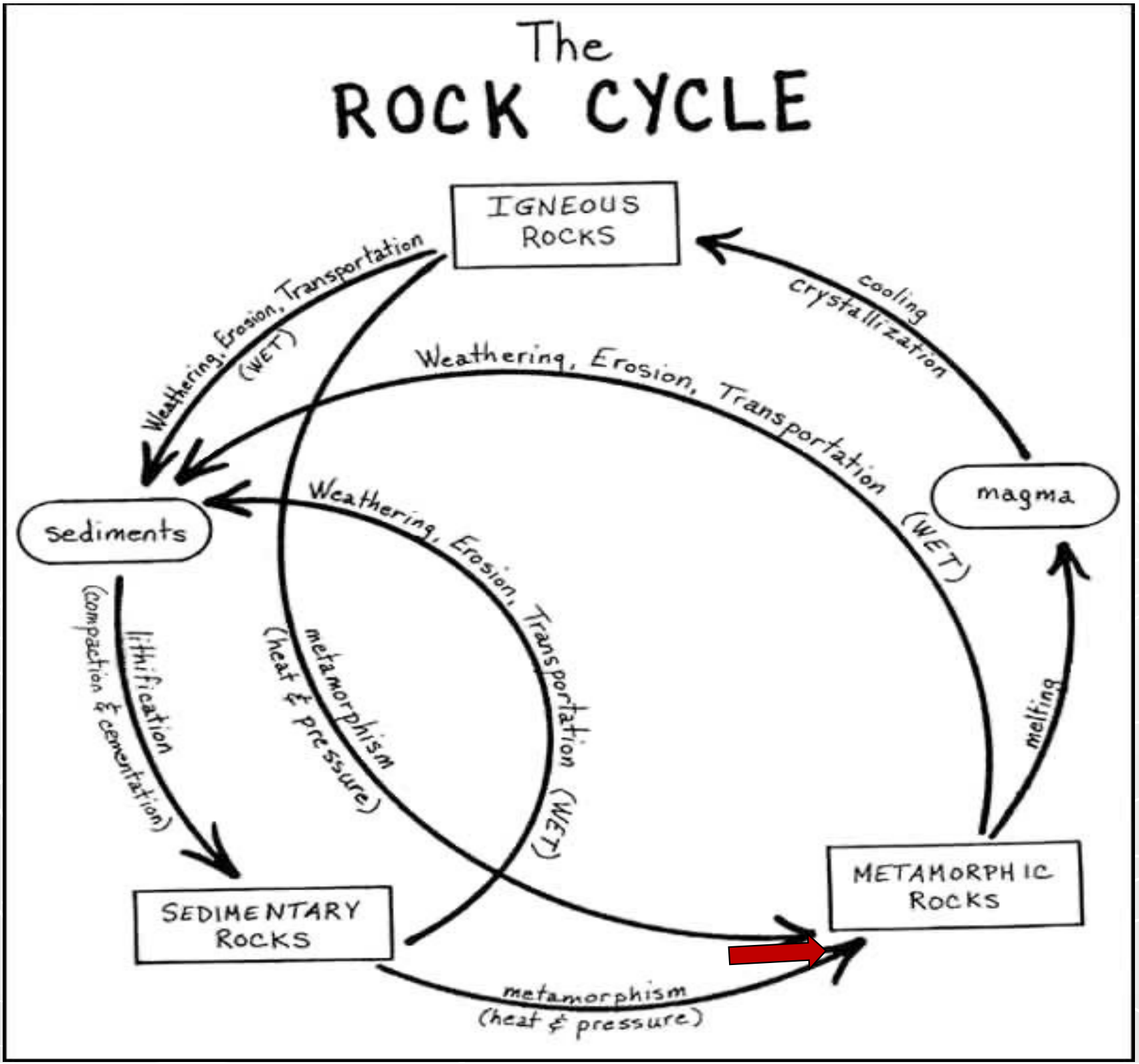
- **mineralogy,**
- **texture, and**
- **chemical composition** of the rocks.

Metamorphism:

- **Process** of changing existing rocks to a new rocks.

- Process **occurs within the earth's crust** and **below the zone of weathering** and **outside the zone of melting**.

- Rocks undergo **chemical and structural changes** **in the new environment.**


The
ROCK CYCLE
IGNEOUS ROCKS
Weathering, Erosion, Transportation (WET)
cooling crystallization
Weathering, Erosion, Transportation (WET)
magma
sediments
Weathering, Erosion, Transportation (WET)
lithification (compaction & cementation)
metamorphism (heat & pressure)
melting
SEDIMENTARY ROCKS
METAMORPHIC ROCKS
metamorphism (heat & pressure)

Agents of metamorphism:

Heat – most essential agent.

Pressure:

- Changes take place **to reduce the spaces** occupied by mineral components.
- Produce **closer atomic packing** of elements.
- Recrystallization.

Chemically active Fluids:

- **Hydrothermal solutions** released in solidification of magma often **percolate within rocks.**
- This **solution reacts** with the surrounding rocks.

Types of Metamorphism:

Contact metamorphism

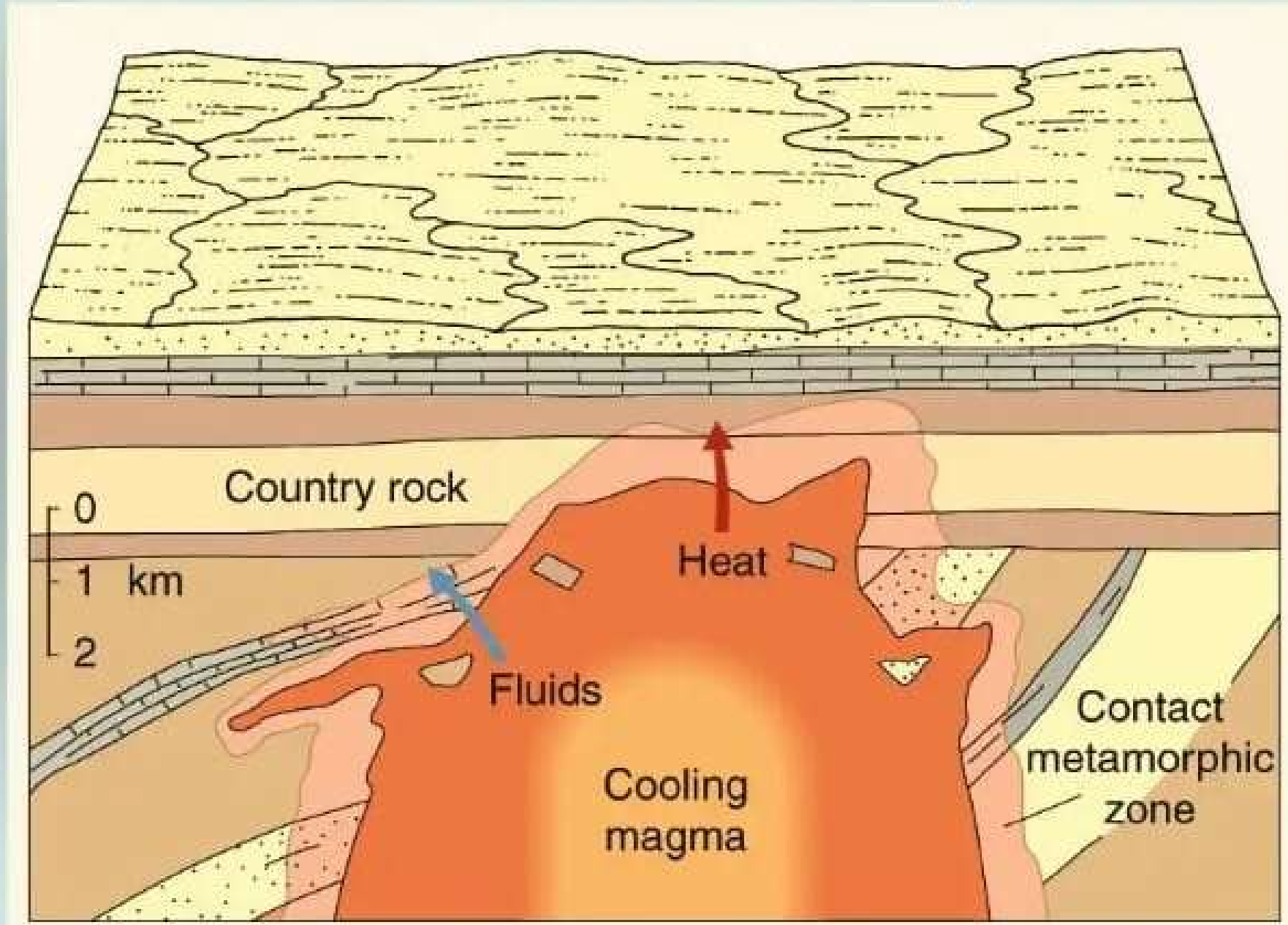
- When magma is **intruded into earth's crust**, it **alters the surrounding rocks.**

- **Alternation of rocks at or near their contact zone** is called contact metamorphism.

- Minerals formed are called **metamorphic minerals**.

- **Zones are called Aureoles, found bordering plutons** ie sills, dikes, laccoliths, stock, lopoliths and batholiths

Contact Metamorphism



$CaCO_3 + SiO_2 \longrightarrow CaSiO_3 + 2CO_2$

Limestone + Quartz → Wallastonite

- Forms when impure **limestone or dolomite** is **subjected to high temperature and pressure,** which sometimes occurs in the presence of silica-bearing fluids.

$CaMg(CO_3) + SiO_2 \longrightarrow CaMg(Si_2O_6) + 2CO_2$

Dolomite + Quartz → Diopside

- Diopside is also found in a variety of metamorphic rocks, such as in **contact metamorphosed skarns** developed **from high silica dolomites.**

Skarns- Coarse grained metamorphic rocks

Regional Metamorphism:

- Develop **over extensive areas** often involving **1000 Sq Km areas** and **thickness about 1000m**.
- Related to **building mountain range**
- Metamorphic rocks found in **root regions of old mountains**.

Orogenic metamorphism terrain, Himalayas



Texture of Metamorphic Rocks

- Refers to **physical appearance or character of a rock**,
- Such as **grain size**, **shape**, **arrangement**, and or **pattern** at microscopic surface feature level.

Types of Texture of metamorphic rocks:

Non-foliated:

- **Not consisting of thin sheet**.

Do not have a layered or banded appearance.

- **Aphanitic** – Grains can **not be seen with unaided eyes**.

  -do not exhibit cleavage.

- **Granular-** Individual grains are clearly visible.

  -No evidence of cleavage

  -Example: Marble, Quartz





Foliated:

- **Leafy and exhibit** rock cleavage.

- Have **a layered or banded appearance** that is produced by exposure to heat and directed pressure.

Example: **Gneiss, Slate**



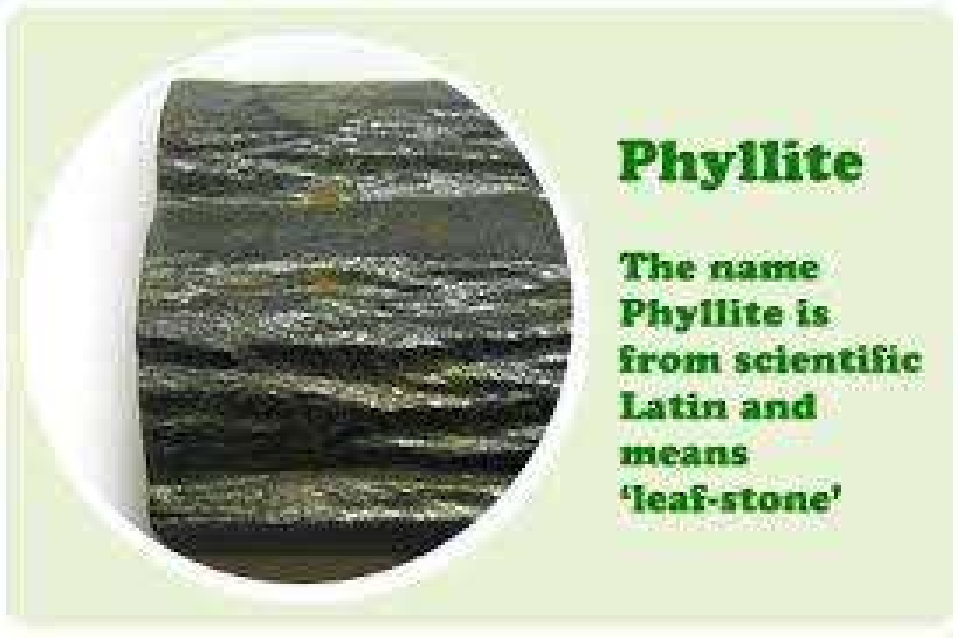



FOLIATED
NON-FOLIATED

Types of Foliated Texture:

Slaty:

- A pervasive, **parallel foliation** (layering) of **fine-grained platy** minerals (chlorite) in a direction **perpendicular to the direction of maximum stress**.
- Found in the **rocks slate** and **phyllite.**
- Phyllite is **a foliated metamorphic rock rich in tiny sheets of sericite mica.**

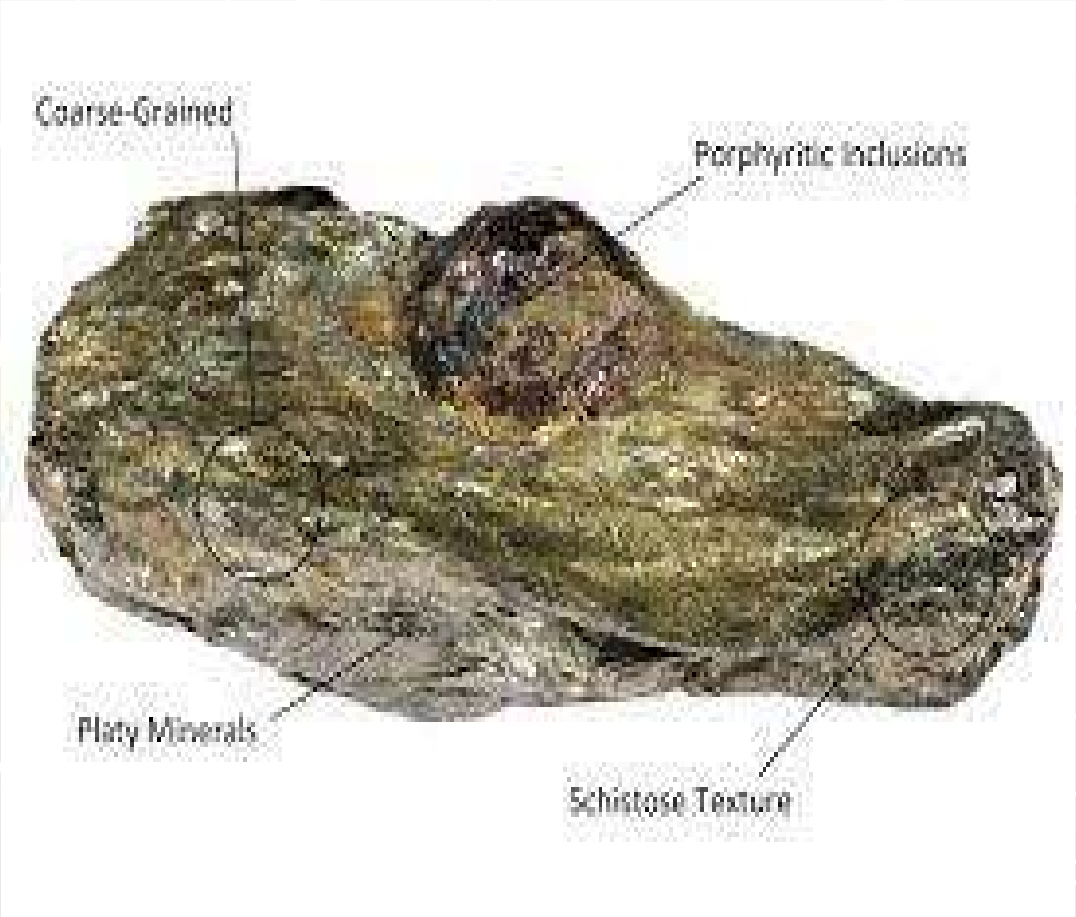




Schistosity:

- Layering in a **coarse grained, crystalline rock** due to the **parallel arrangement of platy mineral grains** such as **muscovite** and **biotite**.

- Other minerals present are typically **quartz** and **feldspar**, plus a variety of other minerals.

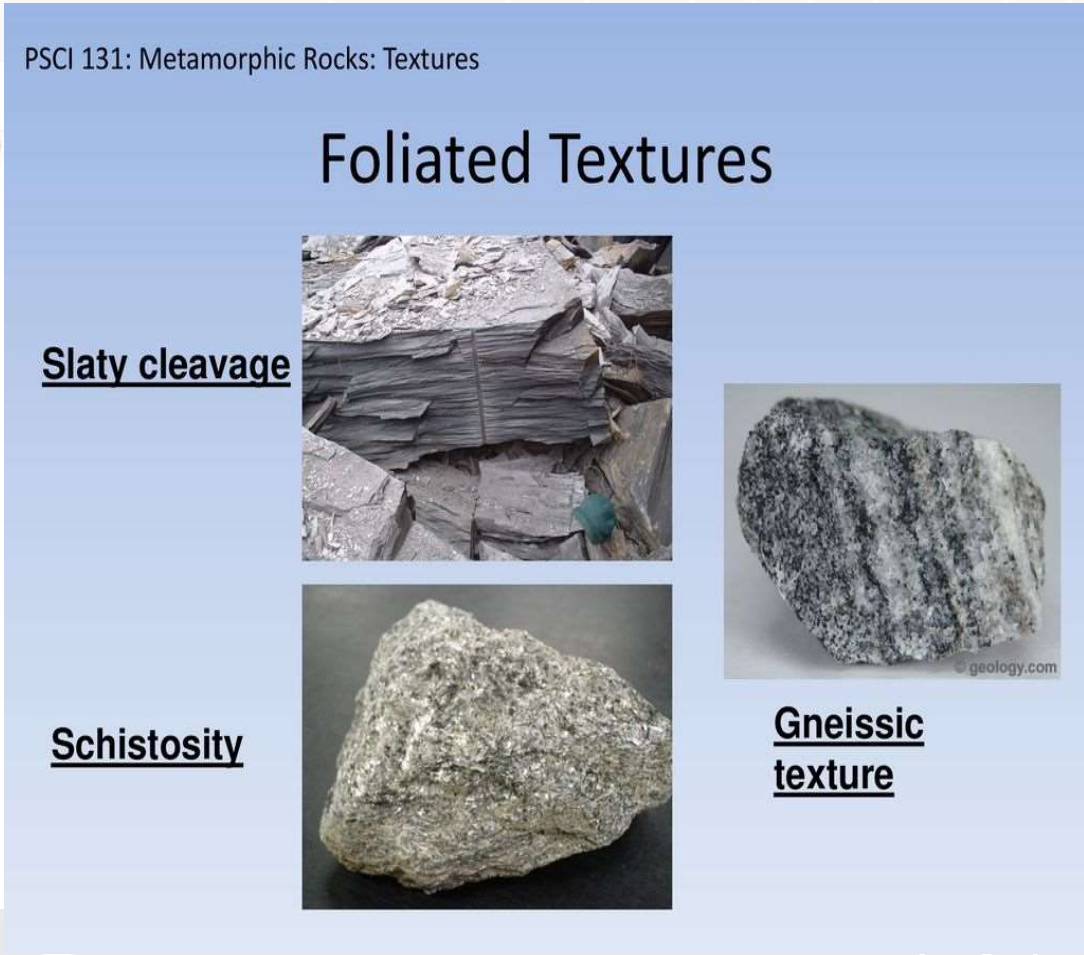




Gneissic

- Layering in a rock in which **bands of granular minerals** (quartz and feldspar) **alternate** with **bands in which platy** (mica) or **elongate** (amphibole) minerals predominate.





Types of Metamorphic Rocks



Name on the **basis of Texture**:

Slate:

What is Slate?

- **A fine-grained, foliated metamorphic rock** that is created by the alteration of **shale** or **mudstone** by low-grade regional metamorphism.

- **Fine grained interlocking crystals**, which **lie in the same direction**, known as cleavage direction, in which rock easily splits.

- It is popular for a **wide variety of uses such as roofing, flooring, and flagging stone** because of its durability and attractive appearance.

Composition of Slate

- Composed **mainly of clay minerals or micas**, depending upon the degree of metamorphism to which it has been subjected.

- Original clay minerals in **shale** **alter to micas** with increasing levels of heat and pressure.





Schist:

- Made of **medium grained interlocking crystals**.
- Its **shiny appearance** is due to the mineral mica.
- Crystals line up to give the rock **wrinkly layers** that is called **foliation**.
- Has been **subjected to higher temperatures and pressures**.
- Resulting **foliation is coarser and more distinct** than that of slate due to the higher degree of crystallization of mica minerals (biotite, chlorite, muscovite) **forming larger crystals, and is often referred to as Schistosity**.

Uses:

- Generally used as a **decorative rock**, e.g. walls, gardens etc;
- High percentage of mica group minerals **precludes its use in the construction and road industries.**





Gneiss:

- Type of metamorphic rock that **contains light and dark layers** formed of minerals such as **quartz** and **mica**

What is Gneiss?

- A **foliated metamorphic** rock **identified by its bands of varying composition,** while **other bands contain granular minerals** with an interlocking texture.
- **Other bands contain platy or elongate minerals** with evidence of preferred orientation.
- It is this **banded appearance and texture** - rather than composition - that define a Gneissic.

Uses of Gneiss:

- Gneiss usually **does not split along planes** of weakness like most other metamorphic rocks.
- Used gneiss as a **crushed stone** **in road construction**, building **site preparation**, and **landscaping** projects.





Marble:

- **Metamorphosed limestone**.
- Made of **calcium carbonate**.
- Has **medium grained interlocking crystals** with no alignment.



Is Glacier Ice a type metamorphic rock?

- Glacier ice, **like limestone** (for example), is a **type of rock**.
- Glacier ice is actually a **mono-mineralic rock** (a rock made of only one mineral, **like limestone** which is composed of the mineral calcite).
- Mineral ice is the **crystalline form of water** (H_2O).
- Most glacier ice **forms through the metamorphism of tens of thousands of individual snowflakes** into crystals of glacier ice.
- **Metamorphism process** is **driven by the weight** of overlying snow.



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Thanks

