Mineralogy Boot Camp Session #4

Physical Properties of Minerals: Part 2

This is the second installment on the description of some of the physical properties of minerals useful for mineral identification. Last month the properties of *color* and *streak* were discussed. Next month we'll finish the physical properties with a description of *habit*, *cleavage*, and some other miscellaneous tests. Remember, best practice is to base your identification on *several* properties, not just one property.

Hardness

The property of hardness tests the resistance to scratching, which ultimately is a test of the atomic bond strength. The degree of hardness is determined by comparing how difficult it is for one mineral to scratch other minerals or some common physical objects. In 1822 German mineralogist Friedrich Mohs designed a relative scale of mineral hardness using ten relatively common minerals. This system is now known as *Mohs scale of mineral hardness*. The table below lists Mohs scale along with some other useful objects for checking hardness.

Mohs Scale of Mineral Hardness		
Mineral	**Mohs number**	**Observations on Useful Reference Objects**
Talc	1	
Gypsum	2	Typical fingernail: ≈2.2
Calcite	3	(untarnished) US copper penny: ≈3.2
Fluorite	4	Common nail: 4.0-4.5
Apatite	5	Glass plate: ≈5.5
Feldspar	6	
Quartz	7	Streak plate: 6.5-7.0
Topaz	8	
Corundum	9	
Diamond	10	

The *absolute hardness*, as determined by careful laboratory testing, shows that the Mohs scale is not linear, but rather a relative ranking of mineral hardness. For example, corundum (9) in absolute hardness is twice as hard topaz (8), but four times harder than quartz (7). Quartz (7) in absolute hardness is five times harder than fluorite (4) and 50 times harder than gypsum (2). Nonetheless, the Mohs scale is a quick and useful field test.

User notes:
A common mistake many novice mineral identifiers make is using too much force, attempting to grind the specimen into whatever reference they are using, such as a glass plate. The goal of this test is to determine how *easy* it is to scratch one thing with another thing. The specimen should be held firmly, but not pressed with so much force so that it immediately begins to crumble on

the glass (or the glass is in risk of breaking). Back and forth motion is not necessary; if the specimen is going to scratch the glass, it should be apparent with just one short movement. Most minerals will exhibit a small range in hardness, depending on which crystal face is being tested (remember that the hardness numbers listed in textbooks were determined on perfect pure specimens, and your sample is probably not that). Just like deciding on the specimen color, hardness tests should be done on the freshest part because weathering can easily cause a weakening of the outer surface, giving an appearance of lower hardness. Be aware that when testing for hardness, softer minerals may leave a streak that looks like a scratch. As mentioned previously in description of the streak, use a finger to check: powders will wipe off where scratches won't be removed. Always test whatever tools you are using for your assessments: while the hardness of some are well established (like the copper penny and glass plate), pocketknives blades may range from about 4 to over 6 (despite what many handbooks state, which is 5.0-5.5). A good habit is to "reverse the testing": try to scratch specimen *A* with object *B*, then try to scratch object *B* with specimen *A*. This is a check to see if you're getting consistent results. If possible, get a few common minerals of known hardness (such as calcite, fluorite, and quartz) to use for testing purposes. Suitable small specimens can be acquired for low cost at the IMMG Gift Shop or at local Gem & Mineral shows. Figure 1 shows some simple materials and minerals useful for checking specimen hardness through a wide range. If the specimen you are testing consists of an aggregate of grains (like quartz sand grains cemented together making a sandstone), realize that you may be testing the strength of the *cement*, not the mineral grains themselves.

Figure 1. These are some handy tools for hardness determinations. Minerals in back row, from left to right, are fluorite (4), quartz (7), topaz (8), and corundum (9). Front row consists of #8 common nail (just over 4, as it will barely scratch fluorite), penny (3.2), and ¼-inch-thick glass plate (5.5). Note scratches in glass from previous tests.

Specific Gravity

The specific gravity (SG) of a material is the ratio of the weight of that material to the weight of an equal volume of water. This is related to density, except that specific gravity has no units whereas density must have units prescribed (for example, grams per cubic centimeter). Specific gravity has no units because it is determined by the *ratio* of the density of the material to the density of water, which is considered to be 1 gram per cubic centimeter. This allows the units to cancel, and is thus expressed as just a number. This property depends on both the chemical composition of the mineral (what elements are present), and how the elements are packed within the atomic structure. Certain elements (like lead or iron) have a high atomic weight, leading to minerals with a higher specific gravity. How close the atoms are packed to each other, for example the tight packing of carbon atoms in diamond (SG = 3.5) compared to the looser packing of carbon in graphite (SG = 2.2), will also influence the specific gravity. The table below lists the specific gravity of some relatively common minerals, listed from relatively low (gypsum) to relatively high (copper).

Average Specific Gravity for Some Common Minerals										
Gypsum	2.3		Fluorite	3.2		Corundum	4.0		Magnetite	5.2
Quartz	2.7		Hornblende	3.2		Barite	4.5		Galena	7.5
Dolomite	2.9		Topaz	3.5		Pyrite	5.0		Copper	8.9

User notes:

Specific gravity is a property that takes practice in order to develop a sense of what typical minerals feel like in your hand ("calibrate your wrist" with specimens of known specific gravity). With experience, one can estimate the specific gravity to within the closest 1.0 value without difficulty. The best method is to use specimens of approximately the same size (volume) to make comparisons. See Figure 2 for an example where the specimens are all about the same weight, so the specific gravity expresses itself by differences in volume. As with hardness, there's often a small range of specific gravity values for a particular mineral. If the sample is a mixture of two (or more) minerals, the overall specific gravity will be somewhere between the values for the minerals present. For example, if the specimen is half quartz (SG = 2.7) and half barite (SG = 4.5), the overall specific gravity is likely to be something close to 3.5.

Figure 2. This is another way to think about specific gravity. The four materials in the photo (three minerals and a volume of water) each weigh approximately 2 pounds. Elongate silky specimen in rear is gypsum (SG = 2.3). Metallic specimen on left is galena (SG = 7.5). Blue-white specimen in center is calcite (SG = 2.7). Water (SG = 1.0) in beaker is about 1000 milliliters. Since all are the same weight, the difference in sizes (volumes) is an indication of their respective specific gravities: the smaller the volume, the greater the specific gravity.