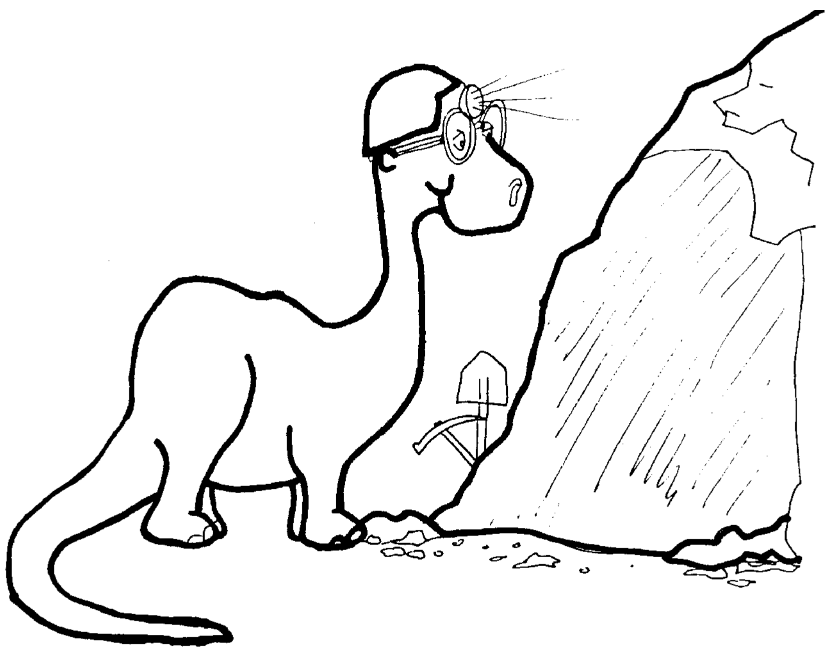
Rock Cycle

Understanding the Earth's Crust

SIXTH GRADE

MINERALS

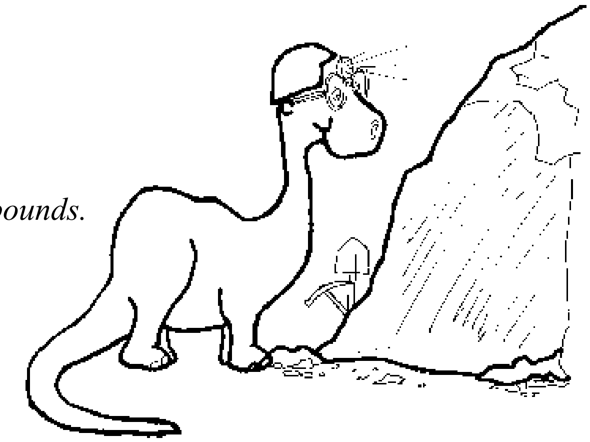


2 WEEKS
LESSON PLANS AND
ACTIVITIES

ROCK CYCLE

OVERVIEW OF SIXTH GRADE

CHEMISTRY



WEEK 1.
PRE: *Comparing different solutions.*
LAB: *Exploring how elements can be released from compounds.*
POST: *Analyzing the periodic table.*

MINERALS

WEEK 2.
PRE: *Exploring the composition of minerals.*
LAB: *Exploring the varieties of quartz.*
POST: *Exploring minerals made from silicon and oxygen.*

WEEK 3.
PRE: *Determining specific gravity.*
LAB *Predicting the use of minerals.*
POST: *Comparing an ore with a mineral.*

ROCKS

WEEK 4.
PRE: *Discovering how rocks are formed by plate tectonics.*
LAB: *Distinguishing where rocks are located within the rock cycle.*
POST: *Writing a creative essay on rocks.*

WEEK 5.
PRE: *Discussing decorative uses of rocks.*
LAB: *Distinguishing between adhesives and cements.*
POST: *Comparing mined resources in the United States.*

PAST LIFE

WEEK 6.
PRE: *Exploring the importance of fossils.*
LAB: *Interpreting cores to understand stratigraphy.*
POST: *Discovering how paleontologists document evolution.*

ROCK CYCLE - MINERALS (6A)

PRE LAB

Students study the chemical compositions of minerals.

OBJECTIVES:

1. Exploring the composition of minerals.
2. Distinguish elements that become positive or negative.

VOCABULARY:

charged
ions
mineralogy
negative
positive


Tiger eye, a form of quartz.

MATERIALS:

Gemstones Chart
Periodic Table Placemats
Gem Display Kit

BACKGROUND:

A mineral is a naturally occurring, inorganic element or compound with a definite chemical composition, a characteristic crystalline structure, and distinct chemical properties. The study of minerals is called mineralogy. It includes mineral identification and description, the classification of mineral groups, and the study of mineral occurrences.


Topoz

Gems are substances that have economic and aesthetic value. Most gems are minerals. However; some gems are organic substances such as amber, while others are rocks. Professionals who specialize in the study of gems are called gemologists.

Crystal form is the natural shape a mineral takes when it grows into open space. Crystal form reflects the elemental composition and arrangement of atoms within the mineral. However, most gems are cut or faceted to make attractive gems.

PROCEDURE:

1. Use the Gemstone Chart to help students visualize

gems as a combination of elements (compounds). The chart is arranged in "mineral families." Have the students find and list all the silicate minerals (containing Si and O).


Uncut diamond

2. Have the students list the other “mineral families” that are on the Gemstone Chart. These include corundum, turquoise, diamond, and spinel. Ask the students what the minerals in each “family” have in common. Students should recognize that the last part of the chemical formula (the “suffix”) is similar.

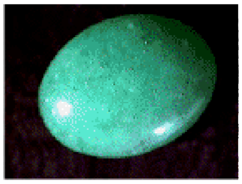
3. Ask students to find the most common elements used in the front or prefix of the chemical formulas. Al (aluminum), Mg (magnesium), Fe (iron), K (potassium), and Ca (calcium) are most common.

4. Have the students locate these elements on the periodic table. Have them determine if there are any consistent differences between the positions of the ‘prefix” and suffix”elements. They should see that most of the "suffixes" are in the right side of the table, and the "prefixes" are mainly on the left. This reflects how the elements combine to make stable compounds. The minerals on the left tend to be positively charged, while those on the right are negatively charged. They combine to make stable compounds.

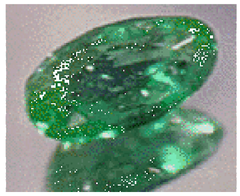
5. Have the students look at the different gems in the Gem Display Kit, and see how many of them are on the Gemstone Chart.

Gemstones

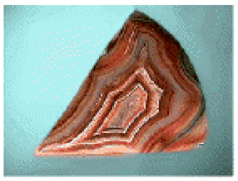
Silicate Gems



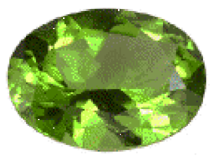
Adventurine - Quartz - SiO_2



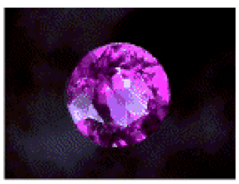
Emerald - Beryl
$Al_2Be_3(Si_6O_{18})$



Agate - Quartz - SiO_2



Peridot - Olivine
$(Fe,Mg)_2SiO_4$



Amethyst - Quartz - SiO_2

Opal - Opal
SiO_2nH_2O

Citrine - Quartz -SiO_2

Almandite - Garnet
$Fe_3Al_2(SiO_4)_3$

Tiger Eye - Quartz - SiO_2

Organic Gems

Pearl -
obtained
from a mollusk

Amber -
a resin of fossil trees

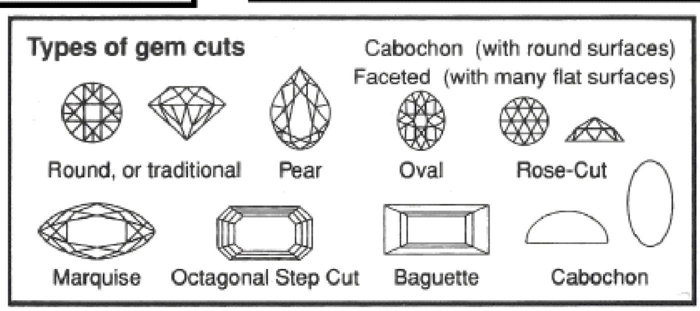
Other Gems

Ruby - Corundum
Al_2O_3

Sapphire - Corundum
Al_2O_3

Hematite -Hematite
Fe_2O_3

Diamond - Diamond
C



ROCK CYCLE - MINERALS (6A)

LAB

Students examine different forms of quartz.

OBJECTIVE:

1. Exploring the different varieties of quartz.
2. Discovering the importance of quartz.

VOCABULARY:

crystalline
mineral

MATERIALS:

Rock Cycle - Minerals (6A)
Gem Display Kit
food coloring
200 ml beaker
eye dropper

Many geodes are filled with quartz.

BACKGROUND:

Quartz is a very common mineral. It is composed of silicon and oxygen atoms, and has the chemical formula SiO_2 (silicon dioxide). Quartz is very hard (7 on the Moh's Hardness Scale). It grows in an easily recognizable hexagonal crystal habit. It fractures when broken, i.e., it does not have cleavage.

Quartz occurs in many varieties. Most common is the clear variety, which the ancient Greeks called "crystallos" or "clear ice." The word "crystallos" eventually evolved into the word "crystal." Depending on its color, which is caused by trace chemical impurities, quartz forms a great variety of gemstones including agate, amethyst, adventurine, bloodstone, smoky quartz, carnelian, citrine, onyx, rose quartz, and tiger's eye.

Quartz is a very important mineral commodity. It has many uses including applications in the computer, communications, food, and jewelry industries. Quartz is also the main component of the sand used to produce concrete and glass, as well as in sandpaper, sandblasting, and smelting.

Your students may be familiar with two other substances that are composed of silicon dioxide, obsidian and glass. While these materials have the same composition as quartz, they lack a crystalline structure, so they are not minerals. They are classified as amorphous solids.

PROCEDURE:

1. Get a beaker with water. Explain to the students that the water represents “pure” quartz because it contains no impurities. As they add food coloring to the water, explain how the resulting color change is analogous to colored quartz. Make sure they understand that a tiny, or trace, amount of color gives the whole substance a different look.

2. In exercise 2, have the students examine the following examples of silicon dioxide and describe their characteristics. They should also determine whether the substances are minerals, rocks, or amorphous solids.

ROSE QUARTZ - a mineral, a common gemstone; pink color caused by trace amounts of titanium
ADVENTURINE - a mineral, a common gemstone that has inclusions of mica and hematite imparting a green color to the stone
CLEAR CRYSTAL OF QUARTZ - a mineral, 6-sided crystal is the shape in which a quartz crystal grows
CHERT - a sedimentary rock, made of very fine quartz crystals; composed of fossil radiolarians (one celled organisms that make a skeleton of quartz)
CITRINE - a mineral, yellowish-brown color caused by high temperatures
AMETHYST - a mineral, purple color, caused by ferric iron in trace amounts
MILKY QUARTZ - a mineral, color caused by trace amounts of water inside the mineral
QUARTZ GEODE - a rock composed of many visible quartz crystals: formed in a rock cavity that slowly filled with quartz along its margins
OBSIDIAN - an igneous rock, non-crystalline silicon dioxide
GLASS - man-made, non-crystalline silicon dioxide
QUARTZ SANDSTONE - a sedimentary rock, composed of rounded quartz grains cemented together
QUARTZITE - a metamorphic rock, probably originally quartz sandstone, that has been subjected to extreme pressures and temperatures
QUARTZ SAND - rounded quartz grains not cemented together

3. The students should conclude that quartz is a very common mineral that can occur in a wide variety of forms. It sometimes makes up gems, or entire rocks like quartzite or quartz sandstone. The reason quartz is found in many materials is that quartz is hard and thus lasts longer than most minerals.

ROCK CYCLE - MINERALS (6A) LAB

PROBLEM: Why is quartz found in many different colors?
PREDICTION:____
PROCEDURE:

Exercise I. The bottle of food coloring that you have represents a "pure" form of one element. The following volumes of food coloring represent a "trace" amount. The water represents quartz and the food coloring represents another element.

1. What happens when you put 1 drop of food coloring into 200 ml of water?
____

2. What happens when you put 4 drops of food coloring in the same 200 ml of water?
____

Exercise II. The samples that you have are composed mainly of silicon dioxide. Can you figure out what is in the various samples? Use the hints below to help.
rose color = titanium; purple or violet = iron; colorless = pure silicon dioxide; milky = fluid (not cause by an element); green = caused by small flakes of mica and hematite

SAMPLE	CHARACTERISTICS
rose quartz	
adventurine	
crystal	
chert	
citrine	
amethyst	
milky quartz	
geode	
obsidian	
glass	
quartzite	
quartz sand	
quartz sandstone	

CONCLUSION: What is similar about the different forms of quartz you examined? What is different?____
____

ROCK CYCLE - MINERALS (6A)

POST LAB

Students make a model of the silica tetrahedron.

OBJECTIVES:

1. Combining elements to form different minerals.
2. Exploring minerals made from silicon and oxygen.

VOCABULARY:

element
mineral

MATERIALS:

worksheet
Googoplex

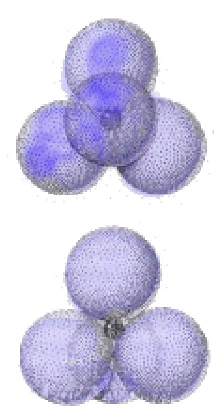
BACKGROUND:

Large crystal of quartz (about 1 meter)

Quartz is a silicate mineral. All silicate minerals share the same basic building block elements: silicon (Si) and oxygen (O) in the molecular configuration SiO_4. This compound is called silica and referred to as a silica tetrahedron. as shown below. The large ball represents oxygen and the smaller ball represents the silicon. These oxygen atoms define a tetrahedral shape, with one oxygen atom at each points.

mica is a sheet silicate

Silicate minerals occur in a great variety because, in addition to joining with other elements, silica tetrahedra can join with each other, creating rings, chains, double chains, sheets, framework, and other three dimensional silicate structures.



Silica tetrahedron

PROCEDURE:

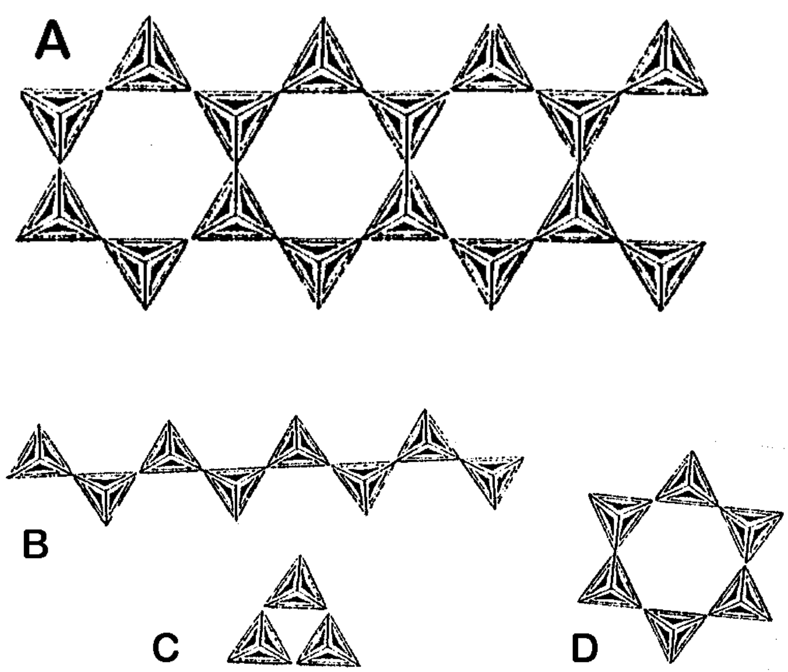
1. Students can discover just how many tetrahedra combinations are possible. Each pyramid on the sheet represents a silica tetrahedron. Have them cut out the separate silicon tetrahedron.

2. Make them arrange the pyramids into a pattern that can repeat itself. The different patterns would be equivalent to some type of silicate minerals.

3. If you have Googolpex, have the students construct three-dimensional tetrahedron models. Have them point out where the oxygen and silicon atoms are located. With both the Googolplex and paper models the corners represent the oxygen atoms. The centrally located silicon atom is not present, but tell the students to assume it is inside the structure.

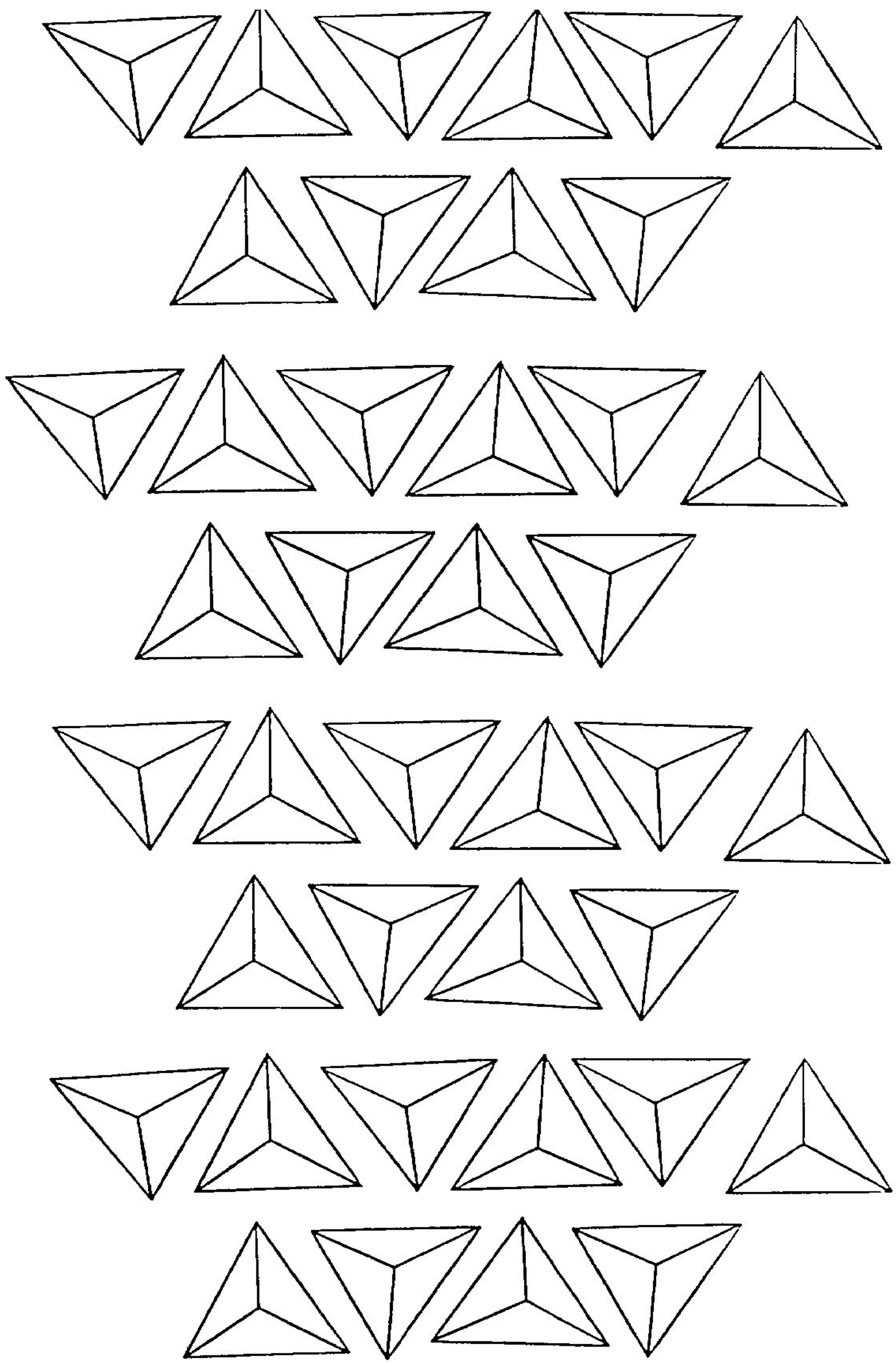
4. Review the tetrahedra combinations made by the students. Explain that these represent just a small portion of the many silicate minerals that are present in the Earth's crust. These make up the thousands of silicate minerals.

"A" represents a sheet silicate; "B" represents a chain silicate; "C" represents a single or double: and "D" represents a ring silicate.



ROCK CYCLE - MINERALS (6A) - POST LAB

SILICON TETRAHEDRON



ROCK CYCLE - MINERALS (6B)

PRE LAB

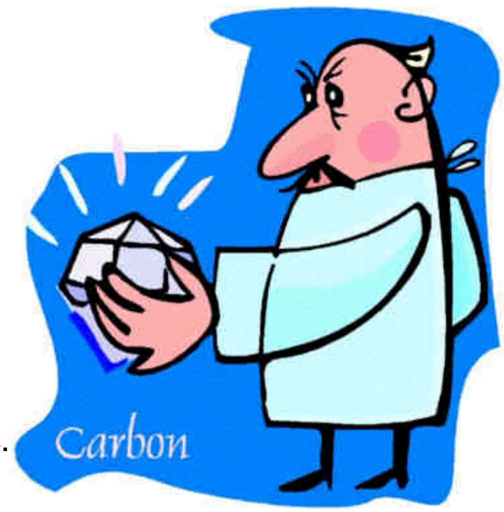
Students determine the specific gravity of minerals.

OBJECTIVES:

1. Determining specific gravity.
2. Distinguishing between weight, density, and specific gravity.

VOCABULARY:

density
specific gravity
weight



MATERIALS:

graduated cylinders
mineral specimens
small items like nails, washers, pennies, etc.

BACKGROUND:

The specific gravity, or relative density, of a mineral is a comparison of the weight of a given volume of a mineral to the weight of an equal volume of water. If a mineral has a specific gravity of 2, this means a given specimen of that mineral weighs twice as much as the same volume of water. The specific gravity of a mineral depends on the elements which compose it and how closely the atoms of those elements are packed together. For example, the specific gravity of lead is much higher than the specific gravity of silicon because lead has a higher atomic weight. Likewise although diamond and graphite are both composed of carbon, diamond has a higher specific gravity because its carbon atoms are packed very closely together.

Specific gravity is very useful in distinguishing minerals. If a mineral has a high specific gravity it will feel heavier than another mineral of the same size. Gold, for example, has a higher specific gravity than pyrite or “fools’ gold.”

Density and specific gravity are sometimes used interchangeably. However, density is a measurement of the weight of a substance per some unit volume grams per cubic centimeter, whereas specific gravity is a ratio with no units. Specific gravity is a relative measurement. Weight is also different from specific gravity. Weight is the heaviness of something, measured in pounds or grams, with no relationship to a given volume.

PROCEDURE:

1. Explain the differences between specific gravity, density, and weight.

2. Have students compare the specific gravity of mineral samples. This is accomplished by comparing two samples that are roughly the same size. Have the students hold one sample in each hand; the one that feels "heavier" has a higher specific gravity. Have the students rank the samples from highest to lowest specific gravity.

3. You may want students to bring 10 small items that are all about the same size from home, such as like nails, screws, or buttons. Have them arrange the objects in order from highest to lowest specific gravity. It may help to have students work together. The more a student compares and contrasts the specific gravity of different objects, the easier it will be for them to determine the specific gravity of minerals. Geologist develop a "feel" for the specific gravity. Early miners knew that gold was heavier, and could easily make the comparison as they learned to distinguish gold from pyrite. Your students need to be miners, and acquire the technique.

ROCK CYCLE - MINERALS (6B)

LAB

Students determine the key characteristics of minerals.

OBJECTIVES:

1. Identifying the key characteristics of minerals.
2. Predicting the uses of minerals.

VOCABULARY:

hardness
specific gravity
streak

MATERIALS:

Rock Cycle - Minerals (6B)
ceramic tiles (or streak plates)
steel nails
pennies
magnets and hydrochloric acid (optional)


Marcasite has characteristic color and fibrous habit.

BACKGROUND:

Students have learned that minerals are identified by their key characteristics. In this lab, students will record the hardness, specific gravity, and any other characteristics that may be important for determining the use(s) of the mineral.


Tremolite has characteristic crystal shape and green color.

Key characteristics are unchanging properties of a substance. They can thus be reliably used to identify that substance. Minerals have key characteristics. These include:

A. CRYSTAL FORM - The natural growth (shape) of a mineral. Minerals take this shape whenever they are able to grow into open space. The crystal form of a mineral often has many smooth, planar surfaces called "faces" that meet at characteristics angles (i.e., halite meets at right angles; quartz meets at 120 degrees).

B. FRACTURE AND CLEAVAGE -The way a mineral breaks. Fracture is irregular breakage. For example, quartz has a conchoidal fracture. Quartz breaks along hollowed and rounded, uneven surfaces. Cleavage is a regular breakage that follows the atomic structure of a mineral. Cleavage results in smooth, planar surfaces. Different minerals may have one, two, three, four, or six cleavages.

C. HARDNESS - The mineral's resistance to scratching. It is controlled by the strength of atomic bonds within the mineral. Mineral hardness is rated from 1 (soft) to 10 (hard) on the Mohs' hardness scale.

D. SPECIFIC GRAVITY - The density of a mineral relative to water. Metallic minerals often have high specific gravities.

E. STREAK - The color of a powdered mineral sample. Streak is determined by scratching the mineral sample on a piece of unglazed porcelain (a streak plate). Most metallic minerals produce a colored streak.

F. LUSTER - The way that a mineral reflects light. There are two types of luster. Metallic minerals look like shiny or rusted metal. Nonmetallic elements reflect light like glass or pearls or glue.

G. TASTE - Certain minerals like halite (salty) and sulfur (bitter) have characteristic "flavors."

H. MAGNETISM - The attraction of a mineral to a magnet.

I. REACTION TO ACID - The mineral reacts by "fizzing" with dilute HCl reacts with carbonate minerals.

PROCEDURE:

1. Before lab, prepare mineral specimen collections and testing materials for each student group. Use the Rock Cycle - Minerals (6B) samples or your own materials. If you are not familiar with any of the properties discussed above, you may wish to experiment on your own before lab.

2. Review the key characteristics of minerals. Discuss with students how to determine each key characteristic. They should be able to test for hardness, streak, specific gravity, and luster. Magnetism and reaction to acid can be tested as well, if the proper materials are available.

Hardness is determined by scratching the mineral with a steel nail, a penny, and a fingernail. If a steel nail cannot scratch the mineral, it is 6 or higher on the Moh's Hardness Scale. If your fingernail cannot scratch it, it is more than 2, and if the penny cannot scratch it is more than 3.5 on the Mohs' scale. Students will thus be able to roughly estimate hardness; this is exactly what geologists do when conducting field research.

Streak is determined by scratching the mineral on the porcelain plate. Most streaks are


Kyanite

white and not very useful for identification. However, most metallic minerals have colored streaks, which are often a diagnostic characteristic.

Students will be able to distinguish the specific gravity of a mineral as its being "heavy" (high specific gravity) or "light" (low specific gravity). In general, metallic elements will seem heavy.


Bornite

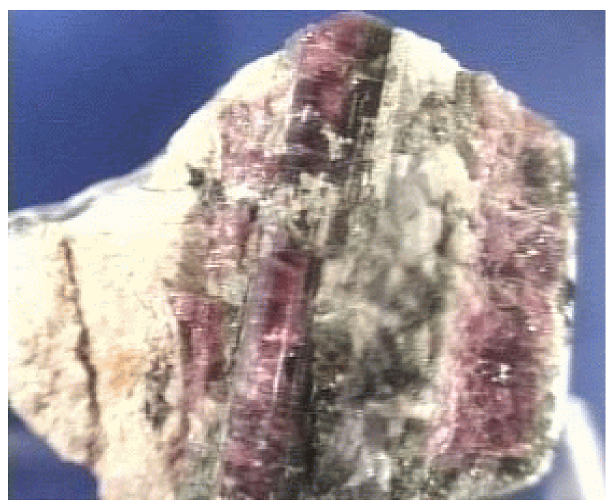
3 Have the students work through the samples and try to identify as many properties as possible for each mineral. Make sure they record their observations.

4. On the worksheet, the chemical formula for the minerals is also given. Students can look at the formula and see if there are any useful elements within the structure of that mineral.

5. Here are some suggested answers:

KYANITE - Al_2SiO_5, hardness 5-7 (depending whether you scratch lengthwise); used in spark plugs and porcelains

FLUORITE - $CaF_{2,}$ hardness 4, specific gravity 3.18; flux for making steel, used in the glass industry, and as a source of fluorine for hydrofluoric acid


Tourmaline

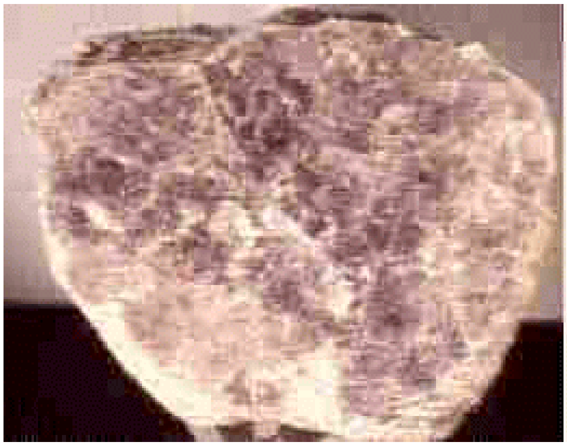
QUARTZ - SiO_2, hardness 7, specific gravity 2.65; used in clocks, glass, computers, abrasives, optical and scientific apparatus

PYRITE - FeS_2 (fold's gold); hardness 6-6.5; source of sulfur

GALENA - PbS (ore of lead); streak - lead gray; specific gravity 7.4 - 7.6

BORNITE - Cu^5FeS_4, ore of copper; hardness 3; "peacock ore," bronze color, purple tarnish, specific gravity around 5

HEMATITE - Fe_2O_3, hardness 5.5-6.5 (used for red coloring in some make-up)


Lepidolite

COPPER - Cu (used for tubing, etc.); hardness 2.5-3

ULEXITE - $NaCaB_5O_9$ $8H_2O$; hardness 2.5; crystallizes in arid region; a source of borax

TOURMALINE IN LEPIDOLITE - Lepidolite $K_2Li_3Al_3$ $(AlSi_3O_{10})$, hardness 2.5-4; color lilac, flat cleavage, in small plates; source of lithium, used in heat resistant glass

TOURMALINE - complex silicate of boron and aluminum; hardness 7-7.5, crystals usually prismatic, semiprecious gem stone, pink tourmaline is known as rubellite; strong piezoelectric property is used in the manufacture of pressure gauges.

ROCK CYCLE - MINERALS (6B) LAB

PROBLEM: How can properties of different minerals help predict the use of that mineral?

PREDICTION:____

PROCEDURE: Write as many characteristics of a particular specimen as you can and predict possible uses of that mineral and why you think it might have that use.

MINERAL	HARDNESS	OTHER	POSSIBLE USES AND WHY
1. **KYANITE** Al_2SiO_5			
2. **FLUORITE** CaF_2			
3. **QUARTZ** SiO_2			
4. **PYRITE** FeS_2			
5. **GALENA** PbS			
6. **BORNITE** Cu_5FeS_4			
7. **HEMATITE** Fe_2O_3			
8. **COPPER** Cu			
9. **ULEXITE** $NaCaB_5O_9$			
10. **TOURMALINE IN LEPIDOLITE** Lepidolite $K_2Li_3Al_3$ $(AlSi_3O_{10})$			

CONCLUSION: Can you tell if a mineral is useful just by looking at it?
____

ROCK CYCLE - MINERALS (6B)

Students discuss the origin of metals and their compositions.

POST LAB

OBJECTIVES:

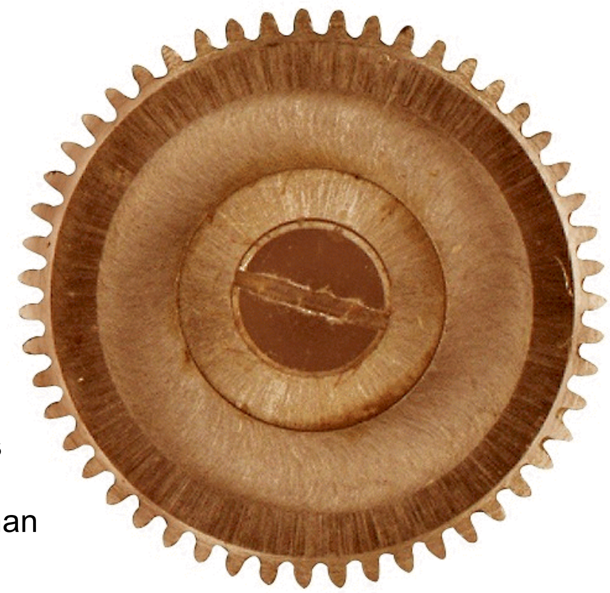
1. Comparing an ore with a mineral.
2. Exploring metallurgy.

VOCABULARY:

metallurgy
mineral
ore

MATERIALS:

specimens of steel, bronze, or other metals
Periodic Table Placemats
Early Humans (Eyewitness) by Nick Merriman
Internet



Bronze

BACKGROUND:

An ore is a mineral deposit which contains economically valuable minerals that can be mined at a profit. The ore can contain metallic elements as well as nonmetallic elements. Ores of metals include bauxite for aluminum, hematite and magnetite for iron, galena for lead, cinnabar for mercury, pentlandite for nickel, cassiterite for tin, ilmenite for titanium, and wolframite for tungsten. Igneous, sedimentary, and metamorphic rocks can all form ores.

After an ore is mined, the desirable minerals or elements must be extracted from it. Extraction methods include crushing, sieving, density separation, and magnetic separation. The result is a concentration of a large quantity of the desired material. If the material is a metal, the minerals are then melted and the metal can be retrieved through smelting. Later, many smelted metals are mixed with other metals or nonmetals to form alloys, which have different useful properties.

Metals have been very important in the evolution of the human society. The malleability, strength, sharpness, and beauty of various metals allowed early humans to fashion tools and jewelry. Prior to 3000 BC it was discovered that copper could be produced by heating a certain type of bright blue stone in a fire. This was the accidental beginning of smelting. Bronze, composed of copper that has been melted and mixed with tin, became widespread around 2000 BC. The resulting alloy was stronger than pure copper, and could be sharpened, melted and recast into desirable shapes. By 750 BC, iron replaced bronze as the "metal of choice," thus beginning the Iron Age.

PROCEDURE:

1. Metallurgy is the science of metals. Have the students look at the elements on the Periodic Placemat. They will notice that there are more metals than any other type of element. Of the 90 naturally occurring elements 70 are metals. In ores, many of these elements are found as native elements: minerals composed of only one element.

2. Use the placemats to point out the metallic elements. Give the students examples of metal alloys:

steel is 98% iron and 2% carbon;
brass is 70% copper and 30% zinc;
bronze is 90% copper and 10% tin;
solder is 50% tin and 50% lead;
pewter is 91% tin, 7% antimony, and 2% copper;
stainless steel is 74% iron, 18% chromium, and 8% nickel; and
sterling silver is 93% silver, and 7% copper.

Make sure the students understand that these alloys are common and that they see them all the time. Make sure they know that they are metals derived from ores enriched with minerals containing metallic elements.

3. Students also see the term "cast" and "wrought" iron in everyday life. These terms refer to different ways of working with iron. Cast iron has a carbon content of 2-4%. Cast iron is poured into a cast and hardened. Wrought iron on the other hand is shaped by rolling, pressing, forging, or stamped at normal or elevated temperatures. Wrought iron is stronger than cast iron.

4. The Eyewitness book, *Early Humans*, explains the progression of metals used in early society. You may want students to bring in different examples of these metals. If you have Internet access you may want students to search for "The Bronze Age," "The Iron Age," and even the "Stone Age." to learn more about early metalworking.