MSc-S2-16P2EVST05-EARTH AND ATMOSPHERE

Topic- Classification of rocks

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Rock

- **Rock** or **stone** is a natural substance, a solid aggregate of one or more minerals or mineraloids.
- For example, granite, a common rock, is a combination of the minerals quartz, feldspar and biotite.
- The Earth's outer solid layer, the lithosphere, is made of rock.
- Rock has been used by mankind throughout history.
- The minerals and metals found in rocks have been essential to human civilization.
- Three major groups of rocks are defined: igneous, sedimentary, and metamorphic.
- The scientific study of rocks is called petrology, which is an essential component of geology.

- At a granular level, rocks are composed of grains of minerals, which, in turn, are homogeneous solids formed from a chemical compound that is arranged in an orderly manner.

- The aggregate minerals forming the rock are held together by chemical bonds.

- The types and abundance of minerals in a rock are determined by the manner in which the rock was formed.

- Many rocks contain silica (SiO_2); a compound of silicon and oxygen that forms 74.3% of the Earth's crust. This material forms crystals with other compounds in the rock.

- The proportion of silica in rocks and minerals is a major factor in determining their name and properties.

- Rocks are geologically classified according to characteristics such as
  - mineral and chemical composition,
  - permeability,
  - the texture of the constituent particles
  - and particle size.

- These physical properties are the end result of the processes that formed the rocks.

- Over the course of time, rocks can transform from one type into another, as described by the geological model called the rock cycle.

- These events produce three general classes of rock: igneous, sedimentary, and metamorphic.

Igneous rock

- Igneous rock (derived from the Latin word *igneus* meaning of fire) forms through the cooling and solidification of magma or lava.
- This magma can be derived from partial melts of pre-existing rocks in either planet’s mantle or crust.
- Typically, the melting of rocks is caused by one or more of three processes:
  - an increase in temperature,
  - a decrease in pressure,
  - or a change in composition.
- Igneous rocks are divided into two main categories
- : plutonic rock and volcanic.

- Plutonic or intrusive rocks result when magma cools and crystallizes slowly within the Earth's crust. A common example of this type is granite.

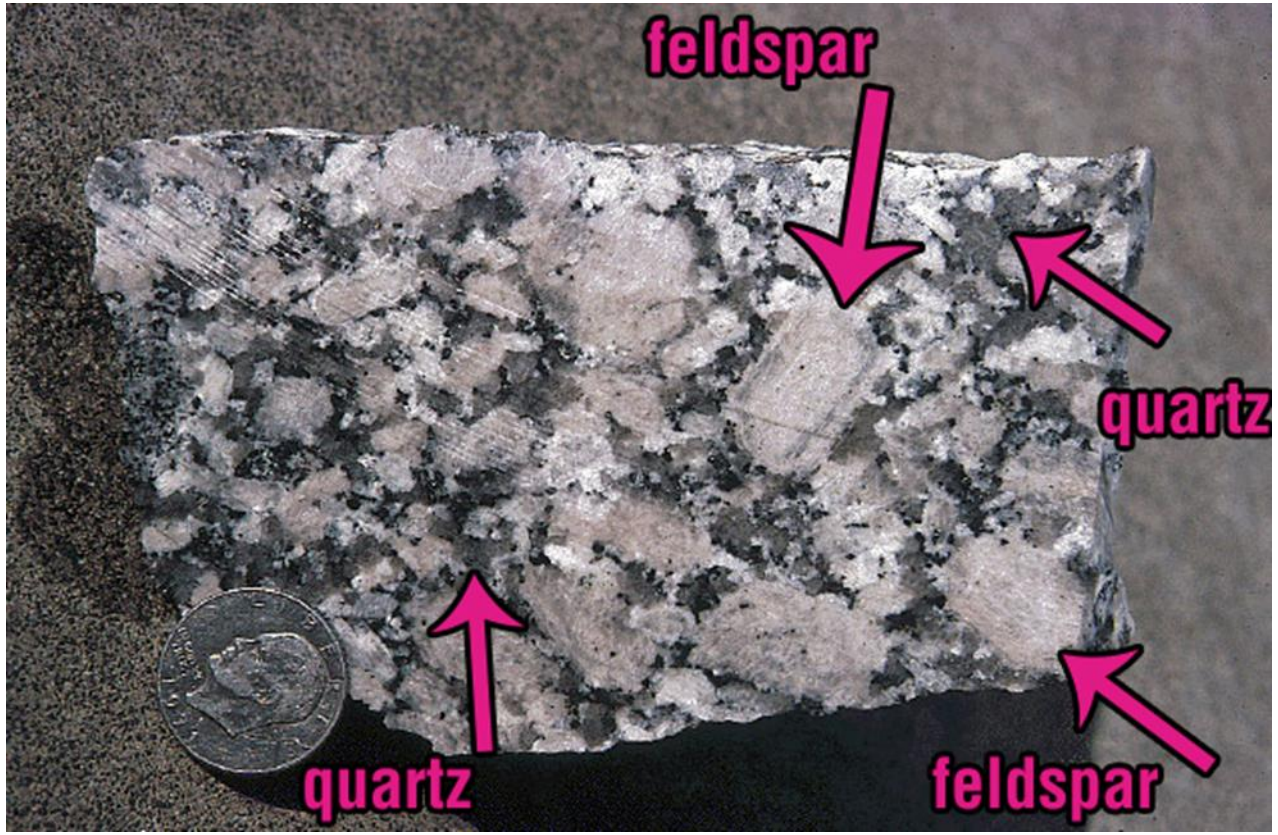
- Volcanic or extrusive rocks result from magma reaching the surface either as lava, forming minerals such as pumice or basalt.

Lava flow on Hawaii. Lava is the extrusive equivalent of magma.

Magma is the heart of any igneous rock. Magma is composed of a mixture of molten or semi-molten rock, along with gases and other volatile elements. As you go deeper underground, the temperature rises; go further and you'll eventually reach the Earth's mantle — a huge layer of magma surrounding the Earth's core

Some important igneous rocks from left to right: gabbro, andesite, pegmatite, basalt, pumice, porphyry, obsidian, granite, and tuff.

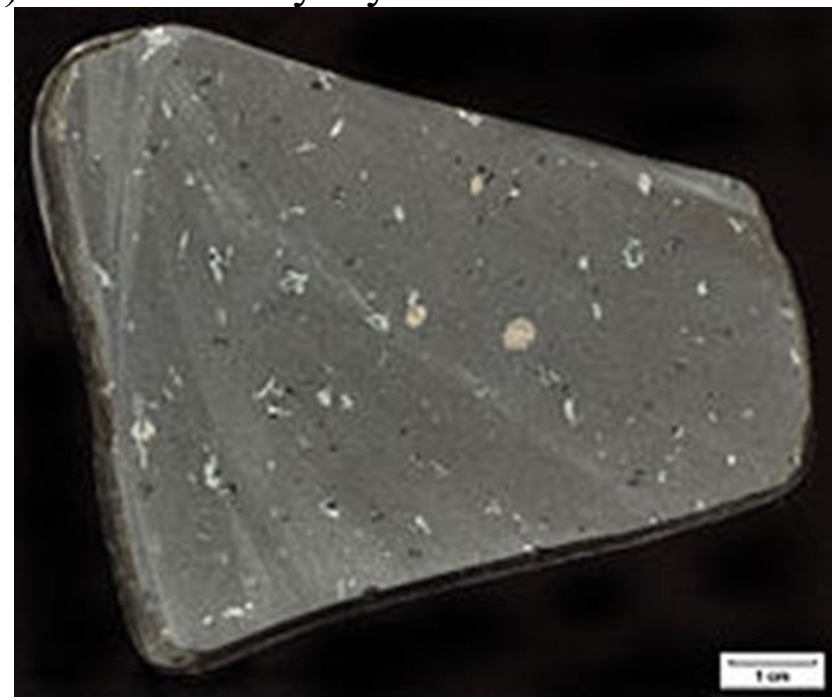
- As you probably know, when magma cools, it turns into rock; if it cools while still underground at high temperatures (but at temperatures still lower than that of the magma), the cooling process will be slow, giving crystals time to develop.
- That’s why you see rocks such as granite with big crystals — the magma had time to cool off. The crystals are also differentiated, as you can see below.



Note the white, almost rectangular feldspar crystals, the grey virtually shapeless quartz crystals, and the black crystals, which can be either black mica or amphibole

Granite containing potassium feldspar, plagioclase feldspar, quartz, and biotite and/or amphibole

- However, if the magma erupts or is cooled rapidly, you instead get a volcanic rock —
- The classical example here is basalt, which can have many small crystals or very few large ones. Volcanic rocks are also called extrusive igneous rocks, as opposed to intrusive igneous rocks. Some volcanic rocks (like obsidian) don’t have any crystals at all.



- Sample of basalt (an extrusive igneous rock), found in Massachusetts

- There are over 700 hundred types of igneous rocks, and they are generally the hardest and heaviest of all rocks.
- However, volcanic rocks can be incredibly lightweight — pumice, for example, can even float, and was called by ancient sailors “the foam of the sea”.
- Pumice is created when a volcano violently erupts, creating pockets of air in the rock.

Specimen of highly porous pumice from Teide volcano on Tenerife, Canary Islands.

The most common types of igneous rocks are:

- andesite
- basalt
- dacite
- dolerite (also called diabase)
- gabbro
- diorite
- peridotite
- nepheline
- obsidian
- scoria
- tuff
- volcanic bomb

Sedimentary Rocks

- Sedimentary rocks are named as such because they were once sediment.
- Sediment is a naturally occurring material that is broken down by the processes of weathering and erosion and is subsequently naturally transported (or not).
- Sedimentary rocks form through the deposition of material at the Earth's surface and within bodies of water.

A conglomerate — a rock made from cemented gravel.

- Sedimentary rocks are quite difficult to classify, as they have several different defining qualities (the chemical make-up, the sedimentation process, organic/inorganic material), but the most common classification is the following:

- **Clastic sedimentary rocks** — small rock fragments (many silicates) that were transported and deposited by fluids (water, bed flows).
- These rocks are further classified by the size and composition of the clastic crystals included in the sedimentary rocks (most often quartz, feldspar, mica and clay).
- **Conglomerates (and breccias)** — conglomerates are predominantly composed of rounded gravel, while breccias are composed of angular (sharper) gravel.
- **Sandstones** — as the name says, it’s a rock made from many-sand-sized minerals and rock grains. The most dominant mineral in sandstone is quartz because it is the most common mineral in the Earth’s surface crust.

An old, red sandstone.

- **Mudrocks**— they’re rocks made from solidified mud.
- They typically contain very fine particles and are transported as suspended particles by turbulent flow in water or air, depositing once the flow settles.
- **Biochemical rocks** — you’ll probably be surprised to find out that most limestone on the face of the Earth comes from biological sources. In other words, most limestone you see today comes from the skeletons of organisms such as corals, mollusks, and foraminifera. Coal is another example of biochemical rock.
- **Chemical rocks** — these rocks include gypsum and salt (halite) and are formed mostly through water evaporation

Yes, salt is a mineral — and it can be quite beautiful. In this context, it’s called halite and can be classified as a sedimentary rock

- This entire mountain in Romania was formed based on a coral reef.

Some common sedimentary rocks are:

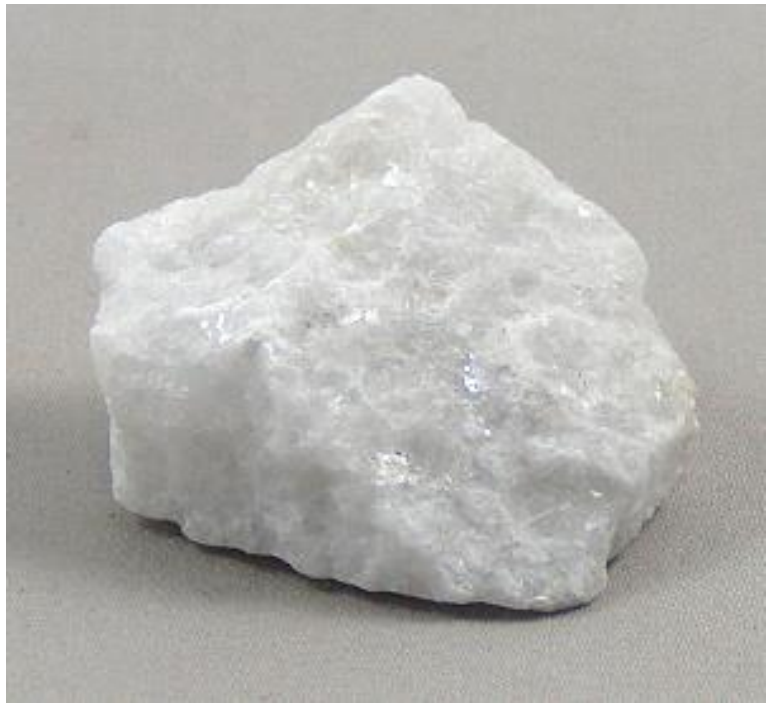
- argillite
- breccia
- chalk
- chert
- claystone
- coal
- conglomerate
- dolomite
- limestone
- gypsum
- greywacke
- mudstone
- shale
- siltstone
- turbidite

Metamorphic rocks

- Metamorphic rocks are formed by subjecting any rock type—sedimentary rock, igneous rock or another older metamorphic rock—to different temperature and pressure conditions than those in which the original rock was formed.
- This process is called metamorphism; meaning to "change in form".
- The result is a profound change in physical properties and chemistry of the stone.
- The original rock, known as the protolith, transforms into other mineral types or other forms of the same minerals, by recrystallization.

- Equally as significant are changes in the chemical environment that result in two metamorphic processes:
- Mechanical dislocation (the rock or some minerals are physically altered)
- Chemical recrystallization (when the temperature and pressure changes, some crystals aren't stable, causing them to change into other crystals).

Folded foliation in a metamorphic rock



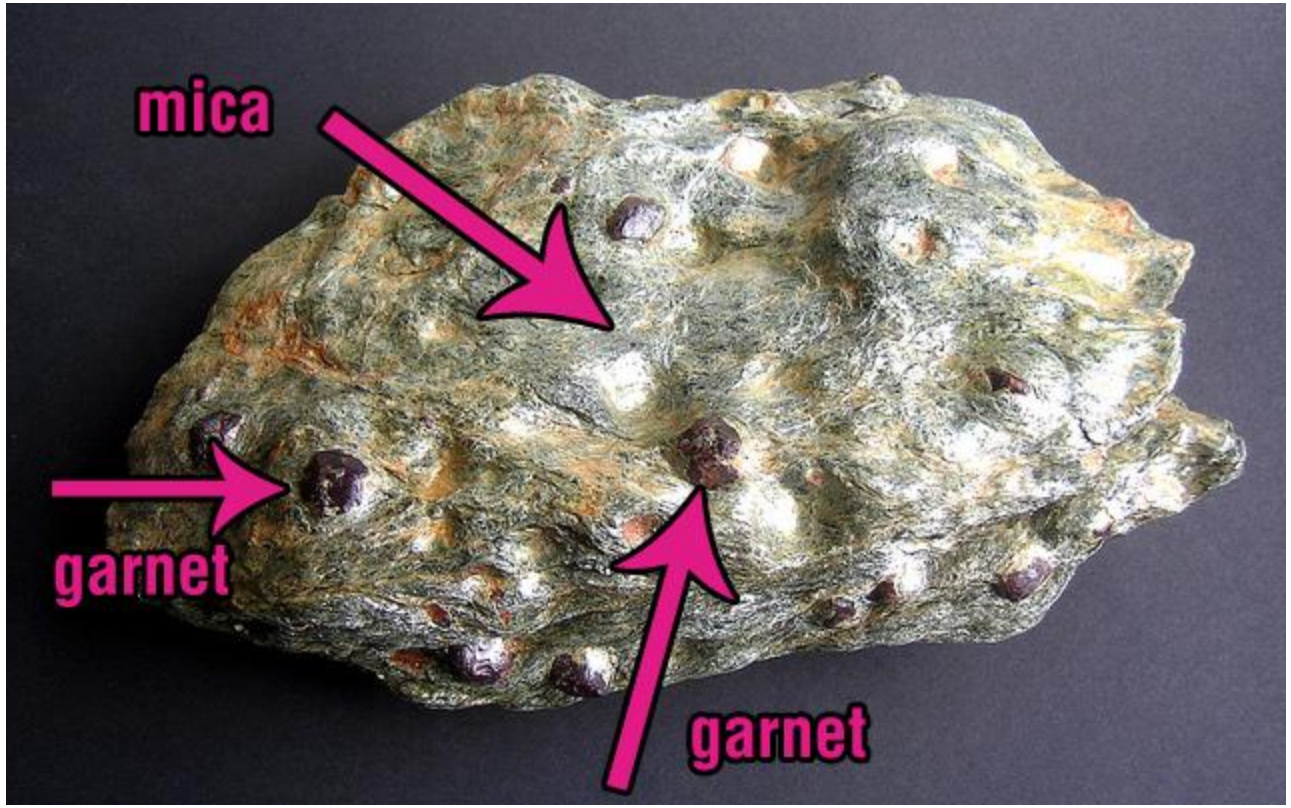
Marble is a non-foliated metamorphic rock.

- Foliated metamorphic rocks — pressure squeezes or elongates the crystals, resulting in a clear preferential alignment.
- Non-foliated metamorphic rocks — the crystals have no preferential alignment. Some rocks, such as limestone, are made of minerals that simply don’t elongate, no matter how much stress you apply.

- Metamorphic rocks can form in different conditions, in different temperatures (up to 200 °C) and pressures (up to 1500 bars).
- By being buried deep enough for a long enough time, a rock will become metamorphic.
- They can form from
- tectonic processes such as continental collisions, which cause horizontal pressure, friction and distortion;
- they can also form when the rock is heated up by the intrusion of magma from the Earth’s interior.

The most common metamorphic rocks are:

- amphibolite
- schist (blueschist, greenschist, micaschist, etc)
- eclogite
- gneiss
- hornfels
- marble
- migmatite
- phyllite
- quartzite
- serpentinite
- slate



A micaschist. The dark brown rounded minerals are garnet, and everything you see with a whiteish tint is the mica. The reddish areas are rusty mica.

Metamorphic banded gneiss

Some examples of Metamorphosis

Igneous or Sedimentary rock	**Influence**	**Metamorphosed rock**
Granite	Pressure	Gneiss
Clay, Shale	Pressure	Schist
Sandstone	Heat	Quartzite
Clay, Shale	Heat	Slate ==> Phyllite
Coal	Heat	Anthracite ==> Graphite
Limestone	Heat	Marble

COLLECTION OF METAMORPHIC ROCKS

Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form".

1  ANTHRESITE	2  GNIESS	3  KHONDALITE	4  MARBLE BLACK	5  MARBLE GREEN
6  MARBLE PINK	7  MARBLE WHITE	8  PEGMATITE MICA	9  PHYLITE	10  QUARTIZITE GRAY
11  QUARTIZITE GREEN	12  QUARTIZITE WHITE	13  SERPENTINE	14  SLATE	15  TIGER EYE

Metamorphic Rocks in India

- The gneisses and schists are commonly found in the Himalayas, Assam, West Bengal, Bihar, Orissa, Madhya Pradesh and Rajasthan.

- Quartzite is a hard rock found over Rajasthan, Bihar, Madhya Pradesh, Tamil Nadu and areas surrounding Delhi.

- Marble occurs near Alwar, Ajmer, Jaipur, Jodhpur in Rajasthan and parts of Narmada Valley in Madhya Pradesh.

- Slate, which is used as a roofing material and for writing in schools, is found over Rewari (Haryana), Kangra (Himachal Pradesh) and parts of Bihar.

- Graphite is found in Orissa and Andhra Pradesh.

Rock cycle

- Rock cycle is a continuous process through which old rocks are transformed into new ones.
- Igneous rocks are primary rocks and other rocks form from these rocks.
- Igneous rocks can be changed into sedimentary or metamorphic rocks.
- The fragments derived out of igneous and metamorphic rocks form into sedimentary rocks.
- Sedimentary and igneous rocks themselves can turn into metamorphic rocks
- The crustal rocks (igneous, metamorphic and sedimentary) may be carried down into the mantle (interior of the earth) through subduction process and the same melt down and turn into molten magma, the original source for igneous rocks.