EARTH MATERIALS!

The physical and chemical properties of rocks play a role in all aspects of environmental science. The purpose of this exercise is to familiarize you with rocks and minerals and how to identify these properties, with a special emphasis on economic minerals and the processes of ore formation and extraction. Hopefully, this will help hone your observational skills and start you thinking about the different rock types, how they form, and their implications on environmental science.

Some things to keep in mind while doing this exercise: When asked to describe or identify a mineral or rock, use the sets of characteristics listed below as a guideline. Rock descriptions should include all of the relevant characteristics below. Remember that simple rock properties that *you* can observe in hand-sample have enormous implications for where and how the rocks formed!

Finally, remember that you are just starting to look at rocks. You are not meant to know all the answers to the questions below, so work in groups, think about the questions, and come up with as thoughtful answers as you can. The more questions you ask your peers and instructors, the more you will learn.

Physical properties of minerals:

CRYSTAL HABIT - the characteristic morphology of the crystal

CLEAVAGE or FRACTURE - the tendency of a mineral to break along planes of weakness

HARDNESS - measure of the ability of a mineral to resist abrasion

SPECIFIC GRAVITY - ratio of mass of a mineral to the mass of an equal volume of water

COLOR - to be considered but not relied upon for identification

STREAK - the color of the powdered mineral, e.g. when scratched on a ceramic plate

LUSTER - the appearance of a mineral in reflected light

OPTICAL PROPERTIES - e.g. transparent, translucent, opaque

OTHER PROPERTIES - e.g. magnetism, reaction with acid, taste, tenacity

Physical properties of rocks:

MINERALOGY - the minerals that make up the rock

GRAIN SIZE: - the size of the mineral grains

TEXTURE/FABRIC - the arrangement of the constituent mineral grains

SPECIAL STRUCTURES - vesicles, clasts, layering, mechanical deformation, etc.

PLUS: Be sure to name which of the three rock types each rock comes from.

1) There are three different minerals on the table, and one rock .

– What is the glassy mineral? Can you recognize any cleavage planes in this mineral? If so, how many and at what angles are they? If not, how might you describe the mineral surface? (5 pts)
– Describe the cleavage of the black, platy mineral. To what group of silicates does it belong and what is the arrangement of silica tetrahedra in its structure, producing its strong cleavage? What is t he mineral?(5 pts)
– Now look at the salmon-colored mineral. How many cleavage planes do you recognize and what are their orientation? What is its hardness? Name the mineral (5 pts)
– Now observe these minerals in rock form. Describe this rock and give it a name. (5 pts)
– There is a fourth mineral in this rock. Knowing what you do about igneous rocks, what is the fourth mineral (note: a powerful tool of identification is *association*, meaning that you should be able to figure out what the fourth mineral is, without even touching the rock.) (5 pts)

2) There is one mineral and three rocks here at station two.
– The large translucent rhomboids are the mineral calcite, or calcium carbonate. How does its cleavage and hardness differ from feldspar? (5 pts)
– The rocks on the table are both composed entirely of calcite, though they don't look much like the mineral next to them. Two of these rocks are sedimentary and one is metamorphic. Describe these rocks, and in doing so, figure out which ones are which. (5 pts)

Keep in mind that carbonate rocks come in all shapes and sizes, and that these two specimens are by no means a comprehensive representation. The other rocks in this box are all carbonates: one of the most common rock types at the surface of the earth.

3) Look at samples #1, #2 and #3. Compare and contrast these samples in terms of rock type, fabric, structure and strength. (5pts)
– #2 is a low-grade metamorphosed version of rock #1. Briefly describe the metamorphic process that took place. (5 pts)
– Compare #3 with #2. If I told you that we need to site a hazardous waste storage facility and we had to choose on which bedrock to build, which would you choose and why? (5 pts)
– Now compare #1 with #3 and hypothesize the sedimentary environments in which they formed. (5pts)

FYI: the other rock in the tray is a high-grade metamorphosed version of rocks #1 and #2. Note the extreme mineralogical and textural change that took place.

4) The samples at this station are mafic (high in Mg and Fe) volcanic lavas called basalt. They all formed in the same volcanic eruption.
– Compare and contrast the textures of these rocks, and then describe how these rocks could form in the same eruption, but have such different textures. (10 pts)

5) These rocks are also volcanic rocks from a single eruption. This, however, must have been a very explosive felsic (low in Mg and Fe and high in Si) eruption.
– What about these rocks indicate to you that it must have been an explosive eruption? Describe the textures and give the genetic implications of these textures. (10 pts)

FYI: the magma that erupted to form these rocks, if crystallized at depth instead of erupting, would be called a granite - the same rock as is at station 1.

6) Both of the minerals here are called evaporites, and form in similar geologic settings. One is mined for use in products such as wallboard and paint. The other has more obvious applications.
– Identify these minerals (10 pts).
– Describe the process by which they form (ie, what geologic setting) (10 pts).

7) The four minerals in the boxes are, or once were, used as copper ore. One is *native copper* (Cu), the blue one is *azurite* ($Cu_3(CO_3)_2(OH)_2$), the green one is *malachite* ($Cu_2CO_3(OH)_2$), and the goldish one is *chalcopyrite* ($CuFeS_2$).
– Assuming that you had large, pure deposits of each of these minerals, rank them in order of the highest yield of copper (by weight) per ton of mineral (show your work) (10 pts).
– As it turns out, finding large, pure deposits of these minerals rarely happens. This is because they form in veins, or fractures in the rock by a process you've all heard of – precipitation. If you were in the business of mineral exploration, and you looked for these deposits in the middle-crust (15-20 km deep, and no, it is not actually possible to go there), you wouldn't find them. Tell me why you wouldn't find them (10 pts). *Hint: in order to understand why they* don't *form somewhere, you will need to think more about the process by which they* do *form.*

8) This is not a mineral. It is a sedimentary rock called *bauxite*, which is composed of the minerals *gibbsite* and *diaspore*, and it is the principle aluminum ore on the planet. One of the remarkable parts about the rock cycle is that it can take a granite (~15% Al by weight) and produce bauxite (~50% Al by weight) through intense weathering.
– How much bauxite is necessary to make a 12-pack of beer (assuming the cans are 80% aluminum)? (5 pts)
– A drawback to bauxite is that it only forms within the first 1 meter of the earth's surface, in soils, by a process called leaching (essentially the opposite of precipitation). If we assume a fraternity consumes 20 cases of beer a week, and has to discretely throw away the cans instead of recycling them so they don't get in trouble with MIT, how much land, per year, are they responsible for destroying? (5 pts)

9) You may all recognize this mineral as *asbestos*, but asbestos is not a mineral, it is a textural term. This particular mineral is *chrysotile*, a type of *serpentine,* which has asbestiform structure.
– What silicate group does serpentine belong to? (5 pts)
– What is asbestos used for? (5 pts)

10) *Zeolites* are one of the most under-appreciated mineral resources on the planet. So much so, that we don't even have samples of them in our collection. Instead, you should go to the web page *http://www.naturalzeolites.com/* and read about them. Then, write a couple paragraphs about why zeolites are important. (20 pts)