CE 2141
ENGINEERING GEOLOGY AND GEOMORPHOLOGY

Lecture 04 – Type of Rock & Rock Cycle

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Assignment 01

Note the following topics with figures:

Group 01 – (26, 14, 39, 24): Internal Structure of Earth & Mineraloids

Group 02 – (12, 23, 38, 34): Minerals & their properties

Group 03 – (32, 21, 22-30, 16): Type of Rocks & Igneous Rock

Group 04 – (19, 35, 13, 30): Sedimentary Rock, Metamorphic Rock & Rock Cycle

Deadline 12 July 2025

Lecture 04: Topics

- Volcanic Rocks
- Composition & Texture of Igneous Rock
- Sedimentary Rocks
- Metamorphic Rocks
- Rock Cycle

Volcanic Rocks

Lava Flow

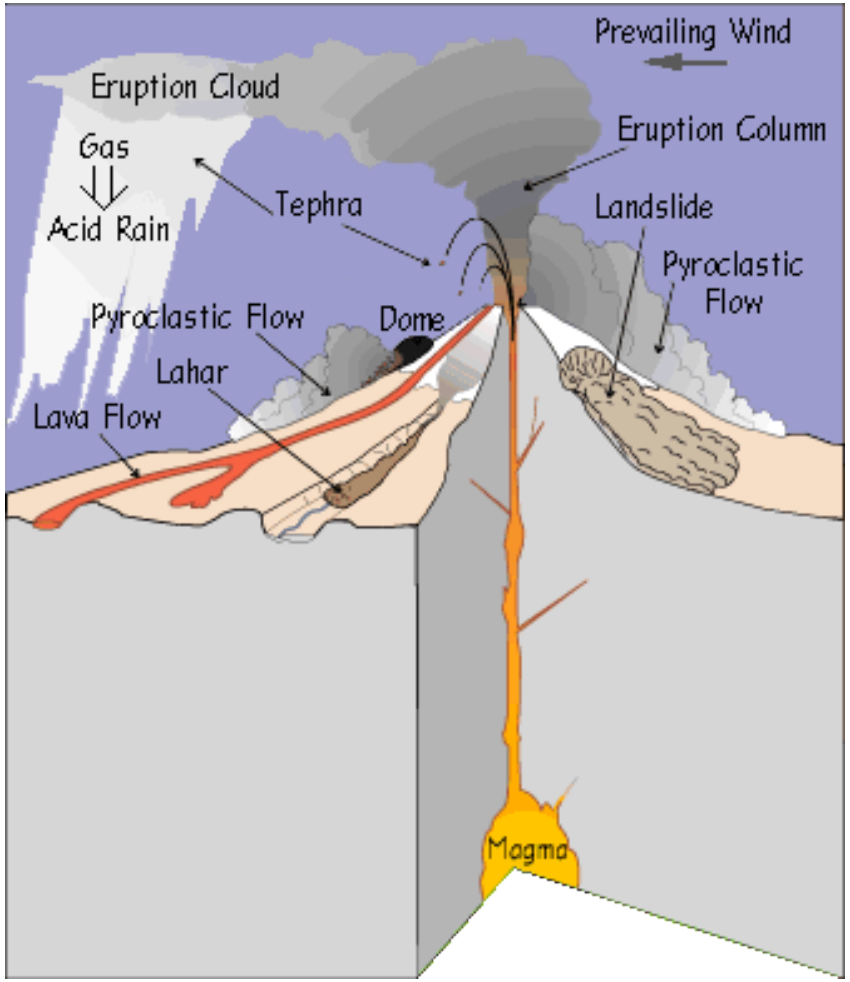
Pyroclastic Flow

Volcanic Rocks

These may be formed by Volcanic Eruption

(a) Lava flows and sheet - molten material poured out onto the surface from a volcanic vent or along a fissure and solidified, or

(b) Ash-beds - fragmental material (pyroclastic flow) of all sizes erupted from volcanic vents.



Composition of Igneous Rocks (Chemical)

TABLE SHOWING AVERAGE COMPOSITION OF IGNEOUS ROCKS
(Reduced to 100 per cent)

SiO_2	59.93
Al_2O_3	14.97
Fe_2O_3	2.58
FeO	3.42
MgO	3.85
CaO	4.78
Na_2O	3.40
K_2O	2.99
H_2O	1.94
Rest	2.14
	100.00

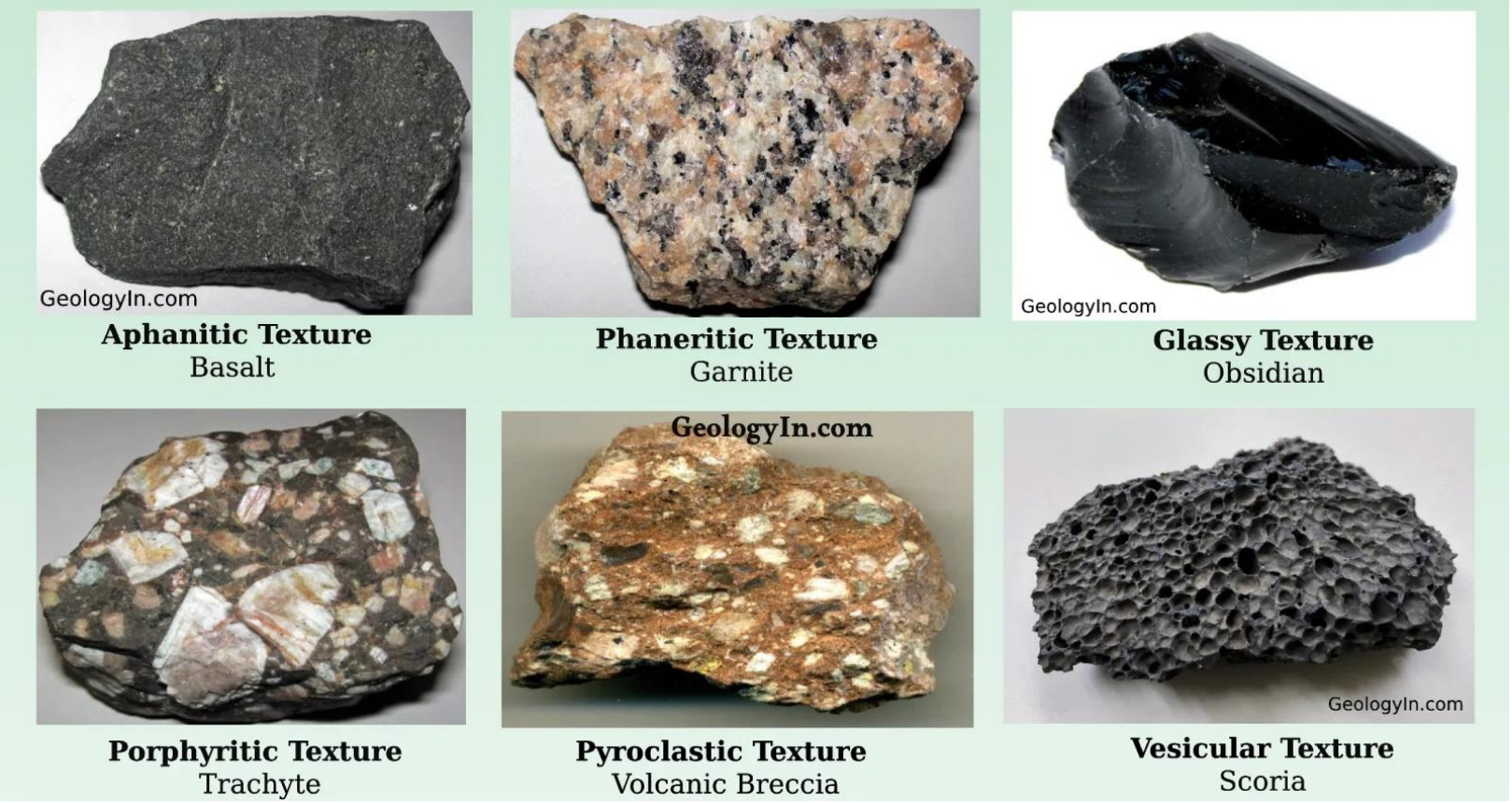
Under "rest" in the table above is included TiO_2, ZrO_2, CO_2, P_2O_5, S, Cl, F, BaO, SrO, MnO, NiO, Cr_2O_3, V_2O_3, and Li_2O.

Composition of Igneous Rocks (Mineral)

For convenience of classification the more important minerals of igneous rocks may be tabulated under two groups as follows:

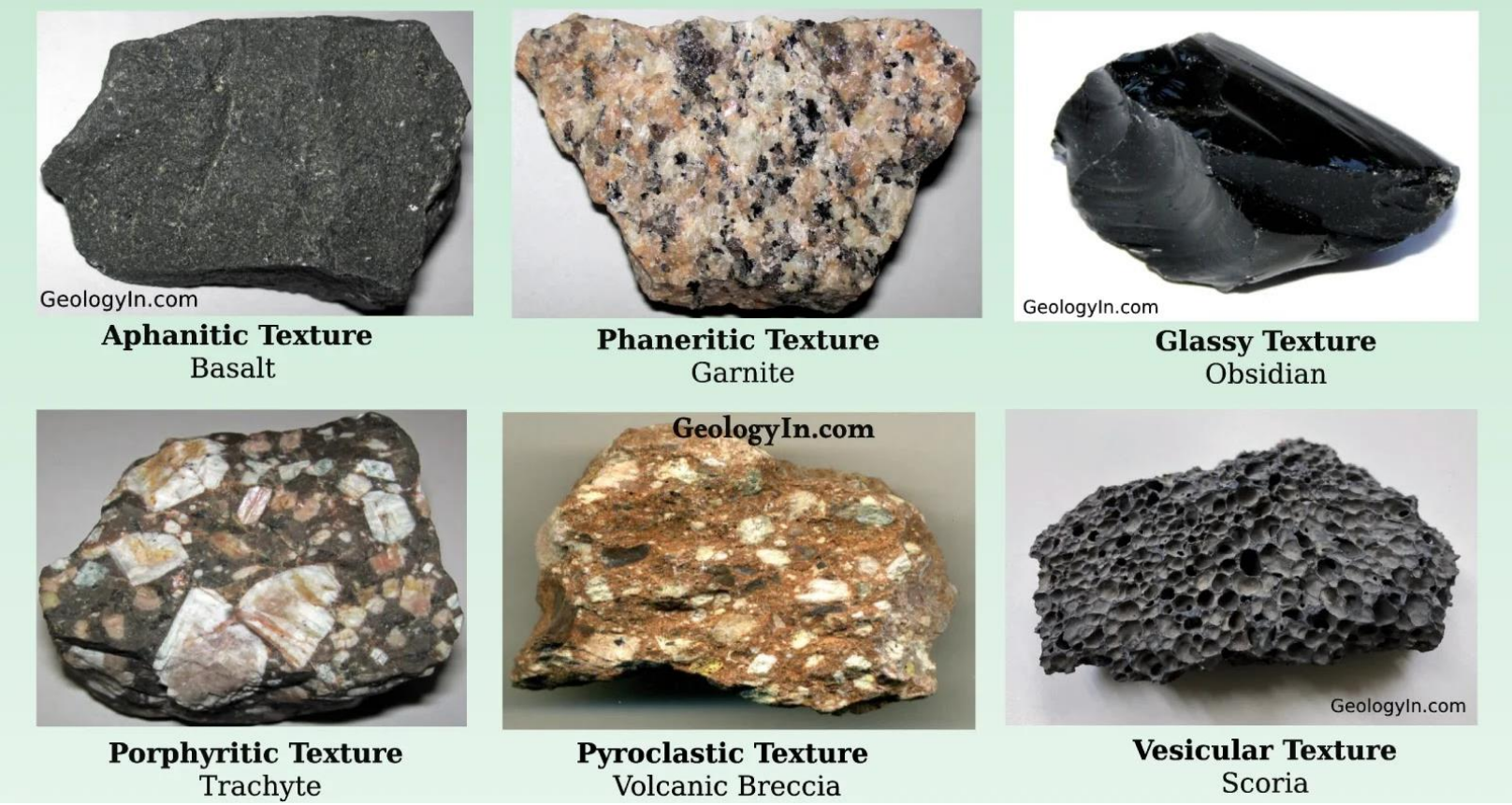
Siliceous-aluminous Group	Ferromagnesian Group
Rich in silica, alumina, and alkalies.	Have more in iron, lime, and magnesia.
Light in color and have a low density or specific gravity.	Dark in color, and have a relatively high density or specific gravity
Feldspar Quartz Corundum 	**Pyroxenes** Olivine Iron ores 

Texture of Igneous Rocks



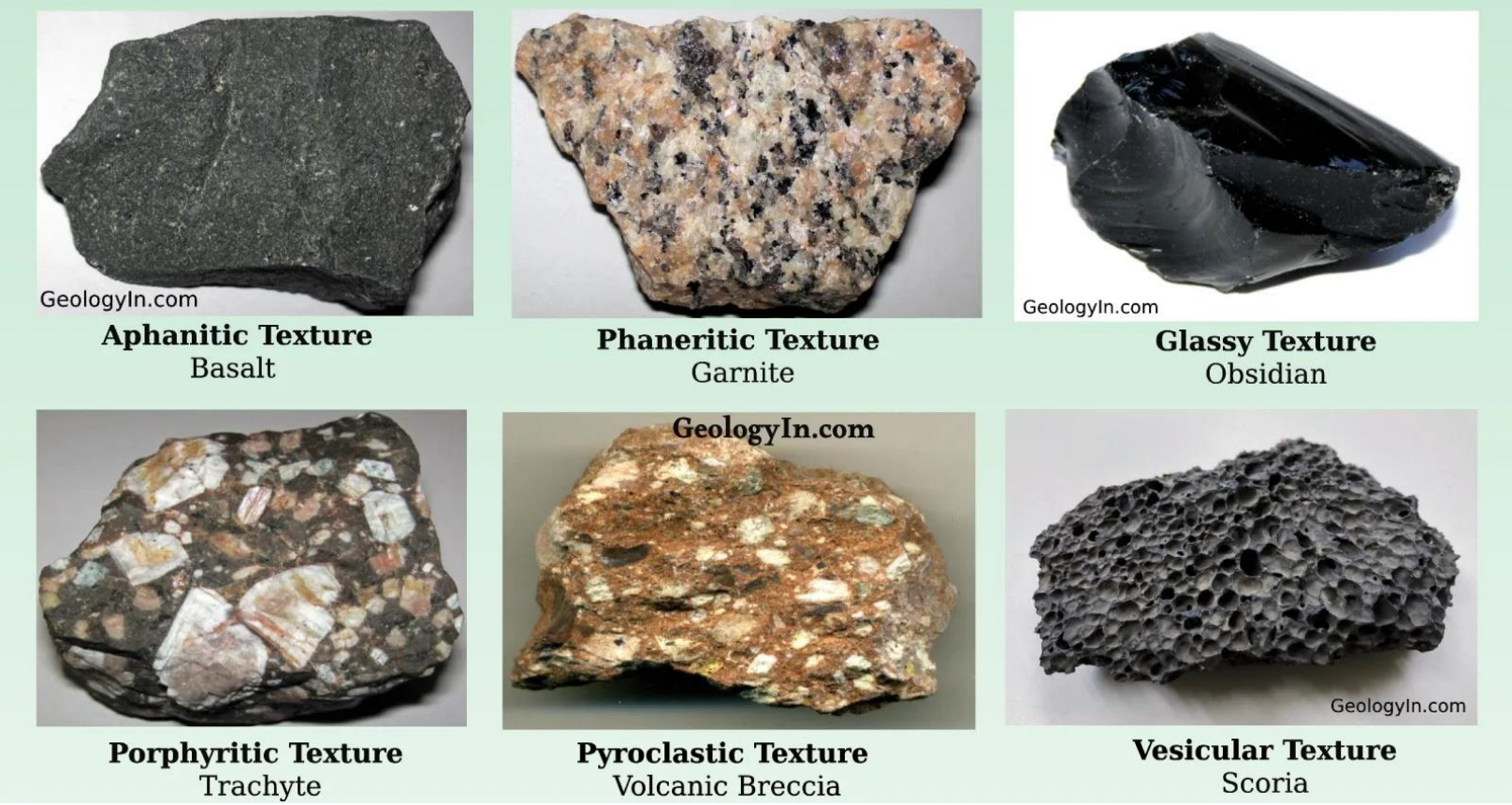
- **Aphanitic texture** is a characteristic of igneous rocks that have very small crystals that cannot be seen with the naked eye
- **Phaneritic texture** have visible crystals that can be seen with the naked eye.

Texture of Igneous Rocks



- **Glassy textures** occur during some volcanic eruptions when the lava is quenched so rapidly that crystallization cannot occur.
- **Porphyritic textures** develop when conditions during cooling of a magma change relatively quickly.

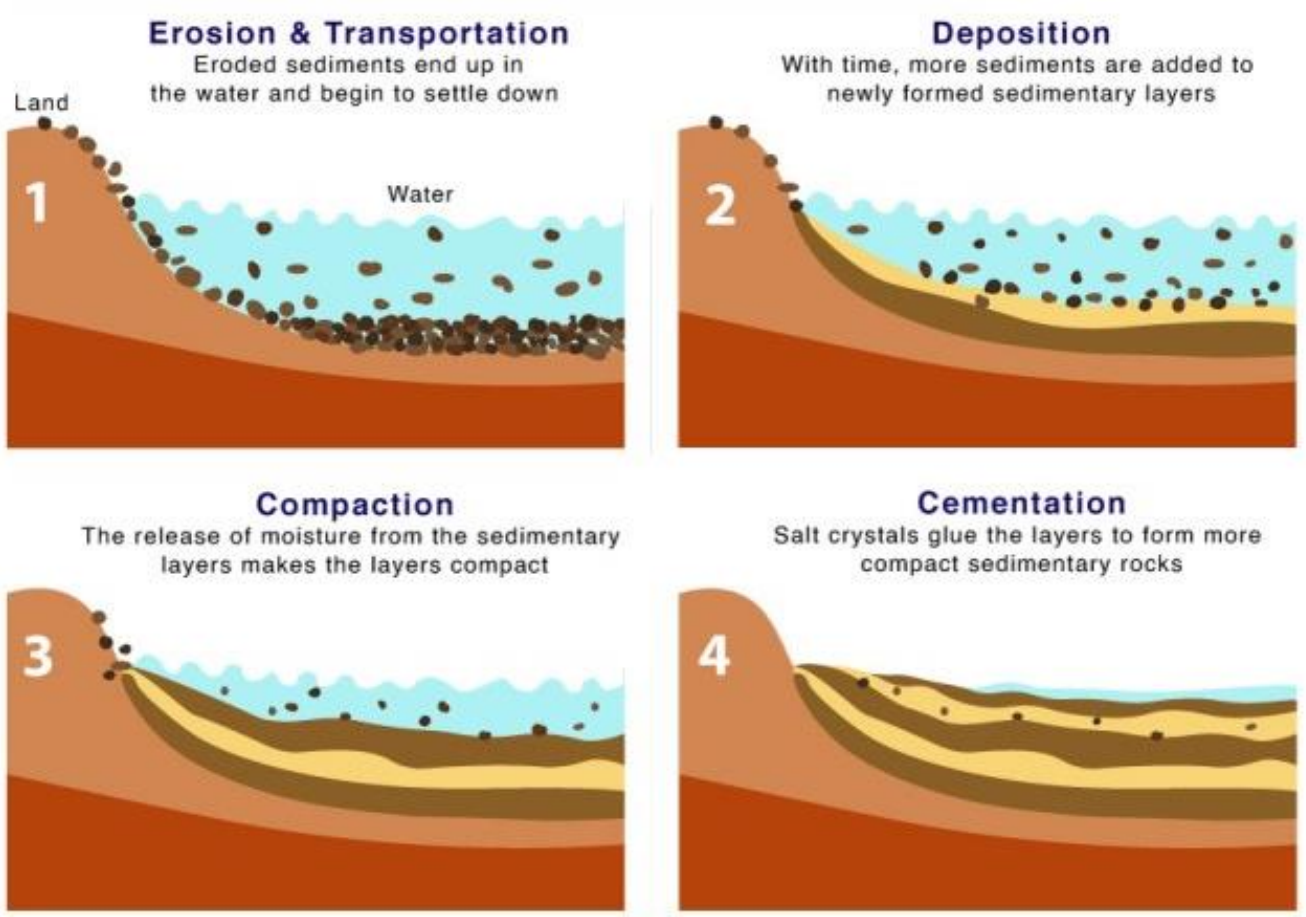
Texture of Igneous Rocks



- **Pyroclastic texture** is characterized by fragments of igneous rock of various sizes and shapes.
- **Vesicular texture** is a volcanic rock texture characterized by small cavities or holes called vesicles.

Sedimentary Rocks

The disintegrated products of pre-existing rocks are formed by water as sediments get deposited in suitable depression of the earth, where it get consolidated and cemented to form sedimentary rock.

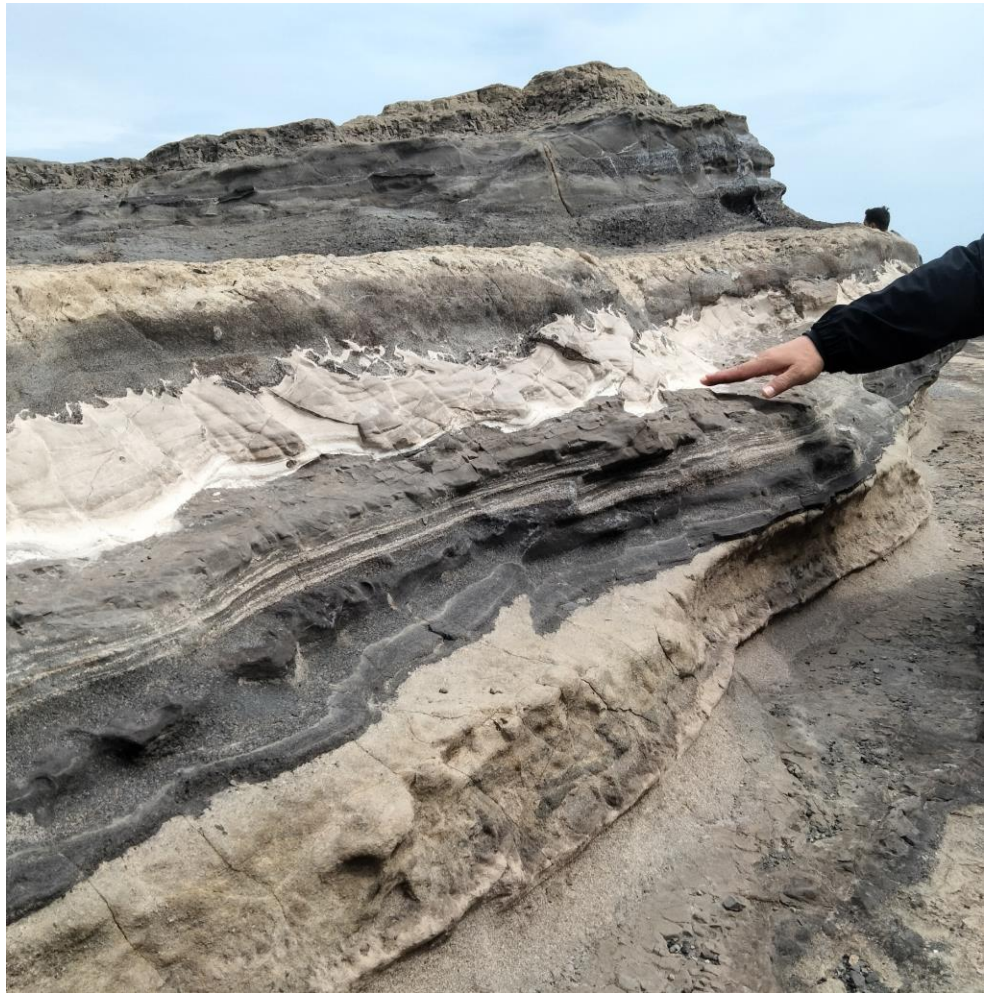


Formation Structure of Sedimentary Rocks

- Stratification
- Lamination
- Cross bedding or current bedding
- Graded bedding
- Ripple marks
- Minor Structure

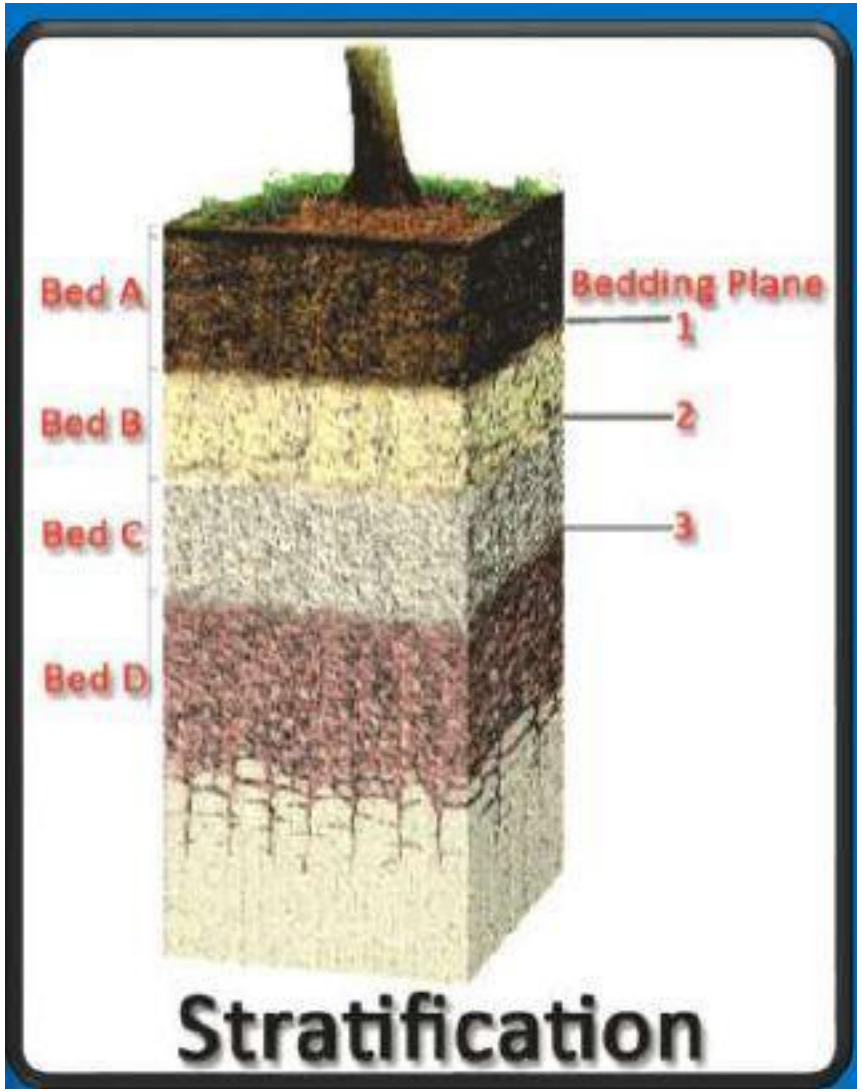
Stratification

- Stratification is the single most characteristics feature of sedimentary rocks.
- Stratification in sedimentary rocks refers to the layered structure formed by the deposition of sediments.



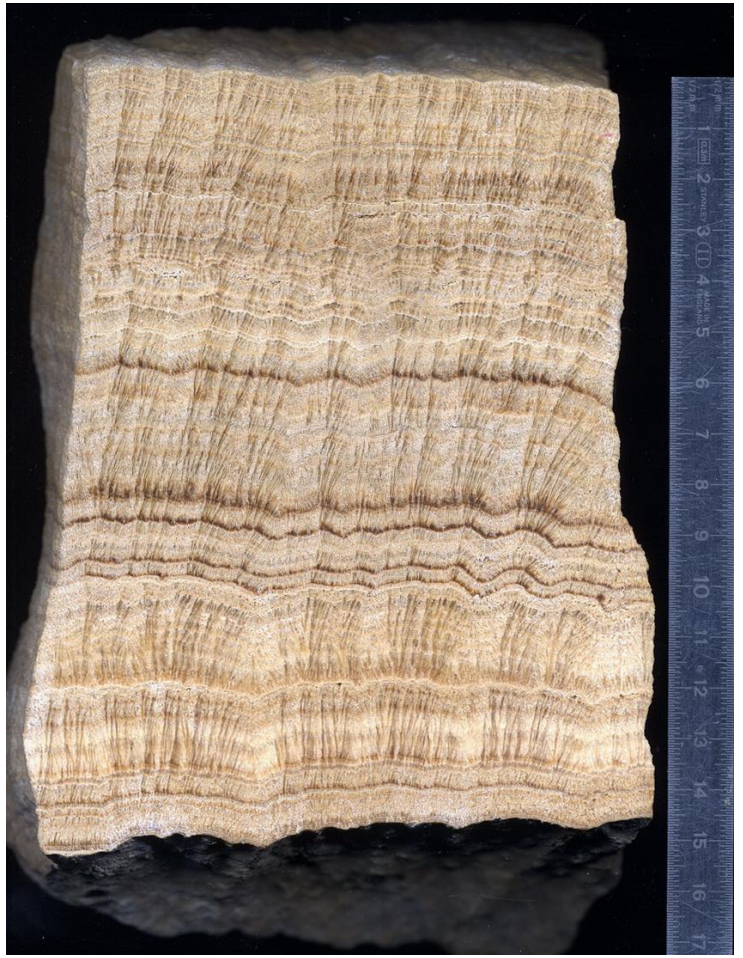
Stratification

- Strata/layers may be similar or dissimilar in color, composition, grain size & texture.
- Bedding planes may separate the strata from each other.
- Thickness of each layer varies from few centimeters to many meters
- In lateral extension it may show continuity for several meters to hundreds of kilometers



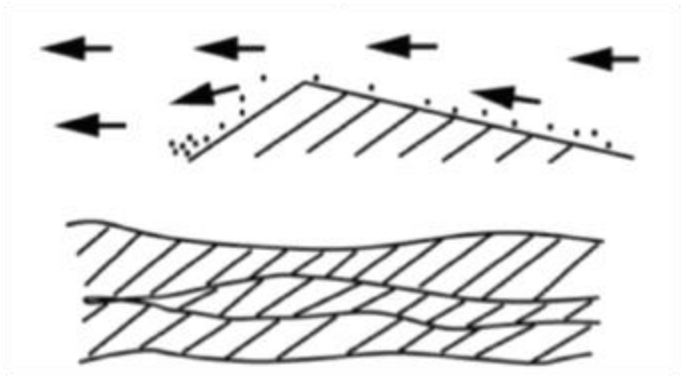
Lamination

- The thin bedding less in thickness are called Lamination. Lamination is found in very fine-grained rocks.
- Individual layers(laminae) are thinner(less than 1 cm)
- Characteristic structure of clays & shales



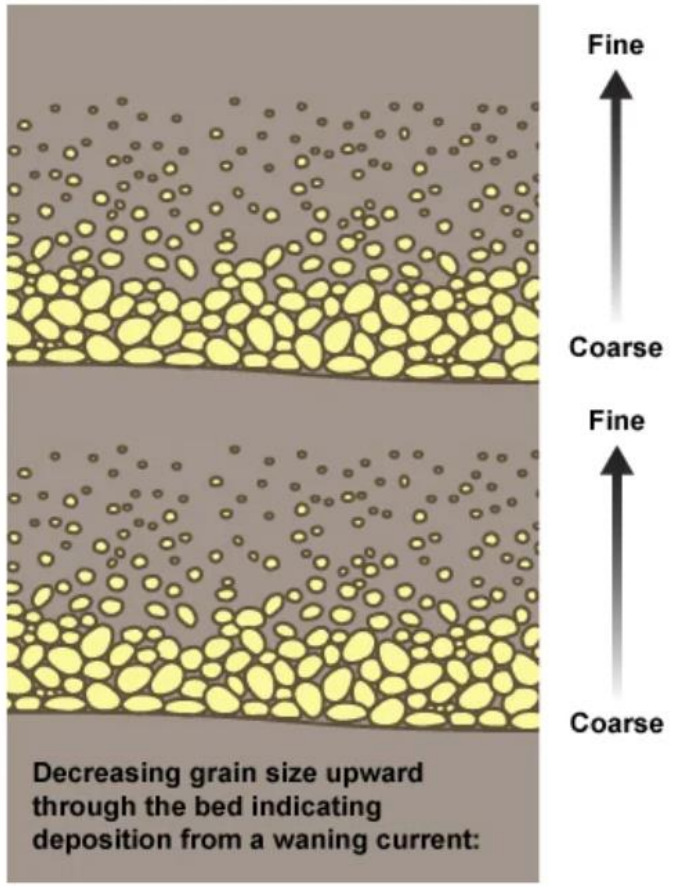
Cross bedding or current bedding

- The cross-bedding displays inclination of the layers to the horizontal.
- Cross beds indicate the presence of currents, such as the flow of a river across a delta or the ebb and flow of strong tidal currents.
- Mounds of sand in shallow water were moved forward, inch by inch, as the sand grains trickled down the frontal incline.



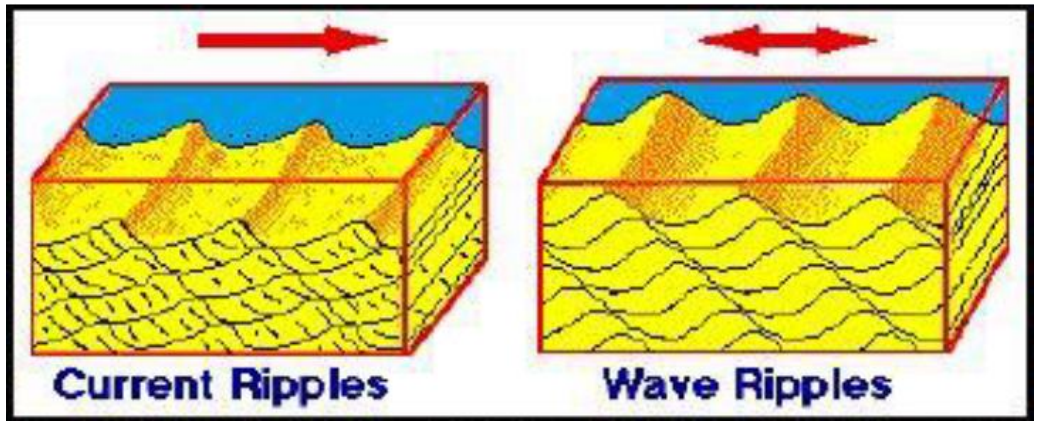
Graded bedding

- Graded bedding is a sedimentary structure characterized by a vertical change in grain size within a single bed, typically showing a transition from coarser sediments at the bottom to finer sediments at the top.
- This structure indicates a lack in the energy of the transporting medium (like water or wind) during deposition.



Ripple Marks

- The surface of some sedimentary deposits shows undulation or ripple marks.
- These are produced by the action of waves and current in shallow water, as well as on the surface due to wind action.



Minor Structure

Some bedding planes shows minor structures such as mud crack, rain prints etc. these are found in fine grained sedimentary rocks.

Mineralogical Composition of Sedimentary Rocks

1. Claystone is a sedimentary rock composed primarily of clay-sized particles, which are minerals that are less than 0.004 millimeters in diameter.

- The main mineral component of claystone is clay minerals, along with varying amounts of quartz, feldspar, and other minerals.
- Geologically, claystone forms through the gradual accumulation and compaction of fine-grained sediment, usually in low-energy environments like river floodplains, lake bottoms, or deep marine settings.

Mudstone

Mineralogical Composition of Sedimentary Rocks

2. Quartz

The mechanical and chemical weathering of an igneous rock sets free individual grains of quartz which produce the detrital forms of silicate that may be precipitated and deposited in the form of quartz as a cementing agent.

- It's a highly durable and chemically resistant mineral, making it a common component of sediments and a key ingredient in many sedimentary rock types.
- Sandstones are a prime example of quartz-rich sedimentary rocks and be found in other sedimentary rocks like shale and siltstone.

Sandstone

Mineralogical Composition of Sedimentary Rocks

2. Calcite

Calcite is a common mineral, primarily composed of calcium carbonate ($CaCO_3$), that is a major component of sedimentary rocks

- It forms through both chemical and biological processes in marine and freshwater environments.
- Limestone is the most common calcite sedimentary rock. Other examples include travertine, chalk, and micrite, which are also varieties of limestone.
- Limestone, is a widely used building material for dimension stone, aggregates, and in the production of cement and concrete.

Limestone

Chemical Composition of Sedimentary Rocks

Components	Clay Type		Quartz	Calcite
	Shale	*Mudstone*	*Sandstone*	*Limestone*
SiO_2	58.38	55.0	78.66	5.19
Al_2O_3	15.47	17.0	4.78	0.81
Fe_2O_3	4.03	4.5	1.08	0.54
MgO	2.45	2.2	1.17	7.90
CaO	3.12	3.0	5.52	42.61
CO_2	2.64	4.2	5.04	41.58
K_2O	3.25	2.8	1.32	0.33
H_2O (total)	~5.0	~4.0	~1.6	~0.8

(Not round to 100%)

Texture of Sedimentary Rocks

Sedimentary textures are the physical characteristics of a sedimentary rock, including the size, shape, and arrangement of its grains. These textures can provide clues about the rock's origin and depositional environment. The 2 main categories are -

Clastic Texture	Non-Clastic texture
• Rocks that have been formed from the deposits of mineral and fragments of other rocks, that have been transported, deposited, then compacted and cemented together. • Shale, sand, conglomerate, siltstone, breccia are few examples of clastic sedimentary rocks.	• Formed when minerals fall out of solution. From evaporation of salt water or from chemical reactions. • Rocks formed either as precipitates or as evaporites of dissolved chemical sediments. • Mineral salts that accumulate in water become concentrated by evaporation until they precipitate from solution.

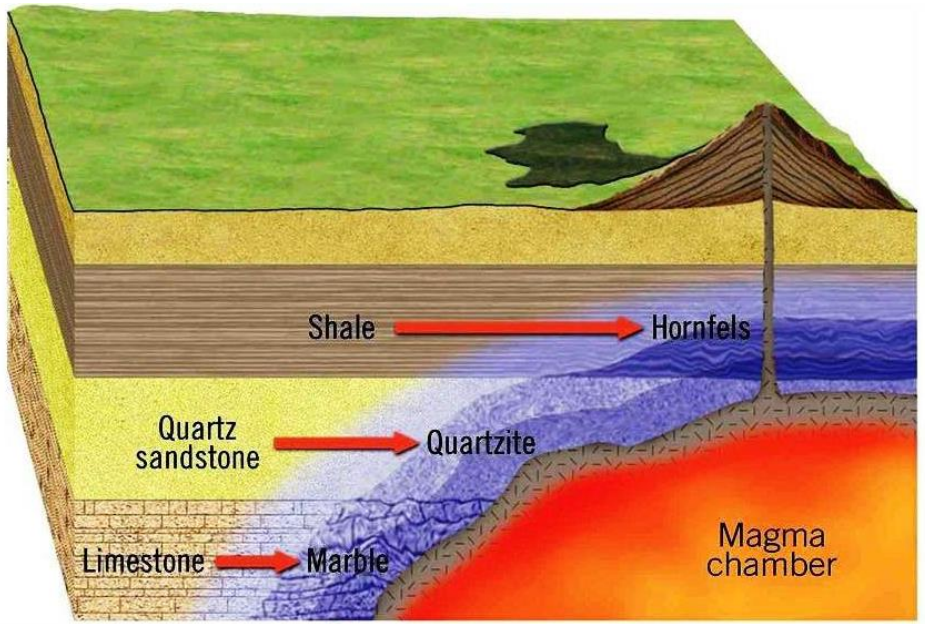
Diagenesis of Sedimentary Rocks

- Diagenesis is the process by which sedimentary rocks are altered after they are deposited, but before they are buried and lithified (turned into rock).
- This process involves physical, chemical, and biological changes that can affect the mineralogy, texture, and other properties of the sedimentary rock.
- Diagenesis can occur at relatively low temperatures and pressures, usually within the upper few kilometers of the Earth's crust.

Metamorphic Rocks

The term "metamorphic" means "to change form."

• Any rock (igneous, sedimentary, or metamorphic) can become a metamorphic rock. If rocks are buried deep in the Earth at high temperatures and pressures, they form new minerals and textures all without melting. If melting occurs, magma is formed, starting the rock cycle all over again.



Key Factors in Metamorphic Rock Formation

- **Heat**: High temperatures can cause minerals to recrystallize and new minerals to form.
- **Pressure**: Increased pressure, both from the weight of overlying rocks and tectonic forces, can cause rocks to deform and align minerals in a specific direction (foliation).
- **Chemically active fluids**: Fluids like water, often heated by magma, can carry dissolved ions that react with the existing rock, altering its chemical composition and forming new minerals.

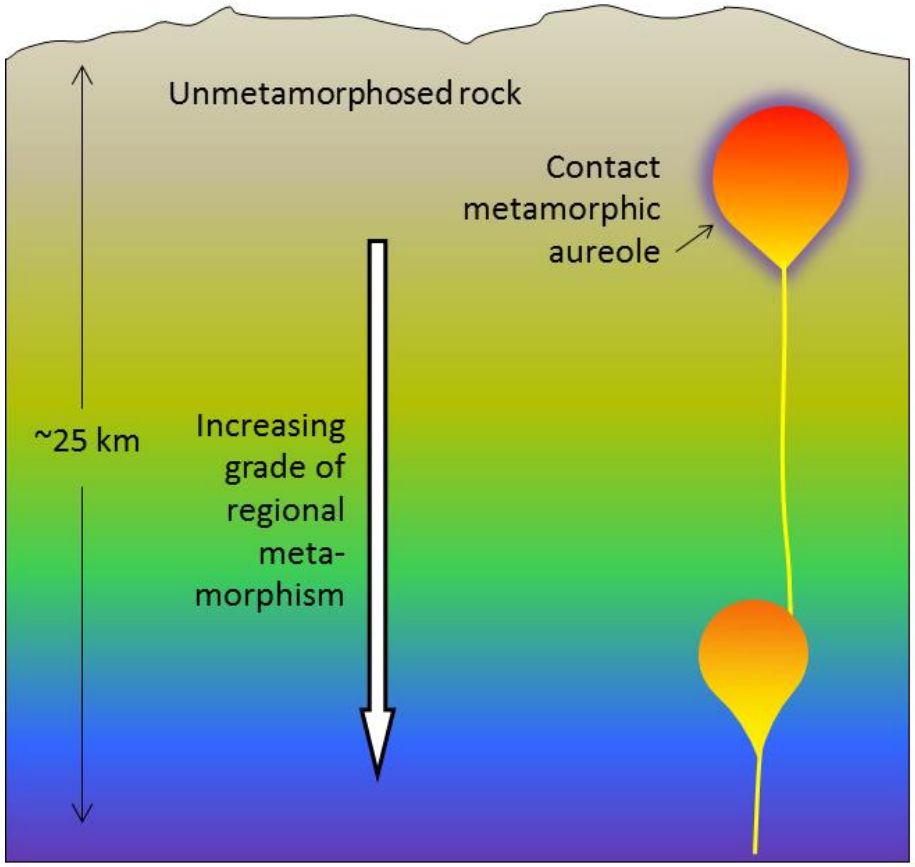
Type of Metamorphism

Depending on the formation process and condition Metamorphism can be divided into 3 class –

1. Contact Metamorphism
2. Regional Metamorphism
3. Dynamic Metamorphism

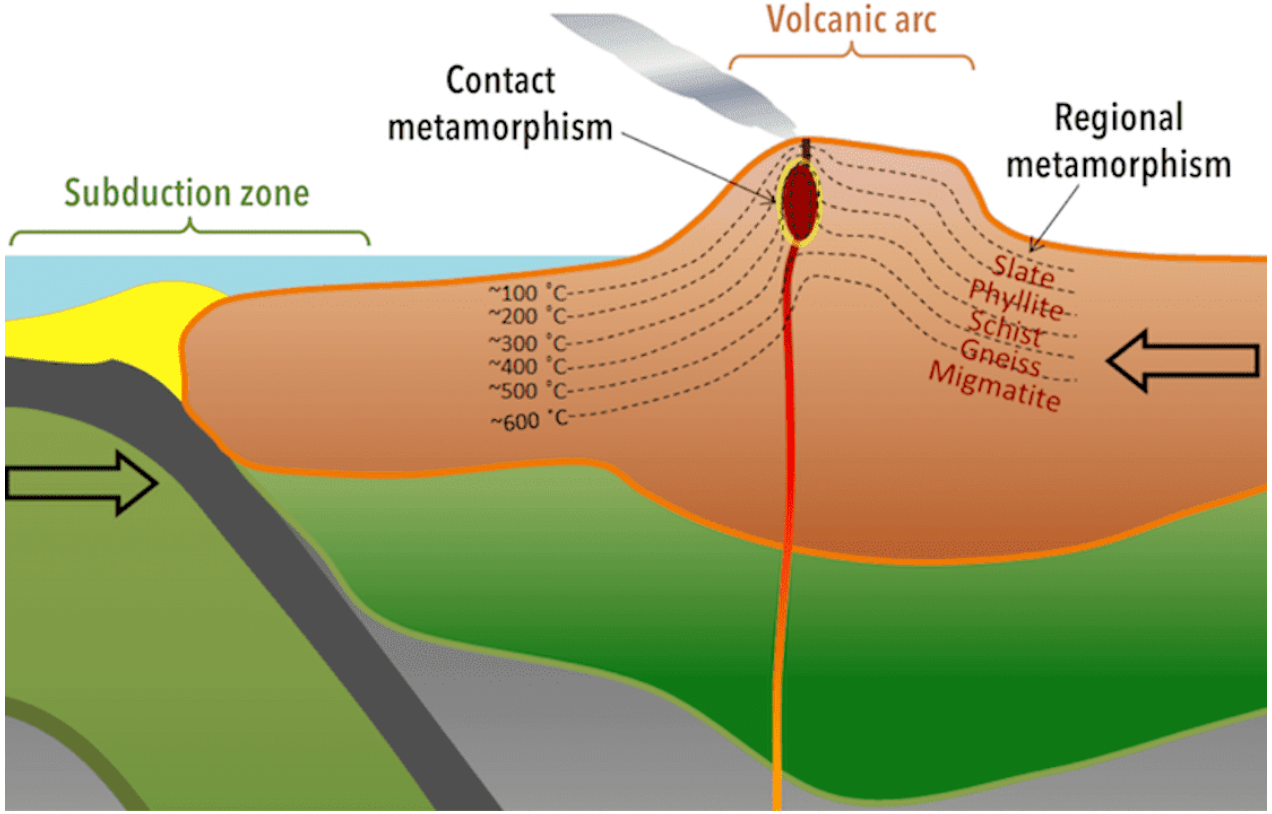
Type of Metamorphism

Contact Metamorphism is a type of metamorphism that occurs when rocks are heated by the intrusion of hot magma. The heat from the magma causes the surrounding rocks to recrystallize and form new minerals.



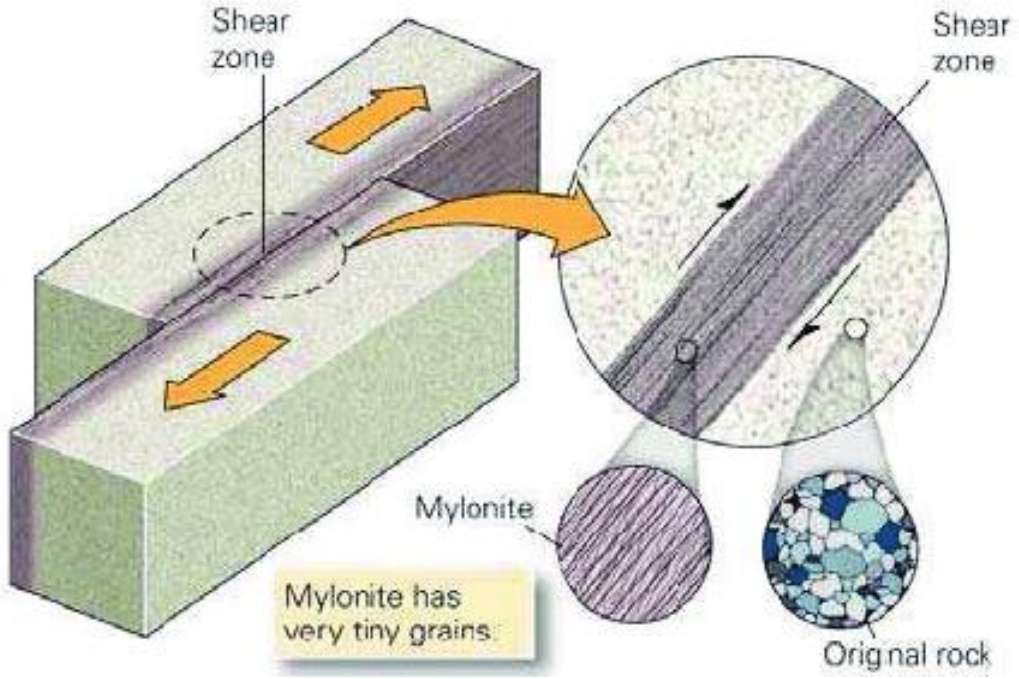
Type of Metamorphism

<u>Regional Metamorphism</u> includes any metamorphic process that occurs over a large region. It is therefore the most widespread and common type of metamorphism.



Type of Metamorphism

Dynamic Metamorphism is a type of metamorphism that occurs primarily due to mechanical deformation of rocks, often under high shear stress conditions like those found along fault zones. It is characterized by the physical change rocks undergo when subjected to stress, rather than significant temperature changes.



Chemical and Mineral Composition Metamorphic Rocks

- Metamorphic rocks inherit much of their composition from the original parent rocks (either igneous or sedimentary), with only minor alterations during metamorphism.
- This inheritance helps geologists use chemical analysis to distinguish between metamorphosed sedimentary and igneous rocks.
- For example, metamorphosed sedimentary rocks often retain the properties of mudstones, sandstones, or grits, while metamorphosed igneous rocks resemble granites or diorites.

Texture of Metamorphic Rocks

- Metamorphic rocks are typically crystalline in texture and may resemble igneous rocks, often referred to as crystalline schists.
- They can display porphyroblastic textures—large minerals (porphyroblasts) embedded in a finer matrix.
- These large crystals are products of metamorphic processes and are sometimes called pseudomorphs, reflecting mineral growth post-original rock formation.

Rock Cycle

The rock cycle is a continuous process that describes how the three main types of rocks (igneous, sedimentary, and metamorphic) are formed, transformed, and recycled over vast periods of time.

These transformations are driven by Earth's internal heat, pressure, and external forces like weathering, erosion, and the movement of tectonic plates.