Physical Properties of Minerals

1. Crystalline forms. Many minerals occur as crystals; these are usually desirable and commonly fetch handsome prices in mineral and rock shops. The crystal morphology is a reflection of the internal, ie., atomic, structure of the mineral. We will be concerned with the symmetry of crystal shapes in the third lab exercise. For now, examine the crystals of quartz, galena, pyrite, corundum, and chrysotile. Each has a crystal structure different from the others and, therefore, has a different crystal morphology.

2. Cleavage. Weaknesses in the crystal structure, for example, planes of atoms weakly bonded to other planes, are manifested macroscopically by cleavage. Some minerals do not have such weaknesses and, thus, lack cleavage. Compare calcite with quartz. Break each with a flat chisel or knife blade and a hammer. These two minerals illustrate the difference between cleavage and fracture.

3. Streak. Use a streak plate (a piece of ceramic tile) on stibnite and hematite. The streaks show the color of the finely pulverized mineral. This color is often an aid in identifying the mineral. The streak test works only on minerals that are softer than the plate. It is usually reserved for minerals with metallic lusters.

4. Hardness. Hardness also reflects the strength of atomic bonds in crystal structures. Compare the hardnesses of gypsum, calcite, and quartz. Is your fingernail harder than any mineral? A scale of hardness was established by Mohs. The scale is divided into 10 hardnesses, each defined by a particular mineral.

Table 1: Mohs Hardness Scale

1	Talc	6	Orthoclase
2	Gypsum	7	Quartz
3	Calcite	8	Topaz
4	Fluorite	9	Corundum
5	Apatite	10	Diamond

5. Density. Minerals have different densities reflecting their chemical composition and the close packing of the atoms in their crystal structure. You get a feeling for the difference in density by comparing the hefts of similar-sized pieces of galena and quartz. You can measure the density by weighing a mineral sample and then weighing an equivalent volume of water. By definition, water has a density of 1.0 g/cm^3. The ratio of the density of a mineral to that of water is called the specific gravity. The way to measure the specific gravity is to weigh the mineral (M), then weigh the mineral immersed in water (M^w). The difference is the weight of the water displaced by the mineral's volume. The specific gravity is then $M/(M - M^w)$. The balance used to weigh the samples is called a Jolly balance. We have a torsion-spring balance, which performs the same function much more accurately, especially for small samples, than the Jolly balance does.

   Measure the density of halite and fluorite. This presents some experimental difficulties because halite is soluble in water! Instead of using water, we will have to use a liquid in which NaCl is not soluble. Toluene will suite our purposes. Toluene, though, has a density of 0.866 g/cm^3. So if the weight of the mineral in toluene is M^t, then the specific gravity is

$$0.866 \times \frac{M}{M - M^t}$$

Each of you should measure the specific gravity of halite or fluorite on a different piece of the mineral. Keep track of your measurement; compare it with the others; determine the average and the standard deviation* of the measurement. What are some possible sources of error on the measurement?

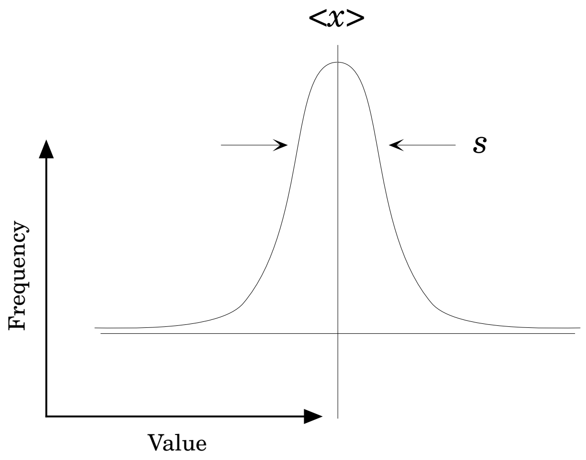
*The average, or mean, value $\langle x \rangle$ is given by

$$\langle x \rangle = \frac{1}{n} \sum x_i,$$

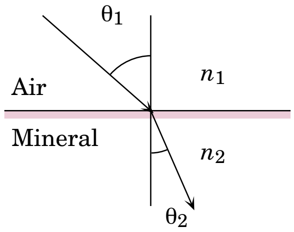
in which n is the number of measurements of value x; the x_i are the individual measurements. The standard deviation about the mean, s, is given by

$$s^2 = \frac{1}{n-1} \sum \left(x_i - \langle x \rangle\right)^2,$$

in which the term in parentheses is the deviation of the individual measurements from the mean.


Normal, or Gaussian Distribution

6. Index of Refraction. The index of refraction of any substance, mineral or not, is a measure of the "bending ability" of the substance on light. The definition of the index of refraction is the ratio of the speed of light in a vacuum to that through the substance: $n = c/v$. The greater the index, the slower light travels through the substance. When light travels from one medium, like air, into another, like diamond, the path of the light beam is bent according to Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$.



The closer the indices of refraction are to each other, the less light is bent when crossing the interface. If the indices are identical, the mineral seems to disappear! This phenomenon is used to determine the index of refraction of a mineral. The mineral is immersed in oil with a known index of refraction. When the indices of the oil and mineral match, the mineral disappears. If the indices are very different, the mineral appears to stand out with high relief. The procedure is to use oils successively with different indices of refraction until a match with the mineral is found. You will get a chance to measure the indices of refraction of some minerals later in the course. There is a microscope set up with some fluorite immersed in oil with an index of refraction of 1.43. Take a look; then look up the index of refraction of fluorite.