MINERALS

Teacher Guide

including

Lesson Plans, Student Readers, and More Information

Lesson 1 - What is a mineral?

Lesson 2 - Mineral Characteristics Lab

Lesson 3 - Family of Minerals

Lesson 4 - Uses of Minerals

Lesson 5 - Borate Minerals

designed to be used as an Electronic Textbook
in class or at home

materials can be obtained from the Math/Science Nucleus

EARTH SCIENCES

INTEGRATED SCIENCE, MATH, AND TECHNOLOGY
Electronic Text and Laboratory Exercises

by
Joyce R. Blueford, Ph.D.

ART WORK: Joyce R. Blueford, Scott Hassler
WEB ART: Doris Raia
WEB DESIGN: David Lundeen, Doris Raia

CONTRIBUTORS:

Scott Hassler, Ph.D. Geology
Joy Lopez, M.S. Technology Education
Eleanor Kohnen, B.S. Biology
Christine Souza, M.A. Business

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The labs in the secondary school science program were originally created for junior high students in the Ravenswood School District, East Palo Alto, California. As more children in the district participated in the K-6 Integrated Science, Math, and Technology program there was a need for a challenging junior high program. Hewlett Packard had generously donated funds to create a new laboratory classroom. The district, under Superintendent Charlie May Knight contracted out to the Math/Science Nucleus to create a hands-on experience for students twice weekly to go along with the California Science Framework.

Our goal was to work with the Ravenswood teachers, to get their feedback as we piloted with students. Drs. James Gonzales and Joyce Blueford worked with the teachers and content consultants to create a series of initial labs. For over 5 years we refined and developed the labs.

Consequently, other school districts that used our program urged us to continue refining the lesson plans. Over the last 10 years several teachers have continued to use and help refine the materials, notably Eleanor Kohnen (St. Joseph's School, Fremont) and Joy Lopez (Holy Spirit, Fremont).

The Earth Science labs and electronic text were adapted from a college freshman class in geology. Dr. Blueford had realized that many college students did not have the basic skills to enjoy Earth Sciences. These labs and electronic text were designed to prepare students to understand and enjoy the Earth around them.

GRAPHICS

We would also like to thank the following organizations, companies, and individuals who have provided graphics for this electronic version.

- ArtToday, http://www.arttoday.com
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- Jet Propulsion Lab, http://www.jpl.gov
- U.S. Geological Survey, http://www.usgs.gov

EARTH SCIENCES - MINERALS

Lesson 1 - What is a Mineral?

MATERIALS:

reader

Objective: Students learn the properties of minerals.

Teacher note

Minerals are the a basic building blocks of rocks. Minerals have a definite chemical composition with an internal crystalline pattern. Minerals have to be natural or else they are classified as man-made and inorganic in origin.

Rocks are a combination of minerals. Certain groups of minerals indicate certain temperatures and pressures, so the history of the rocks can be interpreted. Minerals are economically important as gems, metals, abrasives, fertilizers, and many other commodities. Historically minerals have played an important part in the settling of the western United States with the discovery of gold. Wars have been fought over the right of minerals.

Students should read the information and discuss the information. The following websites may be useful.

http://www.cobweb.net/~bug2/rock1.htm - "The Rock Doctor". A good detailed description of mineral characteristics. Also has sections on rocks.

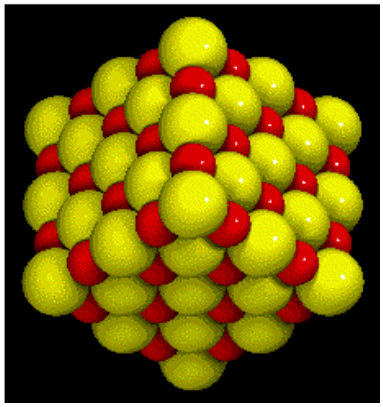
http://csm.jmu.edu/minerals/ - an online mineral museum at James Madison University. Excellent photographs.

Minerals are nature's way of creating large pieces of pure elements and compounds. In medieval times, kings and queens would seek out "alchemists" to create gold, silver, and other precious minerals from chemical "magic."

Minerals have always been important when their uses were discovered. Pieces of quartz could be rubbed together and produce sparks to create fire. Gold could be hammered into thin sheets that could be made into useable items without fear of breaking or rusting. Mineral wealth, even today, reveals a country's economy and their ability to sell or create products.

The study of minerals is called **mineralogy.** It includes mineral identification and description, the classification of mineral groups, and the study of where minerals occur.

Mineralogists use a very specific definition of a **mineral**. Minerals must be created by nature. If they are made by human intervention they are referred to as "man-made." Minerals are *inorganic*, meaning that they are made from nonliving matter.



The crystal structure of halite. Red = Na, yellow = Cl

Minerals have an internal, **crystalline** structure. Molecules that make up the mineral are arranged in a set pattern. This crystalline structure is sometimes reflected as a crystal, if the mineral is given room to grow. However, even organic substances can grow crystals. For example, sugar which is organic, can make sugar crystals commonly called "rock candy." So not all crystals are minerals.

Minerals have a *definite chemical composition*. Minerals are always composed of the same elements. Minerals are rarely composed of one element. These **native minerals,** include gold, silver, copper, and sulfur. However, most minerals are made of compounds (combinations of two or more different elements). For example, **halite (NaCl)** or table salt, is always composed of only two elements, sodium (Na), and chlorine (Cl). Geologists classify minerals into **chemical families** based on their compositions.

Calcite - non-metallic luster

The characteristics of a mineral that enables us to distinguish it from other substances are known as properties. Mineral properties can include **color**, **hardness**, **specific gravity**, **streak**, **luster** and even **taste**. Certain properties are characteristic of certain minerals, which makes identification easier. For example, a salty taste is usually halite. However, most minerals require several properties to identify it. So it is important to learn the logic of mineral identification.

Copper - metallic luster

Whenever a geologist picks up a specimen, there are some logical steps that they consider. They try and eliminate a group of minerals quickly by performing simple tests. Let's go through a situation of identification and then we will learn in detail some of these characteristics.

Dr. Gladenkov, a Russian geologist, is working on an island in east Russia called Sakhalin. He has taken some American geologists to understand the geology of the island. Buried in weathered rock you can find very pale blue mineral crystals. He calls the mineral glenonite, but none of the American geologists ever heard of such a mineral. It scratches easily with the steel knife, but is harder than a fingernail. Its crystalline structure resembles calcite, another common mineral. However, when you drop some HCl acid on the specimen is does not fizz. So it is not related chemically to calcite.

When the American geologists return home, they research the mineral. They find out that glenonite is rare, and is formed in cold water. The mineral found on Sakhalin was indeed glenonite.

Talc, Ropes Mine, Michigan can be scratched with a fingernail.

In this example, the first test performed was hardness which is a mineral's resistance to scratching. If steel can scratch it, you can eliminate quartz. If the steel knife can't scratch it, it probably is quartz. Mineral hardness is rated from 1 (soft) to 10 (hard) on the **Mohs hardness scale**. Most geologists use common objects such as a steel knife to determine the hardness of minerals. Steel has a Mohs hardness of 5.5. If a mineral is scratched by a knife, it is softer than 5.5. If the mineral scratches the knife, it is harder than 5.5.

Each number on the Mohs scale has a specific mineral associated with it. For example, talc has a hardness of 1, while diamond's hardness is 10.

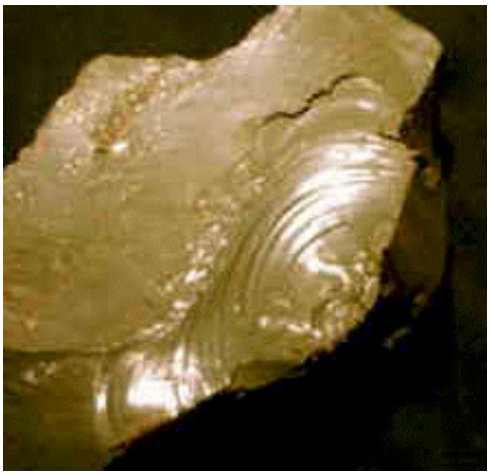
Hardness	Reference Mineral	Common Object
1	Talc	
2	Gypsum	Fingernail (about 2.5)
3	Calcite	
4	Fluorite	
5	Apatite	Steel Knife (about 5.5)
6	Feldspar	
7	Quartz	
8	Topaz	
9	Corundum	
10	Diamond	


Quartz crystal

A mineral's **crystal form** and how a mineral breaks is also helpful in determining a name. For example, if you see a shape that is long with 6 sides that form a point, you probably have a quartz crystal. However, if someone broke or fractured the crystal it would look like little pieces of broken glass.

The crystal form is the natural shape of that mineral if allowed to grow without restrictions. Finding crystals is not easy. The conditions have to be just right for crystals to grow.

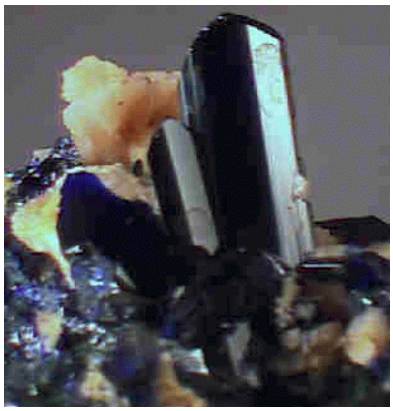
Mineral tend to break in a characteristic pattern. **Fracture** is irregular breakage, like quartz has a **conchoidal fracture** breaking along hollowed and rounded, uneven surfaces. **Cleavage** is a regular breakage that follows the atomic structure of a mineral. Cleavage results in smooth, flat surfaces. Different minerals may have one, two, three, four, or six cleavages. Calcite will break into perfect rhombohedrons.


Conchoidal fracture

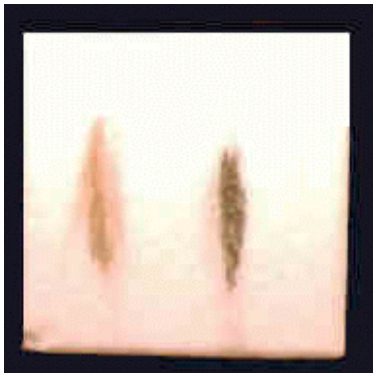

Magnitite

Specific gravity or the **density** of a mineral relative to water, is helpful in the case of some minerals like gold or galena, that have a high specific gravity. The attraction of a mineral to a magnet (**magnetism**) is helpful especially for the mineral, magnitite which is naturally magnetic.

Some minerals that belong to the carbonate mineral family fizz when a drop of dilute HCl (acid) is put on it. Certain minerals like halite (salty) and sulfur (bitter) have characteristic tastes.

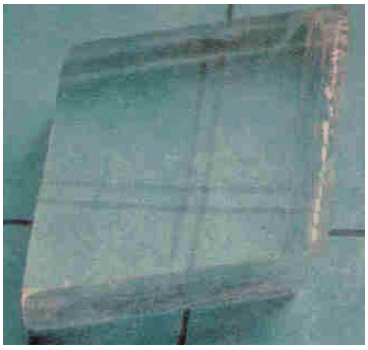

Azurite

Many properties that help identify a mineral are related to light. **Luster**, is 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, pearls, or glue. The color of a mineral is sometimes very helpful. For many minerals with a metallic luster, color is an important means of identification. The lead gray of galena, the brass yellow of pyrite, or the blue of azurite are very diagnostic. However, many times the color may tarnish so it is important to look at a fresh surface.


Streak

The color of a fine powder of a mineral is a known as its **streak**. You can use a porcelain plate to scratch a mineral to observe its streak. Hematite has a characteristic red-brown streak, no matter what form hematite comes in.

The **refraction** of light is important in a few minerals, especially calcite. It produces an image that is doubled.


Calcite - double refraction

EARTH SCIENCES - MINERALS

Lesson 2 - Mineral Characteristics (Lab)

MATERIALS:

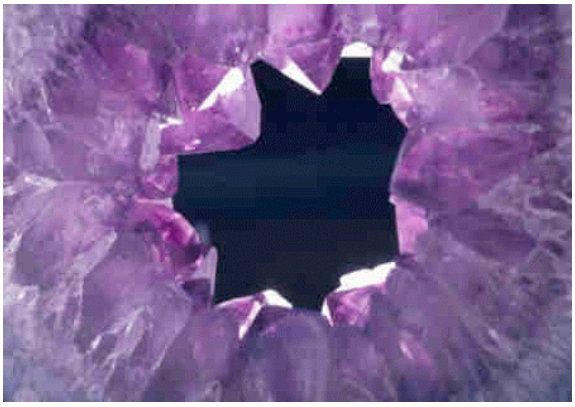
Earth Sciences-MINERALS
streak plate
HCl (dilute)
steel nail
periodic table

Objective: Students identify minerals by using different tests.

Teacher note

Students look at each of the specimens and answer the appropriate question. This lab tries to familiarize students with each of the minerals. It is not just guessing the name of a mineral, but a more realistic way of identifying minerals. These labs are meant to simulate their interest. Students should have read "What is a mineral?" before completing this lab. Make sure that the students know the names of the minerals. Some of the answers can be found in the written materials. The information in "Background Information" can help make these minerals more alive for the students. Remember either "You grow it or you mine it."

You may wish to set up a station in which you can demonstrate how calcite "fizzes" when a drop of HCl touches it. You can set this up as a demonstration at Station #9, depending on your students. If you allow students to perform this test, make sure students clean the specimen with water. Before beginning the lab, demonstrate how to make a streak on a streak plate. Answers are given at the end of this section.



Amethyst - a variety of quartz

The study of minerals can be a life long hobby. Some people are amazed at the natural **symmetry** of crystals, while others are thrilled at the spectacular glitter or color of some minerals.

The following lab invites you to learn about each of the minerals in more detail. Remember through reading the paragraphs on the mineral and observing and performing the tasks asked for, you can learn secrets of minerals that were once only the privilege of the rich.

EARTH SCIENCES - MINERALS Mineral Characteristics

PROBLEM: How can you distinguish different minerals?

HYPOTHESIS:

MATERIALS:
mineral samples, streak plate. HCl (dilute), steel nail, periodic table**,** small piece of quartz

PROCEDURE:
Look at your mineral specimens and answer the following questions.

1. **FLUORITE** is made up of calcium fluoride (CaF_2) which usually grows in cubic crystals. It breaks into 8 different faces to give a diamond look (octahedral cleavage). Fluorite can be found in many colors, and can be scratched by a steel knife. Fluorite is a common mineral, that is found all around the world. In the United States the best known location is in southern Illinois and northern Kentucky. Fluorite is used in making steel, in decorative glass, in enameling cooking utensils, and for hydrofluoric acid. The name comes from the Latin *fluere*, meaning to flow since is melts easier than other minerals.

A. Look at the 2 types of fluorite. Describe their shape.

B. The pieces of both types of fluorite have been broken. When a mineral breaks into smooth surfaces this is called “cleavage.” What word do you think cleave is derived from? Explain.

C. What do the two specimens have in common?

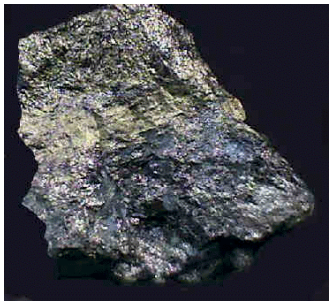
D. Fluorite is calcium fluorite. What elements make up fluorite? (Hint: use your periodic table)

E. Is fluorite harder or softer than quartz?

F. How can you tell?

G. Do you think color is a key characteristic of fluorite?
Why?

2. **BORNITE** (Cu_5FeS_4) is a copper ore that rarely is found in crystal form. Bornite is usually found associated with other copper minerals. Bornite when exposed to the atmosphere will tarnish blue to purple. It's primary use is as an ore of copper. Bornite is named after the German mineralogist von Born.



A. Bornite is a copper compound that is called the "peacock ore." Why is bornite called the peacock mineral?

B. Bornite chemical composition is Cu_5FeS_4. Write out the elements that are in Bornite. Can you guess why it makes this "tarnish" color?

3. The **FELDSPARS** $(K,Na,Ca)(Al)Si_3O_8$ are an important group of rock forming minerals. They have complex compositions, but most commonly contain potassium (K), sodium, calcium, aluminum, and silica. Feldspar are usually light in color, ranging from pink to white.

A. What elements are in feldspar?

B. Is feldspar harder or softer than quartz?
How can you find out?

C. Does feldspar show cleavage?
How do you know?

4. **TALC** is a combination of magnesium, silica, and water. It has the chemical formula $Mg_3Si_4O_{10}(OH)_2$ (the OH stands for water in this formula). Talc is very soft , and samples often have a greasy or soapy feel. Talc is used for carving, to make ceramics, in the process of making rubber and of course to make talcum powder!

A. Is there something that you might put on a baby's bottom that resembles talc?
What is the name of the item?

B. Describe the feel of the mineral.

C. Is talc soft?
How can you tell?

5. **COPPER** (Cu) is an element but also a mineral. Crystals of copper usually occur in malformed and branching groups. Native copper is found in northern Michigan, Bolivia, Arizona, New Mexico, Chile, and Mexico. Native copper is used to obtain copper, but most commercial copper is from other ores.

A. This is called native copper. Is it a compound or an element?

B. Are there many minerals that are both an element and a mineral? Name some.

C. Describe the color and luster of copper.

D. Where is copper used?

6. **GYPSUM** ($CaSO_4 \cdot H_2O$) has a tabular crystalline structure and breaks in thick sheets. There are several forms of gypsum that have different uses. Alabaster is a fine grained variety of gypsum used by sculptors because it is soft and easy to carve. Gypsum is a common mineral found in sedimentary rocks. It is a calcium sulfate whose use is mainly in the production of plaster of Paris which is used in wall boards and other building materials. Gypsum is also used as a fertilizer and used in making concrete.

A. Is gypsum harder or softer than quartz?

B. How can you tell?

C. Describe the shape. Do you think it was broken or formed as a crystal? Why?

D. If you were naked on an island, and you found a mineral that you suspected was gypsum. How could you tell if it really was gypsum?

7. **PYRITE** is usually found in crystals that are either cubic or octahedral. The chemical formula of pyrite is FeS_2. People commonly mistake pyrite for gold, hence its nickname "fool's gold." However, pyrite is a brassy color, while gold is yellow. The name pyrite is from the Greek word meaning fire, because it gives off sparks when struck with steel. Pyrite is used mainly to obtain sulfur for sulfuric acid.

A. What other mineral does pyrite resemble?

B. Describe pyrite's crystal form?

C. Use a streak plate (unglazed side) and determine the color of pyrite's streak.

D. Describe pyrite's luster.

E. What is the common name for pyrite?

8. **HEMATITE** is an iron oxide mineral with the formula Fe_2O_3. It occurs in different forms including gray-silvery metallic hematite and dull red earthy-looking hematite. Hematite can easily be identified by its brown red streak. Hematite is an important ore of iron, and is also used in making colors, such as red ocher and as a polishing powder.

A. Describe the two types of hematite. Why do you think that they are different?

Specular hematite (metallic)

B. Describe the color when hematite is "streaked" on a porcelain plate.

C. Describe the luster and color of your specimens of hematite.

D. Why do you think hematite is called "hematite?" (Clue hema = blood)

9. **CALCITE** ($CaCO_3$) is a form of calcium carbonate ($CaCO_3$). Calcite crystals occur in a wide variety of shapes, but they all show calcite's characteristic rhombohedral cleavage. These are often called "rhombs". Large chemically pure and optically clear crystals of calcite are called "Iceland spar" after a famous occurrence in Iceland. "Dogtooth" calcite is actually a row of calcite crystals which look like teeth. Calcite will "fizz" when a drop of HCl acid is put on it. The most important use of calcite is in the manufacture of cements, which are used to make concrete.

A. What shape is this piece of calcite?

B. What happens when a clear rhomb of calcite is placed over a word?
This is a property called double refraction.

C. Is the rhomb a crystal or did it cleave (break) in this manner?
Can you really tell?

10. **MICA** ($K(Mg, Fe)_3(AlSi_3O_{10})(OH)_2$) belongs to a very complex chemical group. In spite of this, mica is easy to identify, because it has a characteristic way of cleaving into sheets. This is an example of one cleavage. Mica is chiefly used as an insulating material in the manufacture of electrical equipment. Because mica is fireproof it has been used for stove doors, lanterns, and even toasters. The shiny look in wall paper is caused by bits of ground mica crystals.

A. How does mica break?

B. Is mica softer or harder than quartz? How can you tell?

C. Describe mica.

11. **QUARTZ** is composed of silicon and oxygen, and has the chemical formula SiO_2. It is the most common mineral found within the crust of the Earth. Quartz crystals commonly have a **prismatic** shape and are six sided. Quartz has a characteristic look when it breaks called a **conchoidal fracture** (like a scooped out section). It is a very hard mineral and usually can be identified by the fact that quartz scratches steel. Quartz has many uses ranging from gemstones, optical, scientific apparatus, radios, and watches. It is also used to obtain silicon which is important in the computer industry.

A. Examine the quartz crystal. How many sides does it have? Are these created by cleavage or are they formed by crystal growth?

B. Is quartz harder or softer than a steel nail? How do you know?

C. What happens to a quartz crystal if it breaks?

D. Compare the quartz crystal to the other quartz samples. How are they different and similar?

quartz crystal	
milky quartz	
adventurine	
rose quartz	
citrine	
amethyst	
tiger eye	
agate	

E. Why do some pieces of quartz form a single crystal, while others form multiple crystals?

12. **SULFUR** is a **native mineral** because it is made of just one element, sulfur (S). Sulfur is yellow in color, and gives off a characteristic "rotten egg" smell when burnt. Sulfur is used in the chemical industry to make sulfuric acid, fertilizers, insecticides, explosives, coal tar, rubber and paper.

A. Does sulfur feel light or heavy?

B. Describe the color of sulfur.

C. Is sulfur a native mineral? Explain.

D. Scratch sulfur and smell it. Describe the odor.

13. **HORNBLENDE** ($Ca_2Na(Mg,Fe)_4(Al, Fe, Ti)(Al,Si)_8 0_{22}(O.OH)_2$) is a very common mineral in rock, but it is rarely found in isolated crystals. Hornblende is a very dark mineral, because it contains large amounts of the elements iron (Fe) and magnesium (Mg). It is a "boring" mineral, but if you learn to recognize hornblende it will help you name igneous rocks.

A. Describe the color?

B. Is hornblende softer or harder than quartz?
How can you test this?

C. Is hornblende softer or harder than feldspar?
How can you test this?

D. Do you notice any cleavage on your sample of hornblende? Describe.

14. **OLIVINE** (Mg, Fe)2(SiO4) is another common mineral found in rocks. Olivine is not commonly seen on the Earth's surface, but it is the most common mineral in the Earth's mantle. Very clear olivine crystals can be used for the gem "peridot."

A. Where do you think the name "Olivine" came from?

B. Is olivine harder or softer than quartz? How did you test this?

C. Describe the "look" of olivine.

ANSWERS:

1A. dipyramid or diamond shaped; flat; B. Cleave means to break, and usually the surface is nice and flat. C. Flat surfaces D. Ca, F E. softer F. Fluorite can be scratched by quartz. G. No, fluorite comes in different colors.

2A. It tarnishes many different colors, like a male peacock's feathers. B. Copper tarnishes a purple and blue color; and combine it with the "rusting" of iron; and the yellow of sulfur and you get a multicolored look.

3A. K, Na, Ca, Al, Si, O B. Softer, you can scratch it with quartz C. Yes, cleavage is shown in the flat surfaces

4A. color, slippery feelings; talcum powder B. slippery or soapy feeling C. Yes, you can scratch it with your fingernail

5A. element B. No; Gold, silver, sulfur C. metallic, copper color; D. In pipes, pennies, pots

6A. softer B. Quartz can scratch it, but also your fingernail can scratch it; C. flat, tabular; D. you can scratch it with your fingernail

7A. gold; B. cubic to octahedral; C. black D. metallic; E. fool's gold

8A. red-black B. metallic (shiny); gray C. since the streak is red, it is also found in forms that are red

9A. rhombohedral B. it makes it double C. it broke that way, it is difficult to tell except for if you broke it would break into rhomb pieces

10A. in flat sheets; B. softer, you can scratch it with quartz; C. mica is a flat, black, thin mineral that cleaves in sheets

11A. crystals when it has room to grow, massive when there is no room or when it breaks; B. clear; white; great, pink; brown, purple; C. 6; D. harder E. it breaks like glass

12A. feels light; B. yellow; C. native, it only is composed of one element (sulfur); D. rotten egg

13A. black; B. softer. C. Harder; D. Yes, flat surfaces

14A. some olives are green; B. harder; determined if quartz could scratch olivine C. bubbles of glass

BACKGROUND INFORMATION ON MINERALS

FLUORITE

CHEMICAL FORMULA: CaF_2

ETYMOLOGY: Latin fluere - meaning to flow, since it melts more easily than other minerals

CHARACTERISTICS: perfect cleavage; hardness (4.0); specific gravity (3.18); vitreous, color varies, dependant on presence of hydrocarbons, some varieties show fluorescence

KEY CHARACTERISTICS: cubic crystals, octahedral cleavage, fine coloring

OCCURRENCE: associated with calcite, dolomite, gypsum, quartz, galena, sphalerite

DEPOSITIONAL: igneous

USES: flux in making steel; preparation of HF_2 acid; occasionally ornamental

MICA

CHEMICAL FORMULA: $KAl_2(AlSi_3O_{10}OH)_2$(muscovite) - $K(Mg, Fe)_3(AlSi3O_{10)}(OH)_2$ (biotite)

ETYMOLOGY: muscovite - comes from Russia (Muscovy) used to be substitute for glass in Muscovy; biotite named for French physicist J.B. Biot

CHARACTERISTICS: perfect cleavage, thin sheets that are flexible; hardness (2-2.5); specific gravity (2.76-3.1); luster vitreous muscovite - clear to white; biotite - dark color

KEY CHARACTERISTICS: cleavage, color

OCCURRENCE:

DEPOSITIONAL: igneous (plutonic); metamorphic

USES: insulating material in electrical apparatus; wall papers (to give shine); lubricant; fireproofing material

HEMATITE

CHEMICAL FORMULA: Fe_2O_3

ETYMOLOGY: from Greek meaning blood in illusion to the color of the powdered mineral

CHARACTERISTICS: hardness (5.5-6.5); specific gravity (5.26); color: reddish brown to black; lust metallic in crystals, dull in most varieties

KEY CHARACTERISTICS: Indian red streak

OCCURRENCE: common, most abundant and important ore of iron; oolithic ores are sedimentary in origin; botryoidal are kidney ore; specular are micaceous and foliated

DEPOSITIONAL: rare in igneous rocks, more common in metamorphic; sedimentary

USES: iron ore, polishing power

QUARTZ

CHEMICAL FORMULA: SiO_2

ETYMOLOGY: German word of ancient derivation

CHARACTERISTICS: hardness (7); specific gravity (2.65); fracture conchoidal; vitreous; clear to white; colored by impurities

KEY CHARACTERISTICS: hardness, fracture, crystal form

OCCURRENCE: agate (banded, various colors, mostly reds); amethyst (violet or purple color); aventurine (with mica crystals); carnelian (with brown variations); chert (found in limestones, radiolarian, opaque, often called flint); chrysoprase (yellow green); citrine (pale yellow, usually confused with topaz); flint (darker variation of chert): jasper (massive red); moss agate (contains various impurities of minerals which have grown in plant like growths); onyx (layered or banded black); petrified wood (replacement quartz); rose quartz (pale pink); sard (yellow brown or black); smoky quartz (pale brown/black); tiger eye (quartz replaces asbestos and may be many colors, often yellow)

DEPOSITION: igneous, metamorphic; chemical precipitate (sedimentary)

USES: gem stone, mortar, scientific apparatus

CALCITE

CHEMICAL FORMULA: $CaCO_3$

ETYMOLOGY: from the Latin calx meaning burnt lime

CHARACTERISTICS: perfect cleavage; hardness (3); specific gravity (2.72); vitreous, earthy; usually white but gray to yellow; double refraction

KEY CHARACTERISTICS: cleavage, effervesces freely in cold HCl

OCCURRENCE: second most common mineral

DEPOSITIONAL :mainly sedimentary; metamorphic, igneous(decomposition of lime silicate)

USES: manufacture of cement; lime for mortars; fertilizer

GYPSUM

CHEMICAL FORMULA: $CaSO_{4..}H_2O$

ETYMOLOGY: from the Greek name for this mineral

CHARACTERISTICS: cleavage in 4 directions; hardness (2); scratched by fingernail; Specific gravity (2.32); vitreous. pearly, silky; white to brown with impurities

KEY CHARACTERISTICS: softness

OCCURRENCE: associated with halite, dolomite, calcite, sulfur, pyrite; most common sulfate

DEPOSITIONAL: sedimentary

USES: plaster of Paris; fertilizer

FELDSPAR

CHEMICAL FORMULA: [Na (albite), Ca (anorthite)] plagioclase, K (orthoclase) $(Al)Si_2O_8$

ETYMOLOGY: plagioclase from the Greek meaning oblique in allusion to the oblique angle between the cleavage; orthoclase from the two Greek woods meaning little and inclined referring to the slight variation of the cleavage angle from 90 degrees

CHARACTERISTICS: 2 good cleavages; hardness (6), specific gravity (2.5-2.6); color white, yellow, orange-pink. vitreous

KEY CHARACTERISTICS: cleavage and hardness; plagioclase: whitish color, striations caused by albite twinning; orthoclase: pinkish color

OCCURRENCE: plagioclase is more abundant then orthoclase, associated with quartz and muscovite

DEPOSITIONAL: igneous rocks and metamorphic rocks; rarely crystallization from aqueous solutions at low temperate in veins

USES: ceramics, ornamental

PYRITE

CHEMICAL FORMULA: FeS_2

ETYMOLOGY: from the Greek meaning fire (in allusion to the fact that when struck with steel it give off brilliant sparks)

CHARACTERISTICS: hardness (6-6.5); specific gravity (5.02); luster metallic; pale brass to yellow in color; streaks green to brown/black

KEY CHARACTERISTICS: brittle, uneven fracture; best identified in crystals by their cubic appearance and small striations or grooves on the surfaces

OCCURRENCE: formed at high and low temperature in igneous and metamorphic areas; associated with chalcopyrite, sphalerite, galena

DEPOSITIONAL: igneous, contact metamorphism; sedimentary

USES: low grade iron ore, used in the chemical industry to make sulfur and sulfuric acid

TALC

CHEMICAL FORMULA: $Mg_3(Si_4O_{10})(OH)_2$

ETYMOLOGY: doubtful origin, derived from Arabic talk

CHARACTERISTICS: perfect cleavage, hardness (1); specific gravity (2.7-2.8); pearly to greasy; white to green

KEY CHARACTERISTICS: softness, greasy feel

OCCURRENCE: secondary origin; alteration of mg silicates (olivine, pyroxene, amphiboles)

DEPOSITIONAL: mainly metamorphic

USES: slabs used as lab table tops; ingredient in paint, ceramics, rubber, insecticides, roofing,

HORNBLENDE (most common forms of amphibole)

CHEMICAL FORMULA: $Ca_2Na(Mg, Fe)_4(Al, Fe, Ti)(Al,Si)_8O_{22}(O.OH)_2$

ETYMOLOGY: old German word for any dark prismatic mineral occurring in ores but containing no recoverable minerals

CHARACTERISTICS: perfect cleavage (angles of 56 and 124); hardness (5-6); specific gravity (3.2); vitreous, dark green to black

KEY CHARACTERISTICS: crystal form, cleavage angle; dark color

OCCURRENCE: a rock forming mineral, usually not found in separate crystals; usually found in metamorphic rocks because it alters from pyroxenes both during late magmatic stages of crystallization of igneous rocks and during metamorphism

DEPOSITIONAL: igneous, metamorphic

OLIVINE

CHEMICAL FORMULA: $(Mg, Fe)_2(SiO_4)$

ETYMOLOGY: in reference to its olive green color

CHARACTERISTICS: green; fracture conchoidal; hardness (6.5-7); specific gravity (3.27-4.37); vitreous

KEY CHARACTERISTICS: color, granular nature

OCCURRENCE: associated with pyroxene, plagioclase, magnetite, serpentine

DEPOSITIONAL: igneous, metamorphic

USES: clear green ones used as gem (peridot)

BORNITE

CHEMICAL FORMULA: Cu_5FeS_4

ETYMOLOGY: was named after the German mineralogist von Born

CHARACTERISTICS: metallic, color brownish bronze, streak grayish black

KEY CHARACTERISTICS: purple tarnish, and color

OCCURRENCE: England, Arizona, Peru, Bolivia, Chile, California

DEPOSITIONAL: usually found with copper ore in veins

USES: ore of copper

SULFUR

CHEMICAL FORMULA: S

ETYMOLOGY:

CHARACTERISTICS: brittle, yellow in color, when scratched a faint “bad egg” smell is present

KEY CHARACTERISTICS: yellow color and rotten egg odor

OCCURRENCE: in United States found in Texas, Louisiana, Hawaii, Wyoming, Utah, and California; Italy, Mexico, Japan, and Chile

DEPOSITIONAL: often found near volcanic activity, some areas the influence of biological life will generate sulfur; often found in veins

COPPER

CHEMICAL FORMULA: Cu

ETYMOLOGY: Greek word for the copper deposits

CHARACTERISTICS: copper color, metallic, malleability

KEY CHARACTERISTICS: color

OCCURRENCE: Michigan, Mexico, Bolivia, Arizona

DEPOSITIONAL: found in copper veins in either sedimentary or igneous environments of deposition

USES: pipes, pennies, plumbing supplies

radical of Si_3O_{10}. Both have silicon and oxygen in their family name, so they both belong to the silicate family.

Chemical families help to group minerals to look for similar properties. For example, "carbonates' include the radical "CO_3 " which reacts with acids to produce carbon dioxide. Minerals like calcite and azurite will produce a "fizzing" as carbon dioxide bubbles are released when acid like HCl is dropped on the mineral. Many oxides will react with the atmosphere and will "rust." Limonite belongs to the oxide family and has a characteristic rust color.

We will look at 6 positive radials in our chemical family chart including oxides, sulfides, sulfates, carbonates, silicates, borates, and halides. There are a few other groups of chemical families that we have not included in this chart because they are not common minerals.

Some minerals are not really in a family because they are composed of only one element. There are only twenty elements that are found in a native, solid state that we can classify as minerals. Some of these elements are considered **metallic** including gold, silver, copper, lead, platinum, palladium, iridium, osmium, iron, nick, mercury, tantalum, tin, and zinc. There are also **nonmetallic** native minerals including sulfur and carbon in the form of graphite and diamond. Three native minerals are considered **semimetals** which include arsenic, antimony, and bismuth.

Diamond

Bismuth

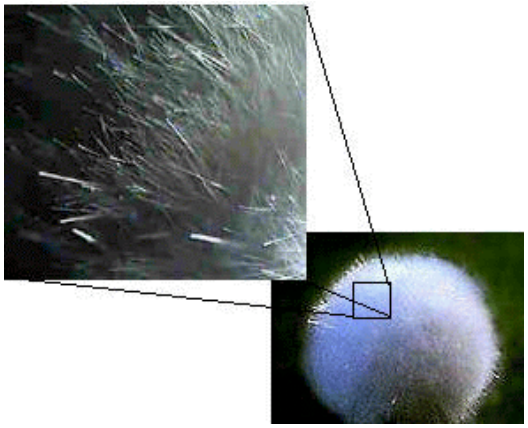
Galena - a sulfide

The six families we will investigate include the **sulfides, sulfates, oxides, halides, carbonates, borates,** and **silicates**. Sulfides and sulfates all have sulfur in the anion. For example galena is a sulfide and its composition is PbS. The sulfides mainly are metallic. The sulfates include the radical SO_4 and include minerals that are nonmetallic. These can include gypsum.

Some families have an anion that is related to oxygen. Oxides contain a anion that is usually a metal in combination with oxygen. For example, hematite is iron plus oxygen (Fe_2O_3). Carbonates include the CO_3 radical and includes minerals like calcite. Borates contain the BO_3 group and include minerals like borax and ulexite. Sulfates also have oxygen within its radical.

Fluorite - a halide

Silicates form the largest chemical class among the minerals. They contain various elements in different combination like sodium, potassium, calcium, magnesium, aluminum, and iron in combination with silicon and oxygen. They have very complex chemical structures.



Okenite - a silicate

EARTH SCIENCES - MINERALS Family of Minerals Lab

PROCEDURE:

After you read the information on chemical families, use the "Chemical Family of Minerals" diagram and a periodic table to answer the questions.

CHEMICAL FAMILIES OF MINERALS

ELEMENT	**ELEMENT + 0_2**	**ELEMENT + S_2**	**ELEMENT + $S0_4$**	**ELEMENT + $C0_3$**	**ELEMENT + BO_3**	**ELEMENT + $Si0_2$**	**ELEMENT + Halogens**
native	oxide	sulfide	sulfate	carbonate	borate	silicate	halide
graphite ***copper*** ***sulfur***	*hematite* *magnetite* *limonite*	*galena* *pyrite* *sphalerite* *chalcopyrite* *bornite*	*gypsum*	*calcite* *dolomite* *azurite* *malachite*	*borax* *ulexite*	*quartz* *feldspar* *mica* *kyanite* *chrysocolla* *talc* *olivine* *hornblende*	*fluorite* *halite*

1. List the 20 elements that are considered native minerals. Look at the periodic table and write down their symbol.

2. What are the elements the make up the following mineral families?

A. carbonate	
B. sulfate	
C. sulfide	
D. silicate	
E. oxide	
F. borate	

3. Fill in the chart below. Look at the previous lab for the formula. Write out the elements name. For example Calcite is $CaCO_{3,}$ the chemical family is "carbonate" and the elements are calcium, carbon, and oxygen.

MINERAL NAME	CHEMICAL FAMILY OTHER ELEMENTS
Fluorite	
Bornite	
Feldspar	
Talc	
Copper	
Gypsum	
Pyrite	
Hematite	
Calcite	
Mica	
Quartz	
Sulfur	
Hornblende	
Olivine	

EARTH SCIENCES - MINERALS

Lesson 4 - Uses of Minerals

MATERIALS:

reader
Internet
reference materials

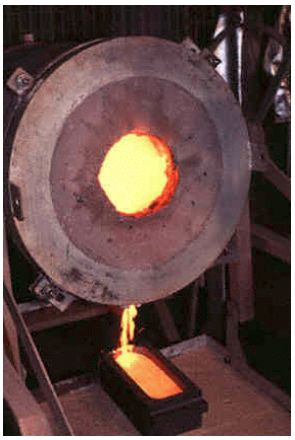
Objective: Students research the uses of minerals.

Teacher note

Mining minerals is very important in our society. The Internet can help your students search information quickly and easily. Have the students read the information on Uses of Minerals and then have them do a homework or computer lab assignment on researching a specific mineral. Minerals most commonly attractive to students would be quartz, diamond, gold, silver, or copper. However, other interesting minerals would include: beryl, corundum, calcite, malachite, feldspar, gypsum, jadeite, spodumene, tourmaline, spinel, topaz, opal, turquoise, garnet, fluorite, mica, dolomite, bauxite, and hematite.

Use the worksheet to guide their Internet search. Make them search the mineral, i.e. search for "diamond mineral." Below are a few websites that might give students some general information.

National Mining Association http://www.nma.org/
Mining Technology information http://www.mining-technology.com/

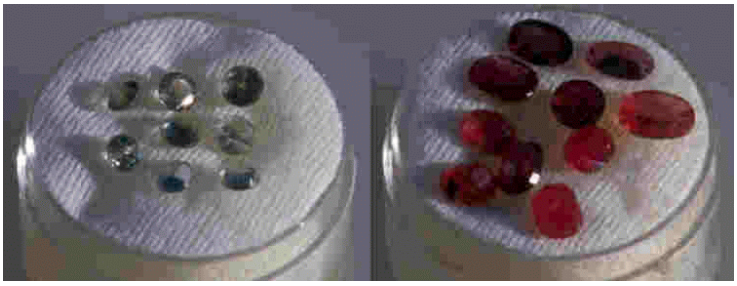


Most products are either grown or mined. **Natural resources** are important for any nation to develop. Money will buy products, but what does the money really represent? Money has to somehow reflect the wealth of a country, which at one time was based on the amount of "gold" a nation has stored away. Gold, a mineral, was that important! However today wealth of a nation is more complicated based on other resources and economic indicators.

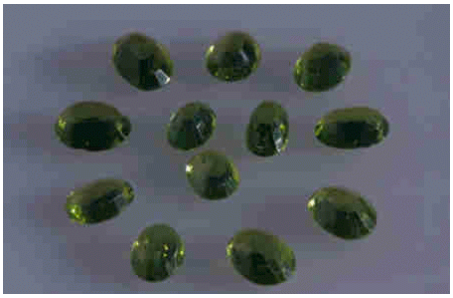
Minerals have always been important because they create products. Even in very early societies, in Egypt (Africa) and Inca (South America), the amount of jewels and gold indicated the wealth of that society. People invaded other countries to take their mineral resources.

Minerals are indeed useful, but they have also caused wars and instability in different regions. Let's look at some of the common uses of minerals today.

Minerals are useful in many industries in the past and today. A major industry that most people think about is the **gem** mineral industry. Minerals that are used for gems are usually hard. People love to purchase jewelry to wear or to give as presents. The very symbol of a marriage engagement in the United States is a diamond. This is not true in many other countries. However, a gold ring, as a symbol of marriage is used in many cultures.



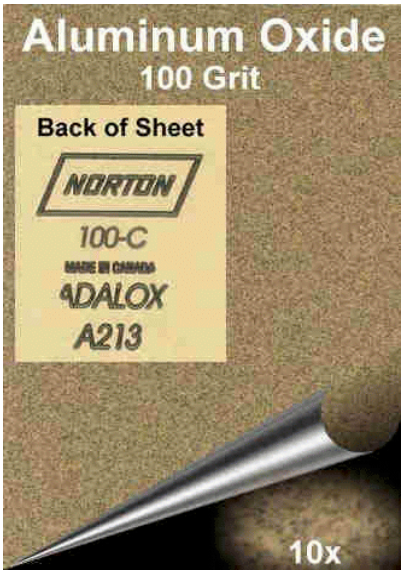
Sapphires (left) and rubies (right)



Peridot

Many gems are the same mineral but different color for example a ruby (red) and sapphire (blue) are the mineral corundum. Emerald (green) and aquamarine (blue) are the mineral beryl. Peridot (green) is the mineral olivine. Quartz probably has the most varieties of gems because it comes in many coloring including amethyst (purple), agate (multicolored), and tiger's eye (brown-yellow).

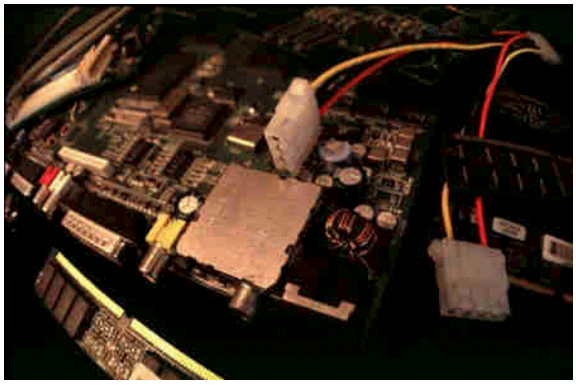
Artists use certain minerals to carve because of their softness. Talc, serpentine, jade, and malachite are soft enough to carve and produce beautiful smooth figures. The color of some of the minerals also make them excellent choices for ornamental uses. For example rose quartz is a pink color, but because it is hard is not used for carving, only as a gemstone.



Hardness is also useful as an abrasive. Some varieties of corundum are used as "sand" on sandpaper to help smooth surfaces. Human-made diamonds and garnets are also used to make different grades of abrasives. Different grain sizes of quartz are also used as an **abrasives**, especially to make very smooth surfaces.

Minerals are also used to extract useful products. An **ore** is a rock that contains a concentrated percentage of minerals. The minerals in the ore are extracted and then the useful element is removed. For example, copper is a very useful metal used in everything from coins to pipes. Native copper is abundant but ores of copper are more common. The minerals of chalcocite, bornite, chalcopyrite, tetrahedrite, and enargite contain copper which can be extracted chemically. You can always tell if a ore rock contains copper minerals, because there is always a blue color to the rock.

Ore of copper



Silicon is used in the computer industry.

Silicon, used in the computer industry is obtained from quartz which is composed of silicon and oxygen. There are many other minerals that are useful to our society from iron, tin, nickel, tin to uranium.

Minerals, especially feldspar, are also used in making pottery and porcelain. Optical and scientific apparatus use minerals like quartz, fluorite, gypsum and mica for their optical properties.

The same minerals that are needed by plants for growth are the same minerals we have been discussing. Fertilizers provide the essential elements of phosphorus, potassium and nitrogen. These elements are found in certain minerals including apatite (phosphorus), sylvite (potassium) and soda niter (nitrogen). They are ground into powder, so their mineral can be easily absorbed by plants.

Products from feldspar

Even humans require minerals for their body. For example, kaolin, a clay mineral can absorb water and acids. *Kaopectate*, a commercial product used to control diarrhea, is made up of kaolin. Minerals are important in more ways than one!

USES OF MINERALS

RESEARCH ASSIGNMENT

Look for information on the uses of the mineral you have been assigned. Answer the questions below on that mineral. Consult either the internet or reference books. Record where you get the information.

Mineral Name:

Chemical Formula:

Characteristics of the mineral to help identify:

Occurrence (list areas of the world where found):

Uses:

Other interesting information:

References (internet and book):

EARTH SCIENCES - MINERALS

Lesson 5 -Borate Minerals

MATERIALS:

reader
borate samples

Objective: Students learn about the importance of the borate minerals.

Teacher note

If your students are really interested in minerals you may want to use this reader as an example for students to do a research paper on a specific mineral. The more you research the more students realize the importance of minerals. Even today, countries fight for mineral rights. For example, Sierra Leone a country in west Africa, is fighting a bloody civil war over who will control the rich diamond fields. In California, it was the "Gold Rush," that populated the west. There is monetary value in minerals, and humans gravitate to the money and excitement of

The Death Valley region is one of the hottest places in the United States. Can you image that millions of years ago, there was an ocean of water that covered this area. Slowly, as plate tectonics started to create nearby mountains, salt water became trapped and evaporate. During the Pleistocene, lakes filled these area that were concentrated with **borate** components. These compounds would later become one of the richest sources of borate (B_2O_3) minerals in the world.

Death Valley

Searless Lake, California

Most borate minerals are found in a type of sedimentary rock that is called an **evaporite** which is formed by **precipitation**. Precipitation is the growth of crystals from a water solution. Evaporites form in many places, especially within lakes in desert areas. The removal of water, concentrates the dissolved elements in the water. In the case of borate minerals, the water contains dissolved sodium, calcium, and B_2O_3.

Kernite

So why are borate minerals important? Borate minerals are used as a component of detergents and aid in stain removal and bleaching. Borates make up part of the non-stick coating on pots and pans. When borates are added to glass or enamel, they increase heat resistance, making the material less likely to crack. For example, the heat-resistant tiles which cover the Space Shuttle contain borate components and even laboratory beakers use boric-oxide to make them heat resistant.

Boron, which is extracted from borate minerals, if mixed with plastics is used to make fiber optics. It is added to steel to make the metal capable of withstanding high pressures. Boron is also used in the agricultural business as a plant nutrient.

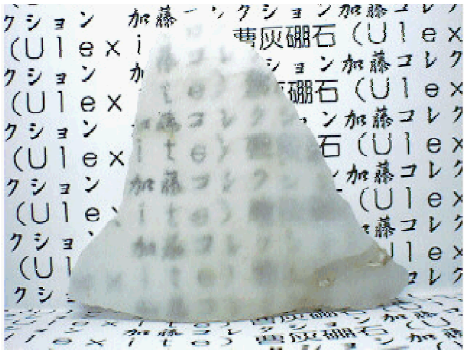
There are different types of borate minerals that are used including borax (sodium borate), colemanite (calcium borate), kernite (sodium borate), ulexite (sodium calcium borate), pricetite (calcium borate) and proberitite (sodium calcium borate).

Borax ($Na_2B_4O_7 \cdot 10H_2O$), the most widespread borate mineral was found to help remove dirt from people and cloth. Borax is crumbly and powdery, and dissolves easily in water. Borax became an alternative to the very harsh soap which was used prior to the discovery of borax in the late 1800's. This light and easy to use substance was hailed the world over as a washing, cleansing, antiseptic, preservative, and medicine miracle.

In the 1880s, large borate deposits were discovered in Death Valley, California. However, the Death Valley borate deposits were located almost 170 miles from the nearest railway. In order to get the borate to the railway economically, the owners of the Death Valley mines used large wagons pulled by teams of 20 mules. The detergents made from this borate were thus sold as “20 Mule Team Borax”.

A 20 mule team hauling borax in Death Valley

Ulexite is a hydrous borate mineral ($NaCaB_5O_6(OH)_6$-$5H_2O$) with unique optical properties. If you put a specimen of polished ulexite on top of a picture, the picture appears as if it is on top of the rock. The same thing works with words, because you can actually read through a ulexite crystal! Ulexite is referred to as the "TV Rock," because of these properties.

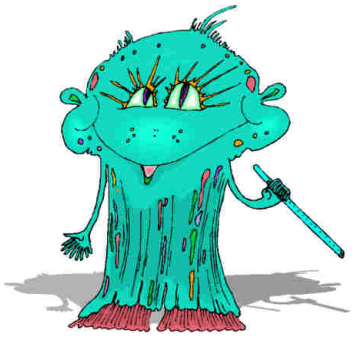


Ulexite naturally occurs as very thin, needle-like crystals. Each crystal acts like a **fiber optic** cable, as it easily transmits undistorted light waves from one end of the crystal to the other. Scientists discovered the reason that ulexite has this property is due to boron. This discovery helped to develop fiber optic cable that allows light to be transmitted. The use of fiber optics have silently changed how the world communicates. Before its discovery sound was send over copper wires as sound waves. Sound today can be converted by the telephone and fax machines into light waves. Light can travel much faster than sound, so the lines of communication are much clearer.

The discovery of borax as a cleaning agent opened a new industry. Research on the uses of the other borate minerals created a demand for the different minerals in the late 20th century. Even "slime" which many children love to play with contains a borate mineral. All the uses for borate minerals have probably not been discovered. What will be the next discovery?

SLIME

Slime works when you get a substance to bond with the molecules of Borax (sodium borate). Polyvinylacetate (white glue) and other substance mixed with borates create new molecules (**polymers**). For example white glue molecules are long to begin with, and they are tangled, which is why the glue is so viscous. Once the Borax links up some of the molecules, it becomes even more viscous with a slimy feel.



Earth Science- Minerals - Unit Test

Part 1. Definitions Place the letter of the definition next to the correct word.

Column 1	Column 2
1. cleavage	a. the resistance of a mineral to scratching
2. element	b. an oxide mineral containing iron
3. compound	c. a combination of two or more different elements
4. hardness	d. a mineral which contains the building block SiO_4
5. native mineral	e. the basic building blocks of everyday matter
6. hematite	f. regular breakage of a mineral a smooth plane.
7. gemstone	g. a natural, inorganic crystalline material
8. silicate	h. a carbonate mineral that reacts with HCl
9. mineral	i. a mineral composed of only one type of element
10. calcite	j. an attractive mineral or stone

Part 2. Multiple Choice Choose the best answer to complete each statement

1. Most rocks are composed of:
    a. plants
    b. minerals
    c. gemstones
    d. crystals

2. Which is not a characteristic of minerals?
    a. inorganic
    b. crystalline
    c. organic
    d. natural

3. Halite (table salt) is composed of:
    a. equal amounts of Na and Cl
    b. lots of Na and a little Cl
    c. lots of Cl and a little Na
    d. water

4. Streak is:
    a. the way a mineral reflects light
    b. the color of a mineral's powder
    c. the shape of a mineral
    d. the "heaviness" of a mineral

5. Which mineral reacts with HCl:
    a. quartz
    b. bornite
    c. talc
    d. calcite

6. Another name for bornite is:
    a. hematite
    b. fool's gold
    c. gemstone
    d. peacock ore

7. Sulfate minerals all contain:
    a. SiO_4
    b. SO_3
    c. NaCl
    d. F

8. Quartz has many:
    a. compositions
    b. streaks
    c. colors
    d. cleavages

9. Ulexite is called "TV Rock" because:
    a. television screens are made from ulexite
    b. lined up ulexite crystals easily transmit images
    c. ulexite grows in desert environments
    d. ulexite crystals are transparent

10. A mineral crystal is:
    a. how a mineral breaks
    b. the shape of a mineral when it has room to grow
    c. a mineral family
    d. a bowl

ANSWERS

Part 1

1-f, 2-e, 3-c, 4-a, 5-i, 6-b, 7-j, 8-d, 9-g, 10-h

Part 2

1-b, 2-c, 3-a, 4-b, 5-d, 6-d, 7-b, 8-c, 9-b, 10-b