VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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Minerals

Spring 2012

Goal: To introduce students to some of the tests that geologists use to determine the properties of minerals.

LESSON OUTLINE

I. Introduction

Discuss the difference between "rocks" and "minerals." Although some rocks contain just one mineral, most rocks are mixtures of two or more minerals.

II. Learning the Tests That Help Distinguish Minerals

Organize the students into pairs. Explain that they will be learning how to do the tests on hematite. Lead the students through each test using hematite.

The five tests they will use are the streak test, hardness test, cleavage, luster test, and magnetism. Student pairs repeat the tests learned with hematite on their 2 minerals, record the results, and identify their minerals. Review their results, emphasizing tests that show differences between the minerals.

Once they have finished identifying their unknowns, hand out the materials for the acid test. Do not distribute the acid bottles to the students until just before the acid test once all students are wearing goggles and are aware of the safety procedures!

III. Other Properties of Minerals

Explain the property of fluorescence that some minerals exhibit. Also share some of the information about colored minerals. One VSVS team member can take the black light and the sample of scapolite around to each group, which fluoresces a bright yellow under the black light, while another VSVS team member can take the box of colored minerals around.

SAFETY NOTE Goggles are required. Please check the lab when you pick up your kit. Students must wear goggles when performing the Acid Test. If goggles are not available for all students, the VSVS volunteers must perform the acid test for the students. Be sure you wear the goggles!

Materials:

1 bag of materials for VSVS members:

- 2 types of Quartz (Rose and clear)
- 1 piece of hematite
- 1 piece of muscovite
- 1 Materials investigation kit (see below for contents)
- 1 bag (for demos) containing:
  - a piece of Aluminum foil
  - a block of wood
  - a piece of glass
  - a sealed vial of 'pearly' soap or lotion

1 sample set of 11 minerals for the VSVS volunteers (includes labels and information)
1 bag containing 16 pieces of muscovite
1 bag containing 16 pieces of hematite
16 plastic bags containing 2 mineral samples (Unknowns)
16 Mineral Investigation Kits containing:
    1 hand lens
    1 piece of copper
    1 piece of iron
    1 piece of glass
    1 black streak plate
    1 white streak plate
    1 magnet
17 plates
17 dropper bottles of 0.5 M hydrochloric acid solution
17 pieces of marble
1 clear box with 12 samples of colored minerals
1 black light
1 piece of fluorescent mineral in a labeled bag
32 Properties of Minerals in sheet protectors
32 Observation sheets
1 Answer Sheet in sheet protector
1 Box of Goggles

I. INTRODUCTION – What are minerals?

Write the following vocabulary words on the board: **mineral, luster test, streak test, hardness test, Moh's scale, and cleavage test**

Ask students, "What makes up rocks?"

If students don't mention minerals, tell students that all rocks are made up of minerals.

If you look at any piece of rock closely, you will see that it is rarely completely smooth like plastic or metal. Instead it is made up of different grains or crystals.

These crystals, which are sometimes minute and sometimes quite large, are called "minerals."

Your Notes:

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Minerals are inorganic compounds that form naturally in the earth.
A mineral has a definite composition, is a solid element or compound, and has a crystal shape.
There are more than 3500 different kinds of minerals, but only 30 or so common ones. Some rocks contain just one mineral, some two to six, and some even more. Most rocks are mixtures of two or more minerals.

Ask students: How do scientists tell these minerals apart from each other?
Scientists can identify minerals through several tests.

- Write the name **hematite** on the board and tell the students they will learn how to do all the tests on this mineral.
- Write the names of the "unknown" minerals **(talc, rose quartz, smoky quartz, halite, galena, magnetite, graphite, feldspar, calcite, gypsum)** on the board, and tell the students that today, as geologists, they will investigate the 2 minerals assigned to them, record data about their properties and then be able to identify their minerals.

Set-up

The class should be divided into pairs. Have the teacher assist in organizing the students into groups or request that the teacher have students grouped prior to your arrival.
Note: Do not pass out acid dropper bottles and goggles until test E(b).
Do not pass out Properties of Minerals handout until after all tests have been done.

1. Distribute the following materials to each pair:
   1 Mineral Investigation Kit (contains mineral hematite)
   2 observation sheets
   1 set of 2 minerals (unknowns)

2. VSVS members will lead the students through each test on the mineral hematite and have them record the results on their investigation sheets. After each test is done on hematite, the students will immediately do the same test on their 2 unknown minerals and record the results on their sheets.

Your Notes:

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When student groups are working independently, VSVS volunteers should circulate to monitor and help groups as needed.

3. After the pairs are finished with all the tests on their minerals, tell them to name their 2 minerals using the information on the Properties of Minerals Handout, which should only be handed out after all tests and observations are completed. Discuss the results and emphasize similarities and differences.

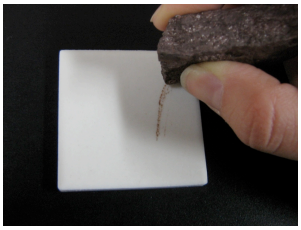
II. Learning the Tests for Minerals

A. Streak Test

Materials for VSVS members
1 hematite mineral
1 bag containing 2 types of Quartz (Rose and clear) and black and white streak plates

Explain the Streak Test.
A "streak" is the color of a mineral when it is ground down to a powder.
A streak test is a test that you do by pushing a mineral across a plate.
This crushes up the mineral, allowing you to see a diagnostic color that a specific mineral has. The mark left on the tile is the mineral's streak.
Show the students the two minerals (from the plastic bag) that are both quartz (pink Rose quartz and white Milky quartz) and emphasize their different colors. The different colors are from different impurities.
Explain that a particular mineral can have several colors depending on impurities. While the color of a mineral may change, its powder and streak will usually stay the same.

Tell the students that the quartz minerals will have the same STREAK test.
Show this by doing the streak test on the black streak plate. Keep the plate flat on the table like the image here.



Your Notes:

Tell the students to:

1. Gently stroke the edge of the hematite across the white streak plate.

Note: Ask students to make only one streak per mineral since the tiles and minerals are needed for other classes.

2. Record the color that the streak produces.
   Hematite has a red to brown streak
3. Tell the students to repeat the test on their unknown minerals using the black streak plate with light-colored minerals and the white streak plate with the dark-colored minerals.
4. Record the results on their observation sheet.
   If no streak is visible on either plate, the students should record "not visible".

Make sure that the students have the following results, but do NOT tell the students the name of the mineral:

Mineral	**Streak**
#1 Hematite	red, brown
#2	white
#3	black
#4	white
#5	colorless, white
#6	black
#7	black, gray
#8	white
#9	white
#10	white
#11	colorless, white

B. Hardness Test

Another clue to a mineral's identity is its hardness - that is, what will it or will it not scratch?

Diamond is the hardest mineral to scratch, and has the highest rating (a 10).

Talc (with a rating of 1) is one of the easiest to scratch.

A mineral's hardness reflects how strong the mineral structure is.

Your Notes:

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Explain Mohs Scale before performing this test.

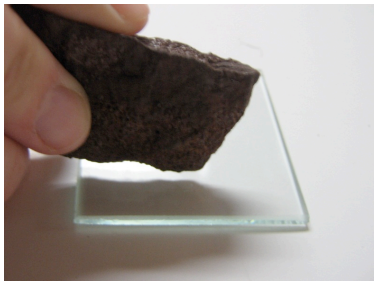
Geologists have devised a set of common materials that are used to scratch a mineral to find where it lies on the hardness scale.

Think about it – geologists often travel into outback areas and need to carry all their materials into the field with them. Carrying an electron microscope is not an option! The following everyday materials are sufficient for geologists to identify the hardness of minerals.

These materials are:

Hardness	**Testers (Everyday Equivalent Objects)**
1	no everyday equivalent
2	Fingernail
3	Copper coin or piece of copper
4	Iron nail/piece of iron
5	Glass
6	Penknife Blade
7	Steel File
8	Sandpaper
9	no everyday equivalent
10	no everyday equivalent

Tell students we will be using just four of the everyday equivalents ("testers") in this lesson. Since several classes will be using the minerals, the students will **scratch the testers** with the mineral.



***NOTE*: Ensure that all testers, especially the glass plate, are flat on the table surface while scratching (like this image). If held aloft, the glass will snap in half.**

Your Notes:

Tell the students to:

1. find the hardness of **hematite** by scratching the **<u>testers</u>** with the hematite, in the following order (from hardest to softest):
    1. piece of glass (hardest)
    2. piece of iron
    3. piece of copper
    4. fingernail (softest)

1. Determine the Mohs hardness of **hematite** by finding the HARDEST (i.e. the FIRST) tester that the mineral will scratch.
    Once a mineral scratches a tester, **do not** continue to try to scratch softer testers (because it will!). Remember these testers and minerals will be used by other classes.

2. Circle the first tester the hematite scratches, along with the Moh's number that is with it.

    If the hematite scratches the glass, its hardness is greater than 5 (>5).
    If the hematite scratches the iron, its hardness is 4-5.
    If the hematite scratches the copper, its hardness is 3-4.
    If the hematite scratches your fingernail, its hardness is 2-3.
    If the hematite does not scratch your fingernail, its hardness is 1-2.

Make sure that the students have the following results for Hematite = 4-5 or >5

3. Repeat the test on the 2 unknown minerals and record the results.

<u>Hardness Test Results.</u>

Make sure that the students have the following results (Some students may get slightly different results. The following ranges are acceptable. Use the number on the mineral to determine if the students have the correct results.):

Your Notes:

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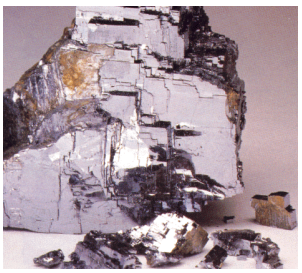
Mineral	What is the 1st item it scratches?	Hardness
#1 Hematite	glass or iron	>5 or 4-5
#2	none	1-2
#3	glass or iron	>5 or 4-5
#4	copper	3-4
#5	glass or iron	>5 or 4-5
#6	copper or fingernail	3-4 or 2-3
#7	none	1-2
#8	none	1-2
#9	glass or iron (fine scratches)	>5 or 4-5
#10	fingernail or none	2-3 or 1-2
#11	glass	>5

C. Cleavage and Fracture Test (Breakage Test)

Materials:
1 bag containing 16 pieces of muscovite



Above: Notice the sharp angles produced by breaking the mineral.

Minerals can break in different ways, depending on how strong the bonds are between the atoms in the mineral. They will break along the planes that are the weakest.They can break by either **cleaving or fracturing. NOTE: Do not break the minerals!! Cleavages will already be apparent as smooth surfaces.**

Tell the students that if the mineral **cleaves,** they will see flat surfaces.

Some minerals can break into sheets (cleavage in one direction). Distribute the samples of muscovite around the class and point out the sheets.

Tell them that the pioneers used muscovite for windows.
Others minerals can cleave in several directions (diamonds cleave in 4 directions).

Above: The mineral muscovite cleaves into thin sheets.

If a mineral **fractures**, it breaks unevenly along curved or irregular surfaces. Have the students look at their hematite tell them that it has no cleavage.

Help them determine if their unknown minerals cleave into planes or fracture.

Your Notes:

Cleavage And Fracture Test (Breakage) Results.

Tell the students to look at their minerals and make sure they circle the correct answer on their observation sheet.

Mineral	Cleavage/Fracture
#1 Hematite	no cleavage, fractures
#2	cleaves - 1 direction, look for layers
#3	no cleavage, fractures
#4	cleaves - 3 directions
#5	no cleavage, fractures
#6	cleaves - cubic
#7	cleaves - (scales)
#8	cleaves
#9	cleaves - 2 planes
#10	cleaves - cubic
#11	no cleavage, fractures

D. Luster (Shininess) Test

Materials:

1 bag containing aluminum foil, wood, glass, and a container with a pearly substance.

The way a mineral reflects light is called **luster.**

Show the students the aluminum foil, the glass and the wooden block.

Explain the terms **metallic luster and nonmetallic luster** by showing the following examples:

The aluminum foil has a **metallic luster –** it reflects light well. It is shiny and looks like a metal. Ask students for other examples that illustrate metallic luster (stainless steel pots, etc).

If the mineral does not look like a metal, it is classified as having a **non-metallic luster.**

These minerals can be further classified as being:

dull – show the students the wood

glassy – show the students the glass

pearly – show the students the vial of soap/lotion

Your Notes:

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Tell the students to examine their hematite to determine its luster *(it has a non-metallic luster)*.
Students may need to hold the mineral up to a light or look through the magnifying glass, to see "specks" of metallic luster.
Have them record the result on their investigation sheets.
Then have the students do the same test on the other minerals and record the results. Make sure the students have the following results (but do not tell them the name of the minerals):

Luster (Shininess) Test Results.

Mineral	**Luster**
#1 Hematite	non-metallic – dull
#2	non-metallic – pearly
#3	metallic
#4	non-metallic – glassy or pearly
#5	non-metallic – glassy
#6	metallic
#7	metallic
#8	non-metallic – glassy
#9	non-metallic – dull or pearly
#10	non-metallic – glassy
#11	non-metallic – glassy

E. Magnetism Test

Explain that some minerals are magnetic. These minerals will be attracted to a magnet.
If the mineral is attracted to a magnet, the mineral is magnetic.
If there is an attraction, the students circle yes; if not, circle no.

Have the students do this test on hematite by touching the magnet to the mineral.
- it is not magnetic

Repeat on their unknown minerals
 # 3 *is the only mineral that attracts a magnet*
Take out your sample #3, **DO NOT** say its name, and show the students that some minerals do actually attract a magnet, since all students won't have this sample.

Your Notes:

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F. Determination of the Unknown Minerals.

Pass out the **Properties of Minerals Handout** and tell students to use it to help them determine the names of their minerals. Circulate around the room while the students are working and help them as needed.

G. Acid Test

Explain the acid test:

There is an important group of minerals called "carbonates" which contain carbon and oxygen. Most tend to be fairly soft and whitish in appearance. Acid makes carbonates fizz and bubble. Geologists use dilute hydrochloric acid when they perform an acid test.

CAUTION: This acid must be used with care. The mixture contains only 0.5 M acid, but students should not be allowed to play around or squirt this on anything but the mineral. <u>If the class tends to be unruly</u> or if enough goggles are not available for the students, the VSVS volunteers should take the acid to the groups and put it on the minerals for them. Then the students can observe and record their observations.

Before any student touches the acid dropper bottle, make sure ALL students are wearing their goggles and continue to do so until the acid is removed from their tables!!!

Pass out the Goggles, acid, plates, and marble.

Explain to the students that marble is a type of rock, NOT a mineral. Explain that they will be testing the marble to see if it reacts with acid.

Tell the students to:

1. Put the marble on their plate.
2. Use the dropper bottle to ***carefully*** put a few drops of acid on the marble.
3. Use the hand lens to examine the marble to see if there is any sign of a fizzing or bubbling reaction.
   Students should see a bubbling reaction. Walk around the room to make sure everyone sees this reaction. Have them record their results on their observation sheet.

Your Notes:

Ask the students what they saw.
Tell them to use their **Properties of Minerals Handout** and see if they can determine what mineral is in the rock marble. *The answer is calcite*.
Have them record their answer on their observation sheet.
Ask the students:

Do you know of any other rock, which is common to Tennessee, that "fizzes" when acid is added? *limestone*
What mineral do you suppose is in limestone? c*alcite*

III. Optional Other Properties: Fluorescence & Color (If there is enough time)

Explain that some minerals are fluorescent. Shine the black light on the sample of Scapolite, which fluoresces a bright yellow under the black light. Explain that fluorescence is the absorption of UV light and then the emission of visible light that we can see.

One VSVS team member can take the black light and the sample of Scapolite around to each group, which fluoresces a bright yellow under the black light.
Another team member can take the box of sample colored minerals around to each group while **some** of the information about colored minerals is shared from the next page.

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We gratefully acknowledge the assistance of Professors Molly and Calvin Miller, Department of Geology, Vanderbilt University.

Your Notes:

Mineral Color Kit Information Sheet

How Minerals Are Colored

Share **some** of this information with the student groups as you show them the 12 mineral samples in the kit.

BACKGROUND INFORMATION ONLY: When light strikes the surface of a mineral, some wavelengths will be absorbed and some will be reflected. The color we see results from the combination of reflected wavelengths of light. Minerals that are colorless or white reflect the total spectrum of light.

For some minerals, color is a fundamental characteristic of its chemical composition. These minerals are termed idiochromatic, meaning that they will always display the same color. (Minerals 1, 2, 3 and 9.)

Certain metallic minerals with similar compositions but differing states of oxidation will exhibit different colors. (Minerals 5, 6, 7 and 10)

Many minerals contain trace elements in their composition which control their color. These trace elements are called chromophores. (Minerals 4 and 8)

Some minerals will display a range of colors due to the mixing of impurities. These impurities may be combinations of minerals or organic compounds.

	Mineral	**Color**	**Formula**	**Reason for color**
1.	Sulfur	yellow	S	chemical composition
2.	Pyrite	brass-yellow	FeS_2	chemical composition
3.	Fluorite	pink	CaF_2	chemical composition
4.	Beryl	green	$Be_3Al_2(Si_6O_{18})$	contain trace elements
5.	Magnetite	black	Fe_3O_4	oxidation state
6.	Olivine	green	$(Fe, Mg)_2SiO_4$	chemical composition
7.	Hematite	red	Fe_2O_3	oxidation state
8.	Quartz var. Rose (Titanium)	pink	SiO_2	contain trace elements
9.	Malachite	green	$Cu_2CO_3(OH)_2$	chemical composition
10.	Limonite	yellow-brown	$(Fe_2O_3H_2O)$	chemical composition
11.	Gypsum var. Selenite	colorless	$CaSO_4.H_2O$	chemical composition
12.	Halite	pink	$NaCl$	mixing of impurities

Name _____

Minerals Observation Sheet

Sample #	**1**					
Streak *What **color** is the streak when the mineral is rubbed on the tile?*						
Hardness *Start by trying to scratch the top item and stop when an item is scratched by the mineral. **Circle** the first item that is scratched and the number from the Mohs' scale that goes with it.*	Glass >5 Iron Nail 4-5 Copper 3-4 Fingernail 2-3 Nothing 1-2		Glass >5 Iron Nail 4-5 Copper 3-4 Fingernail 2-3 Nothing 1-2		Glass >5 Iron Nail 4-5 Copper 3-4 Fingernail 2-3 Nothing 1-2	
Cleavage or Fracture? Breakage Patterns *Does it appear to break/**cleave** in specific directions/shapes (breaks off in sheets, cubes, etc) or does it **fracture**/just break randomly/roughly?*	Cleavage Shape/# of directions: _____ OR Fracture		Cleavage Shape/# of directions: _____ OR Fracture		Cleavage Shape/# of directions: _____ OR Fracture	
Luster *Is it metallic or nonmetallic? If nonmetallic, is it dull, pearly or glassy?* ***Circle answers.***	Metallic	Nonmetallic	Metallic	Nonmetallic	Metallic	Nonmetallic
		Dull Pearly Glassy		Dull Pearly Glassy		Dull Pearly Glassy
Magnetic? *Is it attracted to a magnet? Circle.*	Yes OR No		Yes OR No		Yes OR No	
Mineral Name	**Hematite**					

1. What happened when you put drops of acid on the marble? _____
2. What mineral is in marble? _____
3. What other rock commonly found in Tennessee reacts like marble with acid?
   _____
4. What mineral is in this rock? _____