



# ROCKS AND MINERALS

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# LEARNING OUTCOMES



**By the end of this chapter, you be able to :**

- Explain how igneous, sedimentary and metamorphic rocks are formed, that they are made of minerals and that some minerals are useful.
- Identify the physical properties of rocks and distinguish between the different types of rocks
- Explain the process of weathering and how weathered rock particles from the basis of soil

# WHAT IS THIS?



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# INTRODUCTION



- The earth we live in is made up of rocks. We use the rocks for different purposes such as construction of houses and roads
- **Rocks** are naturally occurring solid aggregates of **minerals, mineraloids, or organic material.**
- They form the Earth's outer solid layer, the lithosphere, and are classified into **three** main types based on their formation processes
- Rocks are composed of various components that determine their characteristics and classification. The **primary components include:**

# COMPONENTS OF ROCKS



**Minerals:** These are naturally occurring, inorganic solids with a **specific chemical composition and crystalline structure**. Common minerals found in rocks include quartz, feldspar, mica, calcite, and olivine.

**Mineraloids:** These are naturally occurring substances that do not have a crystalline structure, distinguishing them from true minerals. Examples include opal and volcanic glass (obsidian).

**Organic Material:** In some sedimentary rocks, organic materials such as **plant debris, shells, and other biological remnants** can be significant components. Coal, for example, is a sedimentary rock composed primarily of plant material.



**Matrix:** This refers to the **finer-grained material in which larger grains, crystals, or clasts are embedded**. In sedimentary rocks, the matrix can consist of finer particles like clay or silt.

**Cement:** In sedimentary rocks, cement is the mineral matter that binds the grains together. Common cementing agents include silica, calcite, and iron oxides.

**Clasts or Grains:** These are the fragments of pre-existing rocks or minerals that are incorporated into a sedimentary rock. Clasts can range in size from clay particles to large boulders.



# TYPES OF ROCKS.



- Rocks are classified into three main types based on their formation processes: **igneous**, **sedimentary**, and **metamorphic**.

## IGNEOUS ROCKS

- Igneous rocks form from **the cooling and solidification of molten rock material** called **magma** (beneath the Earth's surface) or lava (at the surface). These are of 2 types i.e. :
  - **Intrusive (Plutonic) Igneous Rocks:** These form from **magma that cools slowly beneath the Earth's surface**, allowing large crystals to develop. **Example: Granite** – a coarse-grained rock composed mainly of quartz, feldspar, and mica.
  - **Extrusive (Volcanic) Igneous Rocks:** These form from **magma that cools quickly at or near the Earth's surface**, resulting in fine-grained or glassy textures. **Example: Basalt** – a fine-grained rock that is rich in iron and magnesium

**Extrusive igneous rocks cool quickly and as a result these rocks are fine grained or has lack of crystal growth.**

**Intrusive igneous rocks are formed from magma that cools slowly and as a result these rocks are coarse grained.**

**Magma chamber**



# Igneous Rocks Types, Texture, and Composition. By GeologyIn.com

## Extrusive Igneous Rocks

## Intrusive Igneous Rocks

Rhyolite



Lava

Granite



Felsic

Andesite



Diorite



Intermediate

Basalt



Gabbro



Mafic

GeologyIn.com

Magma

Increasing Silica Content

GeologyIn.com

Volcanic Rocks & Aphanitic Texture

GeologyIn.com

Plutonic Rocks & Phaneritic Texture

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# CHARACTERISTICS OF IGNEOUS ROCKS



- **Texture:** Can be coarse-grained (phaneritic), fine-grained (aphanitic), glassy, or porphyritic (large crystals in a fine matrix).
- **Composition:** Typically composed of silicate minerals such as quartz, feldspar, mica, pyroxene, and olivine.
- **Color:** Varies widely; can be light (felsic), intermediate, or dark (mafic) based on mineral content.
- **Formation:** From the cooling and solidification of magma or lava.

# IGNEOUS ROCKS EXAMPLES



**Basalt**



**Obsidian**



**Pumice**



**Rhyolite**



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**Diorite**



**Gabbro**

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**Tuff**



# SEDIMENTARY ROCKS



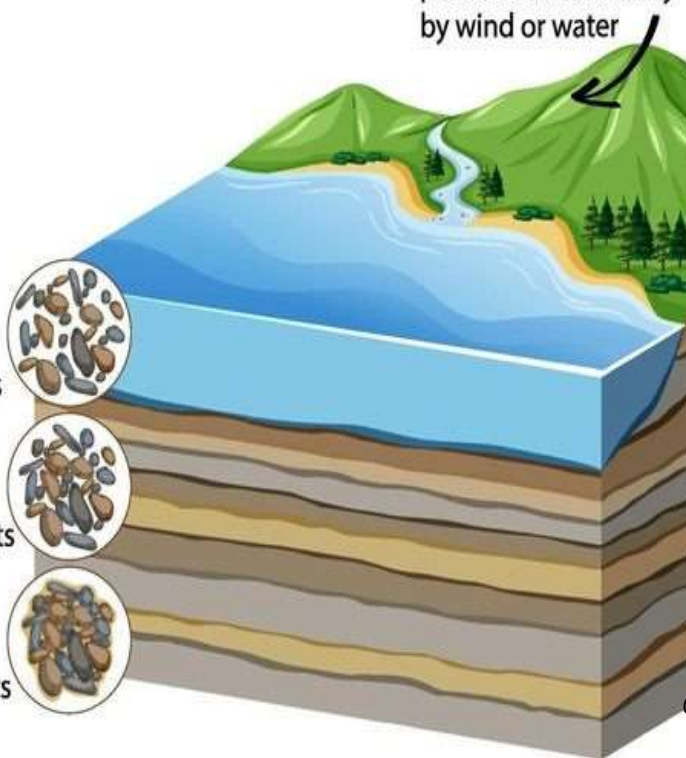
- Sedimentary rocks form from the accumulation and lithification of sediment, which can include fragments of other rocks, minerals, and organic material. The process involves weathering, **transportation**, **deposition**, and **cementation**. These consolidate to form a large hard rock due to pressure of overlying deposits. Materials are eroded and transported by **water**, **ice** and **wind**.
- ✓ **Eroded dissolved minerals are normally deposited at the bottom of water bodies**
- ✓ **Remains of organisms settle at the seabed**
- ✓ **Plant remains that were buried on land become compressed forming layers**
- ✓ **Over along period of time under pressure, these consolidate into a hard rocky mass**

# FORMATION OF SEDIMENTARY ROCKS.



## Formation of Sedimentary Rocks

**Erosion**  
particles carried away  
by wind or water



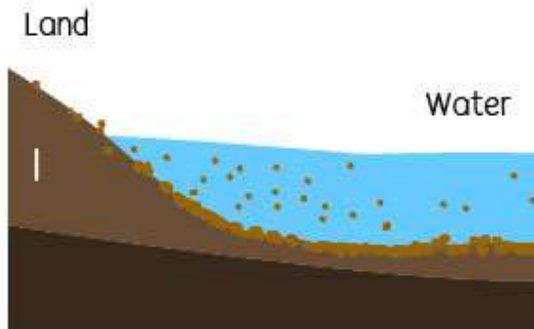
**Deposition**  
loosely packed sediments

**Compaction**  
closely packed sediments

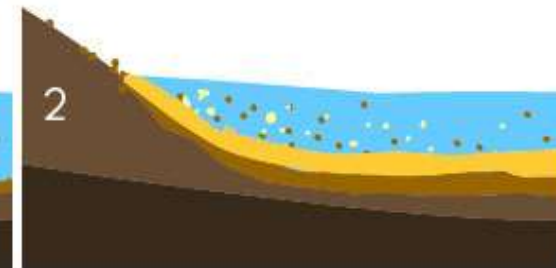
**Cementation**  
tightly packed sediments

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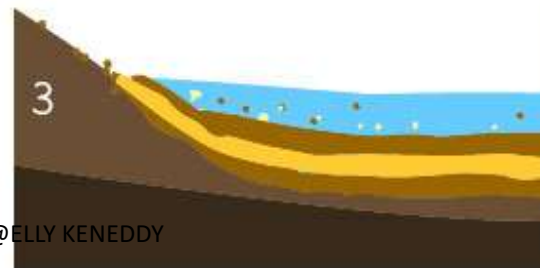
Eroded sediments end up in the water and begin to settle (sedimentation)



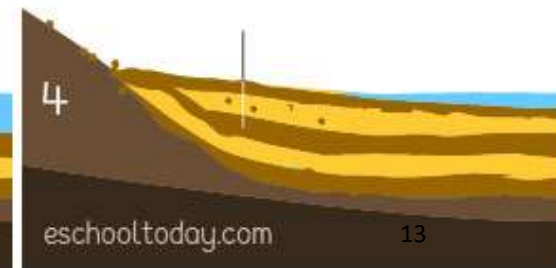
With time, more layers pile up and presses down the lower layers (Compaction)



More layers (strata) and further compaction forces out water from the layers



Salt crystals glue the layers together (cementation)  
Rock mass formed is sedimentary



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# CHARACTERISTICS OF SEDIMENTARY ROCKS



- **Texture:** Can range from coarse-grained (conglomerate) to fine-grained (shale); clastic (fragmental) or non-clastic (chemical or organic).
- **Composition:** Often contains minerals like quartz, calcite, clay minerals, and organic material.
- **Color:** Varies depending on the composition; often includes shades of brown, gray, red, and yellow.
- **Layers:** Typically exhibit distinct layers or strata.
- **Formation:** From the accumulation and lithification of sediment

# CHARACTERISTICS OF SOME SEDIMENTARY ROCKS



Metamorphic rock	Characteristics	Parent rock(s)
Quartzite	<ul style="list-style-type: none"> <li>• It is mostly a white to pale grey rock.</li> <li>• Has a grainy surface with a sandpaper texture.</li> </ul>	Sandstone and quartz
Marble	<ul style="list-style-type: none"> <li>• Made of medium -grained interlocking crystals with no alignment.</li> </ul>	limestone
Slate	<ul style="list-style-type: none"> <li>• Made of fine-grained interlocking crystals that lie flat in the same direction.</li> </ul>	mudstone
Schist	<ul style="list-style-type: none"> <li>• Made of medium-grained interlocking crystals</li> <li>• Has a shiny appearance.</li> </ul>	shale
Gneiss	<ul style="list-style-type: none"> <li>• Made of coarse-grained interlocking crystals.</li> <li>• Has a banded texture.</li> </ul>	granite

# EXAMPLES



## Clastic Sedimentary Rocks By GeologyIn.com

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**Conglomerate**



**Sandstone**



**Shale**



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**Breccia**



**Siltstone**



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**Mudstone**

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# CATEGORIES OF SEDIMENTARY ROCKS



- **Mechanical Sedimentary Rocks:** These form from mechanical weathering debris. Weathered rock material are compacted and compressed to form rocks  
Example: **Sandstone** – composed of sand-sized particles, typically quartz.
- **Chemical Sedimentary Rocks:** These form from the precipitation of dissolved mixed minerals from water at the bottom of water bodies. Formed precipitates accumulate and become compressed to form a rock. **Example: Limestone** – primarily composed of calcite, often formed from the remains of marine organisms.
- **Organic Sedimentary Rocks:** These form from the accumulation of plant or animal debris on land. Over a long time, they are compressed to form a hard rocky mass **Example: Coal** – formed from accumulated plant material, usually in swamp environments.

# METAMORPHIC ROCKS



- Metamorphic rocks form from the alteration of existing rocks (igneous, sedimentary, or other metamorphic rocks) through **high pressure, high temperature, or chemically active fluids**, which cause **changes in mineral composition** and texture without the rock melting.
- **Foliated Metamorphic Rocks:** These have a layered or banded appearance due to the alignment of mineral grains under directed pressure. **Example: Schist** – characterized by its well-developed foliation, often containing mica minerals.
- **Non-foliated Metamorphic Rocks:** These do not exhibit a banded or layered appearance. **Example: Marble** – formed from the metamorphism of limestone, consisting mostly of recrystallized calcite.
- Each type of rock tells a part of the geological history of the Earth, revealing processes such as volcanic activity, sedimentation, and mountain-building events.

# Metamorphic Rocks, Formation and Types

GeologyIn.com

Slate

Phyllite

Schist

Gneiss

Hornfels

Quartzite

Foliated Metamorphic Rocks

Non-foliated Metamorphic Rocks

GeologyIn.com

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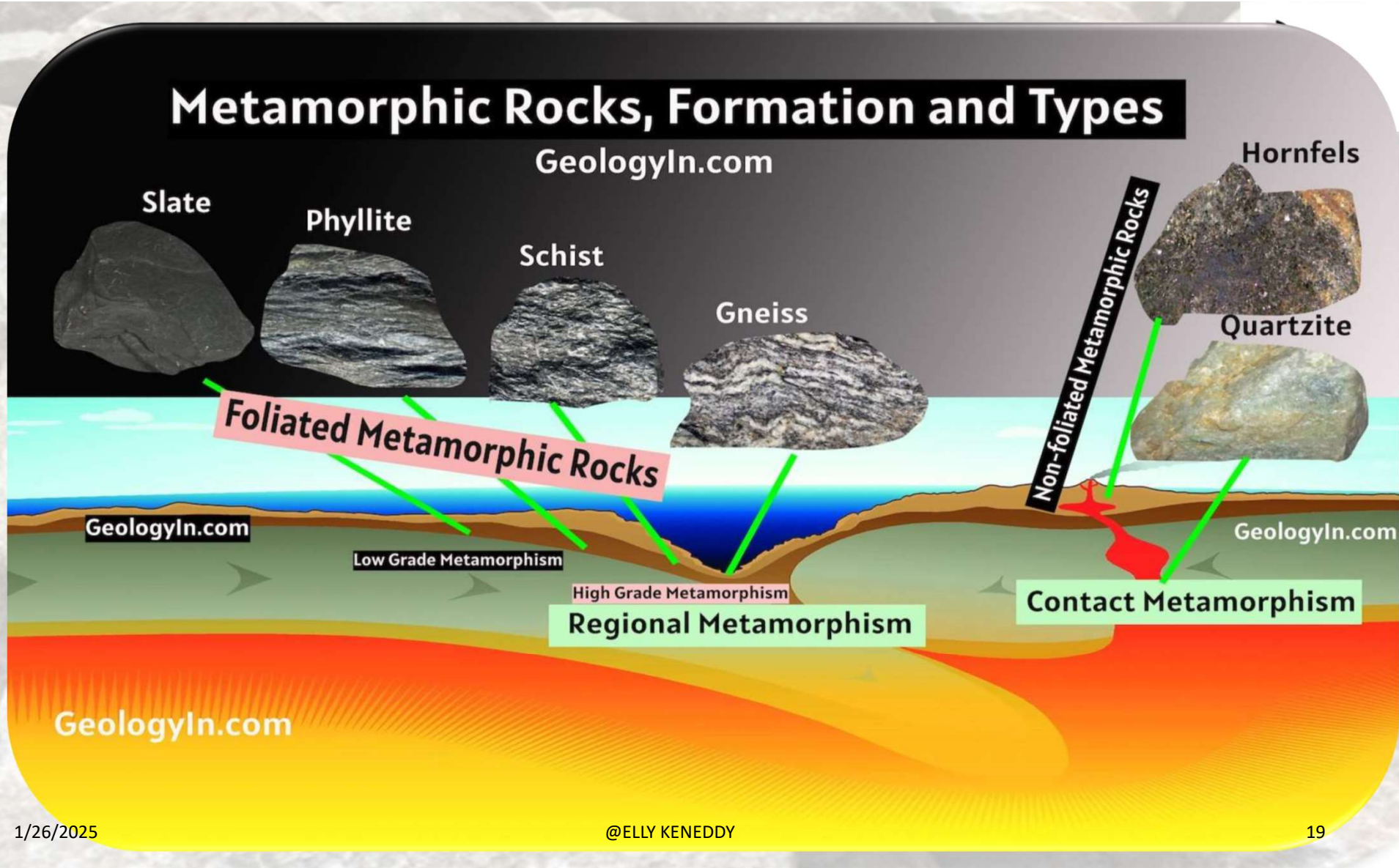
Low Grade Metamorphism

High Grade Metamorphism

Regional Metamorphism

Contact Metamorphism

GeologyIn.com



# Metamorphic Rocks Example



Slate



Phyllite



Schist



Gneiss



Skarn



Novaculite



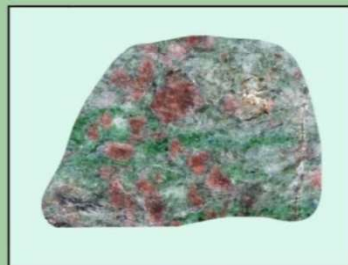
Hornfels



Soapstone



Blue schist



Eclogite



Migmatite



Serpentinite

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# CHARACTERISTICS OF METAMORPHIC ROCKS



- **Texture:** Can be foliated (with a layered or banded appearance) or non-foliated (without a distinct layering).
- **Mineral Composition:** Often features new minerals formed under high pressure and temperature, such as garnet, kyanite, and staurolite.
- **Color:** Varies widely, often influenced by the original rock and the minerals formed during metamorphism.
- **Hardness and Density:** Typically, harder and denser than their precursor rocks.
- **Formation:** From the alteration of existing rocks under high pressure, high temperature, or chemically active fluid

# MINERALS



Minerals are naturally occurring solids with a definite chemical composition and crystal structure.

Minerals that are original components of rocks are called **primary minerals**. (**feldspar, mica, etc.**).

Minerals that are formed from changes in primary minerals and rocks are called **secondary minerals** (**clay minerals**).

Those minerals that are chief constituents of rocks are called as **essential minerals** (**Feldspars, pyroxenes micas etc**) and those which are present in small quantities, whose presence or absence will not alter the properties of rocks are called **accessory minerals** (**tourmaline, magnetite**)

# EXAMPLES OF MINERALS AND THEIR USES.



Mineral	Uses
Quartz	<ul style="list-style-type: none"><li>• Sand that has quartz pebbles is used to manufacture glass.</li><li>• Used to make silicon semi-conductors in computers.</li></ul>
Feldspar	<ul style="list-style-type: none"><li>• Used in glassmaking and ceramics.</li><li>• Used as a filler and extender in paints, Plastics and rubber.</li></ul>
Mica	<ul style="list-style-type: none"><li>• Used in making toothpastes and ceramics.</li><li>• Used as an insulator in various electronics.</li></ul>
Muscovite	<ul style="list-style-type: none"><li>• Used as glass due to its transparent nature.</li><li>• In manufacture of fireproofing and insulating materials.</li></ul>
Calcium carbonate	<ul style="list-style-type: none"><li>• Used as a food supplement as it is a source of calcium in the body. Calcium is required for strong bones and teeth.</li><li>• Used to make antacid tablets.</li></ul>



**Beryl**



**Cassiterite  
(Tin ore)**



**Cassiterite**



**Citrine**



**Cuprite**



**Cuprite**



**Goethite**



**Hematite  
(Kidney ore)**



**Hematite  
(Iron ore)**



**Hematite**



**Howlite**



**Jaspillite**



**Peridotite with  
Phlogopite**



**Prasiolite**



**Pyrite**



**Sodalite**



**Black Tourmaline  
(Schorl)**



**Turquoise**

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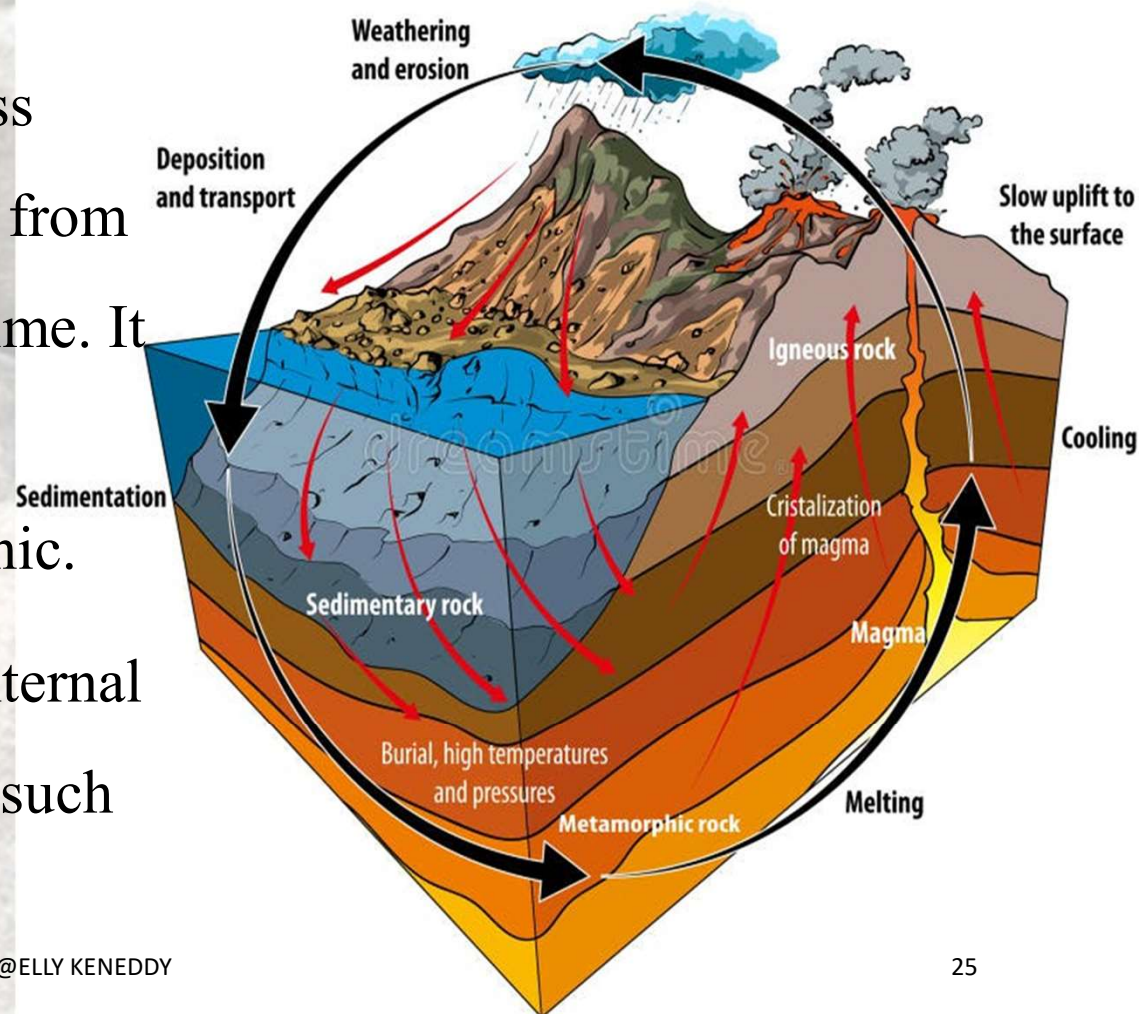
# ROCK CYCLE.

- The rock cycle is a continuous process through which rocks are transformed from one type to another over geological time. It includes three main types of rocks: igneous, sedimentary, and metamorphic.
- The rock cycle is driven by Earth's internal heat, pressure, and surface processes such as weathering and erosion.

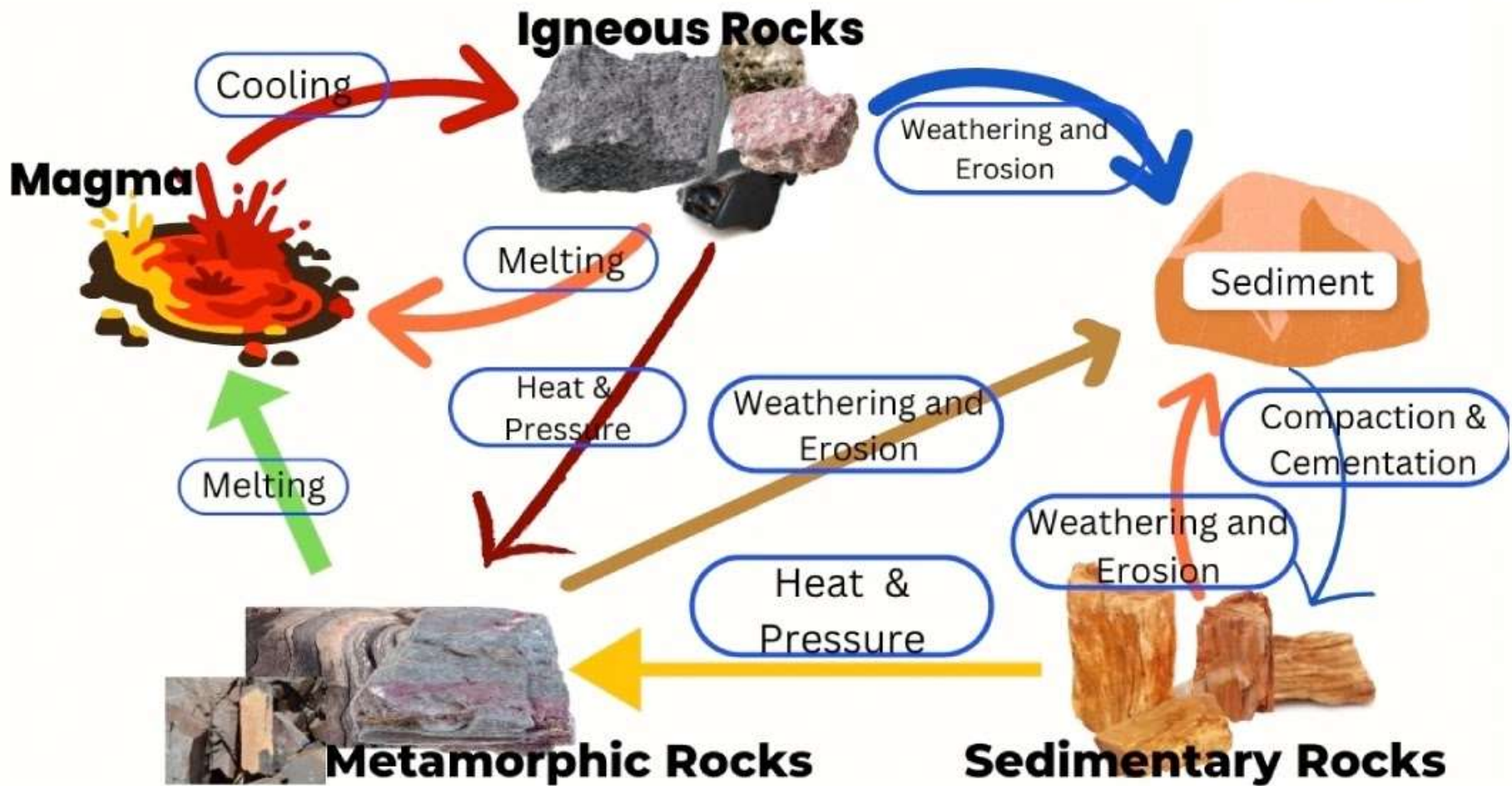
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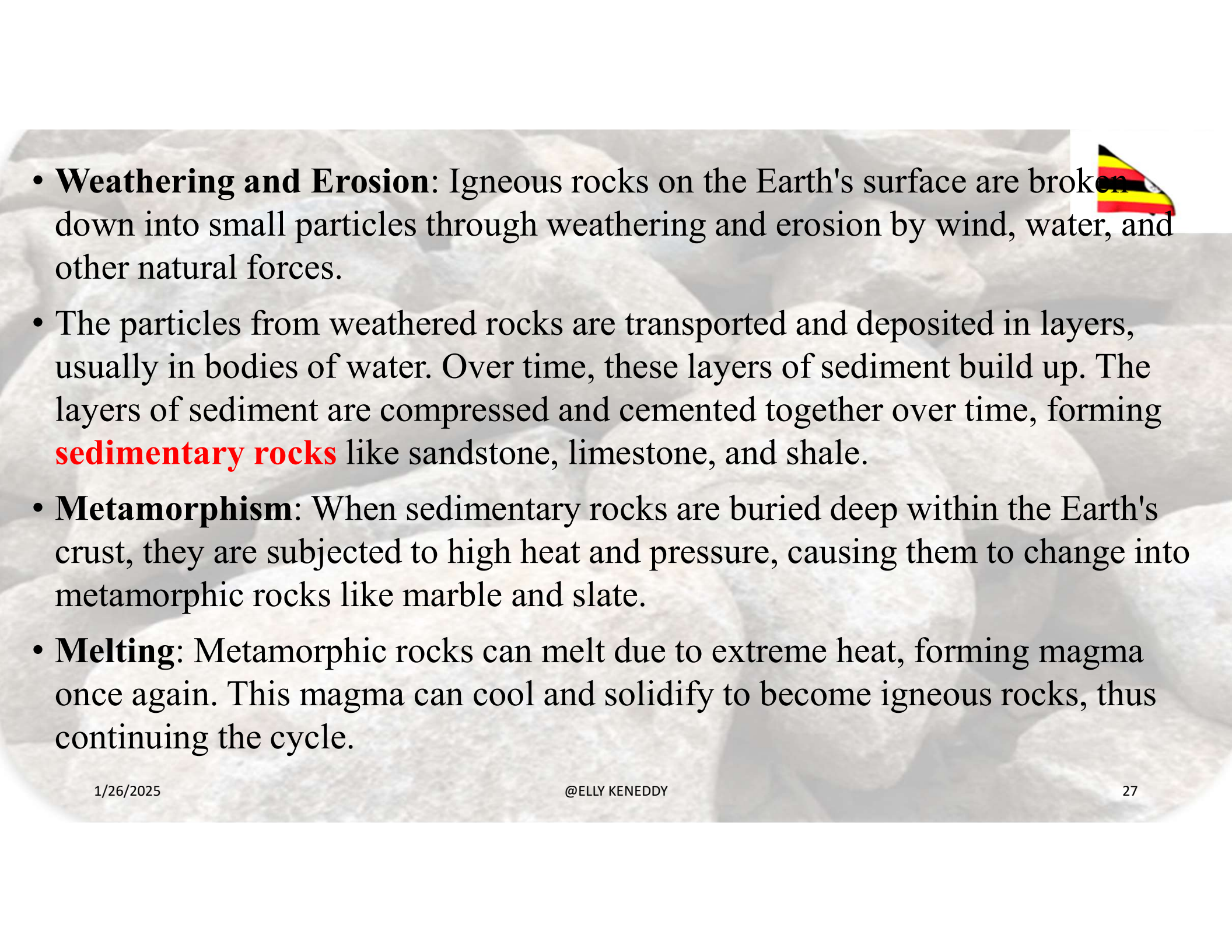
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## THE ROCK CYCLE



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- **Weathering and Erosion:** Igneous rocks on the Earth's surface are broken down into small particles through weathering and erosion by wind, water, and other natural forces.
  - The particles from weathered rocks are transported and deposited in layers, usually in bodies of water. Over time, these layers of sediment build up. The layers of sediment are compressed and cemented together over time, forming **sedimentary rocks** like sandstone, limestone, and shale.
  - **Metamorphism:** When sedimentary rocks are buried deep within the Earth's crust, they are subjected to high heat and pressure, causing them to change into metamorphic rocks like marble and slate.
  - **Melting:** Metamorphic rocks can melt due to extreme heat, forming magma once again. This magma can cool and solidify to become igneous rocks, thus continuing the cycle.

# WEATHERING

- Weathering refers to the disintegration of rocks into small particles. Weathering is important because it results into formation of soil



# PHYSICAL WEATHERING



- The rocks are disintegrated and are broken down to comparatively smaller pieces, without producing any new substances

## Physical condition of rocks

- **Mechanical** weathering breaks down rocks because of environmental factors that include **heat, cold, water** and **wind**. One form of mechanical weathering is constant freezing of water.
- **Freezing of water**
- Water, in liquid form, penetrates joints and holes within a rock. It starts freezing as temperatures drop to 32 degrees fahrenheit and below. As the water freezes, **it expands** and becomes about 10 percent larger. **This expansion pushes the cracks and holes in rocks outward causing the rock to break**



## **Alternate wetting and Drying**

During dry summer/ dry weather – these clays shrink considerably forming deep cracks or wide cracks. On subsequent wetting, it swells.

This alternate swelling and shrinking/ wetting or drying of clay enriched rocks make them loose and eventually breaks

## **Action of glaciers**

In cold regions, when snow falls, it accumulates and change into a ice sheet.

These big glaciers start moving owing to the change in temperature and/or gradient.

On moving, these exert tremendous pressure over the rock on which they pass and carry the loose materials

## **Action of wind**

Wind has an erosive and transporting effect. Often when the wind is laden with fine material e.g , fine sand, silt or clay particles, it has a serious abrasive effect and the sand laden winds 'itch' the rocks and ultimately breaks down under its forc

# CHEMICAL WEATHERING.



Decomposition of rocks and minerals by various chemical processes is called **chemical weathering**. It is the most important process for soil formation.

- Chemical weathering takes place mainly at the surface of rocks and minerals with disappearance of certain minerals and the formation of secondary products (new materials).
- Chemical weathering becomes more effective as the surface area of the rock increases.
- Since the chemical reactions occur largely on the surface of the rocks, therefore the smaller the fragments, the greater the surface area per unit volume available for reaction

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seeds collect in cracks



seed develop into a plant



eventually the plant becomes a tree and exert pressure on rock





## Carbonation

- Carbon dioxide when dissolved in water it forms carbonic acid. This carbonic acid attacks many rocks and minerals and brings them into solution.
- The carbonated water has an etching effect up on some rocks, especially limestone. The removal of cement that holds sand particles together leads to their disintegration

## Oxidation

- The process of addition and combination of oxygen to minerals. The absorption is usually from O dissolved in soil water and that present in atmosphere.
- The oxidation is more active.the presence of moisture and results in hydrated oxides. (e.g) minerals containing Fe and Mg.

## Hydration

- Chemical combination of water molecules with a particular substance or mineral leading to a change in structure. Soil forming minerals in rocks do not contain any water and they undergo hydration when exposed to humid conditions.
- Upon hydration there is swelling and increase in volume of minerals. The minerals lose their luster and become soft hence breaking down.

## Biological Weathering

- Unlike physical and chemical weathering, the biological or living agents are responsible for both decomposition and disintegration of rocks and minerals. The biological life is mainly controlled largely by the prevailing environment.





**ALWAYS AIM FOR THE BEST  
THANKS FOR ATTENDING**

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