Physical Properties of Minerals

Color and Streak

Color is among the more obvious qualities of a mineral, yet the color of a mineral may vary considerably depending on slight variations in chemical composition. Some chemical elements can create strong color effects, even when they are present only as trace impurities. For example, the mineral corundum is commonly white or grayish, but when small amounts of chromium are present, corundum is deep red and given the gem name *ruby*. Similarly, when small amounts of iron and titanium are present, corundum is deep blue, producing the gem *sapphire*.

Streak is the color of the fine powder of a mineral. Streak is observed by rubbing the mineral across a piece of unglazed porcelain known as a streak plate. Many minerals leave a streak of powder with a diagnostic color. Thus, streak is commonly more reliable than the color of the mineral itself.

Luster

Luster is a property that describes the way light reflects from a fresh surface of the mineral. Minerals that have the appearance of metals, regardless of color, are said to have a *metallic luster*. Minerals with a *nonmetallic luster* are further described by various adjectives such as glassy (vitreous), silky, pearly, milky, or earthy (dull).

Hardness

Hardness is the resistance of a mineral to scratching. The physical property of hardness is determined by crystal structure and strength of the bonds between atoms. Generally, the stronger the chemical bonds, the harder the mineral.

Minerals come in a wide range of hardness. To compare them, geologists use the Mohs Hardness Scale (Fig. 3.1 at right). On this *relative scale*, each mineral is harder compared to all those with lower numbers on the scale. For example, 10 (diamond) is the hardest and so will scratch every mineral listed down to 1 (talc), which is the softest. Using this information, a *range of hardness* is determined. For example, a mineral that can be scratched by quartz but not by potassium feldspar has a ***hardness range*** between 6 and 7 on Mohs.

Because minerals of the Mohs scale are not always handy, it is useful to also know the hardness of common objects like a fingernail or knife blade (Fig. 3.1) for comparison testing.

Figure 3.1 - MINERALS OF THE MOHS HARDNESS SCALE

Minerals of Mohs Hardness Scale	Mohs Hardness of Common Objects
1. Talc	
2. Gypsum	
	Fingernail (2.5)
3. Calcite	
	Copper Penny (3.5)
4. Fluorite	
5. Apatite	
	Knife blade Glass plate (5.5) Steel file
6. Potassium Feldspar	
	Streak plate (6.5)
7. Quartz	
8. Topaz	
9. Corundum	
10. Diamond	

The more easily one mineral scratches another, the greater their difference in hardness. If two minerals have same hardness, they will scratch each other but it will take some effort. A softer mineral will not scratch a harder mineral, regardless of the amount of force you put into the attempt. Take care that you are getting accurate test results. Sometimes it may appear that the softer mineral has scratched the harder mineral because there is a ‘line’ left behind on the harder mineral. Close inspection shows that the ‘line’ can be wiped away and there is no scratch under it, similar to chalk on a chalkboard. In these cases, the line was left by the softer mineral because the harder one was actually scratching it.
To perform a hardness test, first see if you can scratch the mineral with your fingernail. If you can, the mineral is the same hardness or softer than your fingernail depending on how much force is required. If you cannot, see if the mineral can scratch a copper penny, then a glass plate, and so on up the scale. This will give you a narrow *range* of the hardness. For example, if it scratches a penny but not a glass plate, the mineral has a *hardness range* of between 3 and 5. If it scratches glass, the mineral is harder than 5.5. Remember that the easier it is to scratch the glass, the greater the difference between the hardness of the mineral and the glass, but you must record ONLY the results of your tests (e.g., you can record ≥5.5, >5.5 or >>5.5 based on how easy it is to scratch the glass but NOT 8 or 9).

Cleavage and Fracture

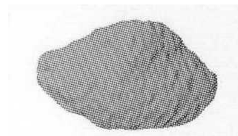
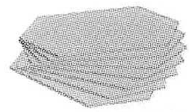
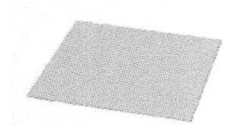
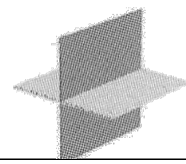
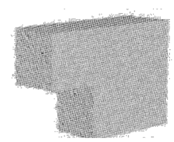
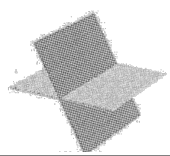
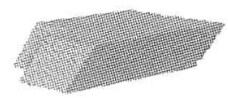
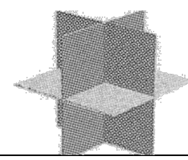
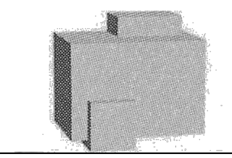
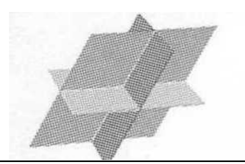
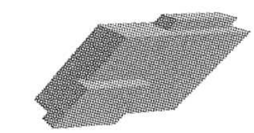
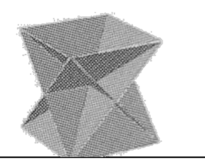
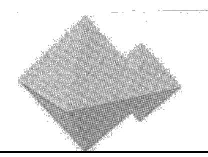
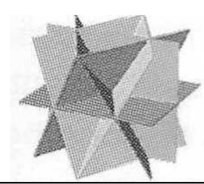
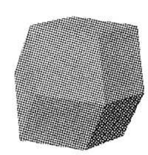
Cleavage and **fracture** refer to the way minerals break. Cleavage is the tendency of some minerals to break along plane of weakness in the mineral’s crystalline structure. If breaking a mineral leaves behind relatively flat surfaces that give off flashes of reflected light when the hand sample is rotated, the mineral has cleavage. These cleavage surfaces are the planes of weakness. Some minerals, such as mica, have one set cleavage planes that are all parallel. Such minerals will repeatedly break into smaller and smaller pieces along that one cleavage plane. Others minerals have two, three, or even four cleavage planes. The quality of the cleavage for each plane varies. Some minerals have excellent cleavage. For instance, you can peel sheet after sheet from a mica crystal to see layer after layer of very reflective (shiny) planes. Others have poor cleavage and only produce relatively flat surfaces with a dull shine. Minerals with no cleavage are said to **fracture**.

Figure 3.2 on the next page shows the common cleavage patterns that cause minerals to break along the planes of weakness, forming certain preferred shapes. Use this figure to help you evaluate the cleavage of mineral samples. There are three observations you must make:

1. The number of different (non-parallel) cleavage planes.
2. The angle at which different planes intersect.
3. The quality of cleavage: excellent, perfect, good, fair, poor

Fracture occurs when a mineral breaks but not along cleavage planes. Many minerals fracture because they have no planes of weak bonds in their atomic structure. In these cases, fractures still can form characteristic shapes or patterns. For example, *conchoidal* fracture creates smooth and curved surfaces, similar to a clam shell. Conchoidal fracture is commonly seen in the mineral quartz. Some minerals break into splintery or fibrous fragments. Others fracture into irregular shapes.

Figure 3.2 Common cleavage patterns of minerals. (From: *Laboratory Manual in Physical Geology*, 4/E by Busch, © 1997. Reprinted by permission of Prentice-Hall, Inc., Upper Saddle River, NJ.)

Number of Cleavage Directions		Shape	Sketch of Cleavage Planes	Directions of cleavage
0	Fracture only, No cleavage			
1	Planar	Flat Sheets		
2 at 90°		Elongated form with rectangular cross-section		
2 not at 90°		Elongated form with parallelogram cross-section		
3 at 90°		Cube		
3 not at 90°		Rhombohedron		
4		Octahedron		
6		Dodecahedron		

Density

An important physical property of a mineral is how light or heavy it feels relative to the size of the sample; its heft. The property that causes this observed difference is **density**, which is mass per unit volume. Minerals with a high density, such as gold, have closely packed atoms. Minerals with a low density, such as ice, have loosely packed atoms. The density of minerals is often reported as **specific gravity** (S.G.), the density of a substance relative to that of an equal volume of water. The most common silicate minerals have densities in the range of 2.5-3.0 g/cm^3 or 2.5-3 times that of water. Minerals made of metallic elements have higher densities. For example, gold (Au) has a density of 19.3 g/cm^3; galena (PbS) about 7.5 g/cm^3, silver (Ag) about 10.5 g/cm^3 and copper (Cu) is 8.9 g/cm^3. Density can be judged by holding (*hefting*) different minerals of similar size and comparing their weights qualitatively. Heavier minerals have higher than average densities, and will seem heavy for their size.

Magnetism

Most mineral are not magnetic at all, but iron-bearing minerals often exhibit the property of **magnetism**. Some are strongly magnetic and some weakly magnetic. Magnetite is strongly attracted to a magnet but ilmenite, and sometimes hematite, exhibits only a weak attraction. To test for magnetism, use a magnet suspended on a string and slowly bring the magnet in the vicinity of the mineral. You should be able to feel the suspended magnet's attraction (or not) to the mineral.

Reaction to Acid

Carbonate minerals (those containing the anion $(CO_3)^{2-}$) will **effervesce** (fizz / form bubbles) when a drop of dilute hydrochloric acid (HCl) is applied to a freshly exposed surface. The fizzing is the release of CO_2 gas, the same gas that is released when you pop the top of a soda bottle. Some minerals, like calcite, react quickly and effervesce vigorously. Others, like dolomite, effervesce slowly in dilute acid and the reaction is more easily seen only if the mineral is first made into a powder (i.e., powder effervescence).

You can quickly perform an acid test by applying a small drop of dilute HCl to the mineral surface. If you get no reaction (liquid stays clear) or a very slow reaction (liquid turns 'cloudy'), scratch the mineral surface with a wire probe to form a powder and then reapply the acid. If you get a faster reaction, that is powdered effervescence and a diagnostic result for dolomite. Otherwise, record that there is no reaction.

Please use a paper towel to wipe the mineral dry after your test, so that the next person doesn't get acid all over their hands!