Physical and other properties of minerals

UNIT 2
Physical Properties of Minerals

* Minerals have definite crystalline structures and chemical compositions that give them unique sets of physical and chemical properties shared by all samples of that mineral.

* For example, all specimens of halite have the same hardness, the same density, and break in a similar manner.

* Because a mineral’s internal structure and chemical composition are difficult to determine without the aid of sophisticated tests and equipment, the more easily recognized physical properties are frequently used in identification.

* Physical properties of the minerals in hand specimen can be broadly divided into 3 categories: 1) **Optical properties** 2) **Crystal shape/habit** and 3) **Mineral strength**
Physical Properties of Minerals

Optical Properties
- Luster - the appearance or quality of light reflected from the surface of a mineral
  - When no light is transmitted, the mineral is described as opaque
  - When light but not an image is transmitted through a mineral it is said to be translucent
- The Ability to Transmit Light - another optical property used in the identification of minerals is the ability to transmit light
  - When light and an image are visible through the sample, the mineral is described as transparent
- Although color is generally the most conspicuous characteristic of any mineral, it is considered a diagnostic property of only a few minerals

Crystal Shape of Habit
- Mineralogist use the term habit to refer to the common or characteristic shape of crystal or aggregate of crystals

Mineral Strength
- Tenacity, describes a mineral's toughness, or its resistance to breaking or deforming
- Hardness, one of the most useful diagnostic properties, a measure of the resistance of mineral to abrasion or scratching
- Cleavage, some minerals have atomic structures that are not the same in every direction and chemical bonds that vary in strength
- Fracture, minerals that have structures that are equally or nearly equally, strong in all directions.
**Optical Properties of Minerals (LUSTER)**

* Of the many optical properties of minerals, their luster, their ability to transmit light, their color, and their streak are most frequently used for mineral identification.

* LUSTER. The appearance or quality of light reflected from the surface of a mineral is known as luster.

* Minerals that have the appearance of metals, regardless of color, are said to have a metallic luster.

* Most minerals have a nonmetallic luster and are described using various adjectives such as vitreous or glassy.

* Other nonmetallic minerals are described as having a dull or earthy luster (a dull appearance like soil) or a pearly luster (such as a pearl).

* Some others exhibit a silky luster (like satin cloth) or a greasy luster (as though coated in oil).
Optical Properties of Minerals (LUSTER)
Optical Properties of Minerals
(ABILITY TO TRANSMIT LIGHT)

* **THE ABILITY TO TRANSMIT LIGHT.** Another optical property used in the identification of minerals is the ability to transmit light.

* When no light is transmitted, the mineral is described as **opaque**.

* When light, but not an image, is transmitted through a mineral it is said to be **translucent**.

* When both light and an image are visible through the sample, the mineral is described as **transparent**.
Optical Properties of Minerals
(ABILITY TO TRANSMIT LIGHT)

- **Transparent Mineral**
- **Translucent Mineral**
- **Opaque Mineral**
COLOR. Although color is generally the most conspicuous characteristic of any mineral, it is considered a diagnostic property of only a few minerals.

Slight impurities in the common mineral quartz, for example, give it a variety of tints including pink, purple, yellow, white, gray, and even black.

Other minerals, such as tourmaline, also exhibit a variety of hues, with multiple colors sometimes occurring in the same sample.

Thus, the use of color as a means of identification is often ambiguous or even misleading.
Optical Properties of Minerals (STREAK)

* **STREAK.** The color of the mineral in powdered form, called streak, is often useful in identification.

* A mineral’s streak is obtained by rubbing it across a streak plate (a piece of unglazed porcelain) and observing the color of the mark it leaves.

* Although the color of a mineral may vary from sample to sample, its streak is usually consistent in color.

* Streak can also help distinguish between minerals with metallic luster and those with nonmetallic luster.

* **Metallic minerals generally have a dense, dark streak, whereas minerals with nonmetallic luster typically have a light colored streak.**
Optical Properties of Minerals (STREAK)
Mineralogists use the term **crystal shape** or **habit** to refer to the common or characteristic shape of a crystal or aggregate of crystals.

A few minerals exhibit somewhat regular polygons that are helpful in their identification.

For example, magnetite crystals sometimes occur as octahedrons, garnets often form dodecahedrons.

Halite and fluorite crystals tend to grow as cubes or near cubes.

While most minerals have only one common habit, a few have two or more characteristic crystal shapes such as the pyrite.
Mineral Strength (TENACITY)

* **Mineral Strength:** How easily minerals break or deform under stress is determined by the type and strength of the chemical bonds that hold the crystals together.

* Mineralogists use terms including **tenacity**, **hardness**, **cleavage**, and **fracture** to describe mineral strength and how minerals break when stress is applied.

* **TENACITY.** The term tenacity describes a mineral’s toughness, or its resistance to breaking or deforming.

* Minerals that are ionically bonded, such as fluorite and halite, tend to be brittle and shatter into small pieces when struck.

* By contrast, minerals with metallic bonds, such as native copper, are malleable, or easily hammered into different shapes.

* Minerals, including gypsum and talc, that can be cut into thin flakes are described as **sectile**.

* Still others, notably the micas, are elastic and will bend and snap back to their original shape after the stress is released.
**Mineral Strength**

(HARDNESS)

- **HARDNESS.** One of the most useful diagnostic properties is hardness, a measure of the resistance of a mineral to abrasion or scratching.

- This property is determined by rubbing a mineral of unknown hardness against one of known hardness, or vice versa.

- A numerical value of hardness can be obtained by using the Mohs scale of hardness, which consists of 10 minerals arranged in order from 1 (softest) to 10 (hardest).

- It should be noted that the Mohs scale is a relative ranking, and it does not imply that mineral number 2, gypsum, is twice as hard as mineral 1, talc. In fact, gypsum is only slightly harder than talc.

- In the laboratory, other common objects can be used to determine the hardness of a mineral.
These include a human fingernail, which has a hardness of about 2.5, a copper penny (3.5), and a piece of glass (5.5). The mineral gypsum, which has a hardness of 2, can be easily scratched with a fingernail.

On the other hand, the mineral calcite, which has a hardness of 3, will scratch a fingernail but will not scratch glass.

Quartz, one of the hardest common minerals, will easily scratch glass.

Diamonds, hardest of all, scratch anything, including other diamonds.
**CLEAVAGE.** In the crystal structure of many minerals, some atomic bonds are weaker than others.

- It is along these weak bonds that minerals tend to break when they are stressed.

- Cleavage is the tendency of a mineral to break (cleave) along planes of weak bonding.

- Not all minerals have cleavage, but those that do can be identified by the relatively smooth, flat surfaces that are produced when the mineral is broken.

- The simplest type of cleavage is exhibited by the micas. Because these minerals have very weak bonds in one direction, they cleave to form thin, flat sheets.
Some minerals have excellent cleavage in one, two, three, or more directions, whereas others exhibit fair or poor cleavage, and still others have no cleavage at all.

When minerals break evenly in more than one direction, cleavage is described by the number of cleavage directions and the angle(s) at which they meet.

Each cleavage surface that has a different orientation is counted as a different direction of cleavage. For example, some minerals cleave to form six-sided cubes.

Because cubes are defined by three different sets of parallel planes that intersect at 90-degree angles, cleavage is described as three directions of cleavage that meet at 90 degrees.
Mineral Strength (CLEAVAGE)

* **Basal cleavage**

  Cleavage exhibited on a horizontal plane of the mineral by way of its base. Minerals with basal cleavage can sometimes be "peeled". An example of basal cleavage are the mica minerals.

* **Cubic cleavage**

  Cleavage exhibited on minerals of the isometric crystal system that are crystallized as cubes. In this method of cleavage, small cubes evenly break off of an existing cube. An example is Galena.

* **Octahedral cleavage**

  Cleavage exhibited on minerals of the isometric crystal system that are crystallized as octahedrons. In this method of cleavage, flat, triangular "wedges" peel off of an existing octahedron. An example is Fluorite.
**Mineral Strength (CLEAVAGE)**

* **Prismatic cleavage**

  Cleavage exhibited on some prismatic minerals in which a crystal cleaves as thin, vertical, prismatic crystals off of the original prism. *An example is Feldspar.*

* **Rhombohedral cleavage**

  Cleavage exhibited on minerals crystallizing in the hexagonal/trigonal crystal system as rhombohedrons, in which small rhombohedrons break off of the existing rhombohedron. *An example is Calcite.*
Mineral Strength (FRACTURE)

- **FRACTURE.** Minerals having chemical bonds that are equally, or nearly equally, strong in all directions exhibit a property called fracture.

- When minerals fracture, most produce uneven surfaces and are described as exhibiting irregular fracture.

- However, some minerals, such as quartz, break into smooth, curved surfaces resembling broken glass.

- Such breaks are called **conchoidal** fractures.

- Still other minerals exhibit fractures that produce splinters or fibers that are referred to as splintery and fibrous fracture, respectively.

- **Conchoidal fracture** - breaks along smooth curved surfaces.

- **Fibrous and splintery** - similar to the way wood breaks.

- **Hackly** - jagged fractures with sharp edges.

- **Uneven or Irregular** - rough irregular surfaces.
Density and Specific Gravity

- **Density**, an important property of matter, is defined as mass per unit volume.

- Mineralogists often use a related measure called **specific gravity** to describe the density of minerals.

- Specific gravity is a number representing the ratio of a mineral’s weight to the weight of an equal volume of water.

- Most common rock-forming minerals have a specific gravity of between 2 and 3.

- For example, quartz has a specific gravity of 2.65.

- By contrast, some metallic minerals such as pyrite, native copper, and magnetite are more than twice as dense and thus have more than twice the specific gravity as quartz.

- Galena, an ore of lead, has a specific gravity of roughly 7.5, whereas the specific gravity of 24-karat gold is approximately 20.
**Magnetism:** Magnetism is the characteristic that allows a mineral to attract or repel other magnetic materials.

**Diamagnetic minerals** - minerals not attracted by a magnet.

**Paramagnetic minerals** - minerals attracted by a magnet.

- Magnetite (Fe₃O₄) – strongly magnetic.
- Ilmenite (FeTiO₃) – can be weakly magnetic.

- Certain minerals will **effervesce** (bubble) when dilute hydrochloric acid is applied to the surface.
- This is characteristic of those minerals containing the **carbonate anion**

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\text{CaCO}_3 + 2\text{HCl} \xrightarrow{\text{‡}} \text{Ca}^{2+} + \text{H}_2\text{O} + 2\text{Cl}^- + \text{CO}_2 \text{ (gas)}.
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- The amount of effervescence depends upon how soluble the mineral is (calcite vs. dolomite).
Other properties of Minerals

- **Taste:** This technique can only be applied to those minerals which are soluble.
- Care must be taken in nature, for some minerals contain arsenic, lead, and other toxic elements.
  - Acid or sour: sulfuric acid, indicates the presence of sulfur
  - Alkaline: potash
  - Astringent: (puckering) Alum
  - Bitter: Epsom or bitter salts
  - Cooling: saltpeter (NaNO₃)
  - Metallic: decomposed FeS₂, brassy taste
  - Saline: Salty, NaCl

- Some minerals exhibit special optical properties.
- For example, when a transparent piece of calcite is placed over printed text, the letters appear twice.
- This optical property is known as **double refraction**
Fluorescence: The fluorescent minerals are those that emit visible light when activated by invisible ultraviolet light (UV), X-rays and/or electron beams. Example is Gypsum

Phosphorescence is the ability of a mineral to glow after the initial activating ultraviolet light is removed. Example is Fluorite

Thermoluminescence is a property of some minerals to glow when they are heated. Example is Calcite

Triboluminescence is a property of some minerals to glow when they are crushed, struck, scratched or even rubbed in some cases. Examples are Calcite and Fluorite