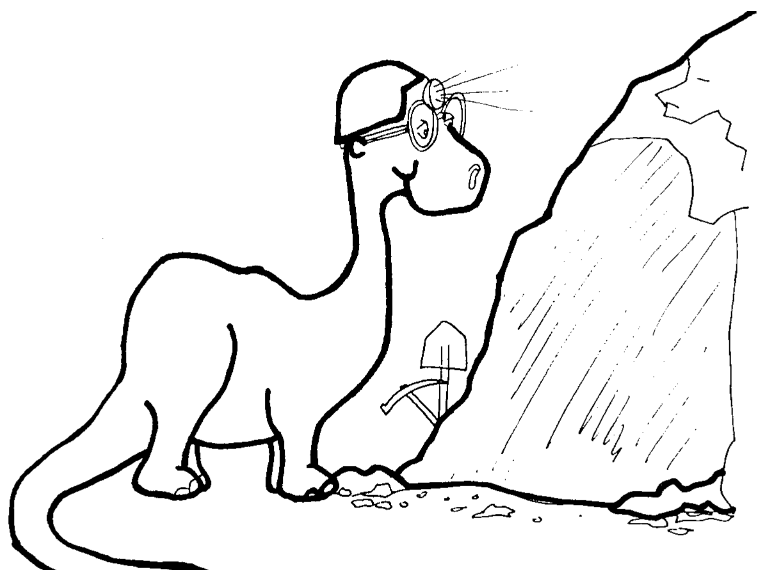
GUIDE TO

MINERAL AND ROCK KIT

by

JOYCE R. BLUEFORD, Ph.D.
GEOLOGIST



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MATH/SCIENCE NUCLEUS

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BASIC INFORMATION TO HELP USE KIT

How are crystals, minerals, gems and rocks different? CRYSTALS usually refer to substances that create a definite geometric shape. Organic and inorganic substances can form crystals. MINERALS are naturally occurring, inorganic combinations of one or more elements. They can form crystals that would reflect the internal arrangement of the elements if the mineral is given enough room to grow. Most minerals however, are confined to cramped living quarters when growing in a rock, with no room to make large crystals. GEMS are mainly inorganic (some minerals and rocks), but can be organic (ie. amber or pearls). A gem is something that has market value because of its beauty, its rareness, and popular appeal to humans. Most gems are cut and polished to accentuate their beauty. Rocks are made of minerals in different combinations.

This kit illustrates some basic concepts about crystals, minerals and rocks. Of course, the samples in your kit only represent a few examples of rocks, minerals and crystals, but will hopefully help you to illustrate some basic principles to your students.

BASIC PRINCIPLES

Good examples of rocks and minerals in your kit can be used to illustrate basic principle listed below.

I. MINERALS ARE MADE UP OF ONE ELEMENT (NATIVE MINERALS).

A. Copper

II. MINERALS ARE MADE UP OF MORE THAN ONE ELEMENT (COMPOUNDS).

A. Quartz
B. Calcite
C. Gypsum

III. MINERALS HAVE DIFFERENT CRYSTAL SHAPES.

A. Quartz
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C. Copper

IV. MINERALS CAN BE USED AS JEWELRY.

A. Quartz

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A. Granite
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VI. ROCKS ARE CREATED IN THE ROCK CYCLE.

A. Granitic Sand
B. Granite from Monterey

All of these samples are from a beach south of Monterey. Granite is the "MOTHER ROCK" from where the feldspars and sand are eroding, by the constant wave along the beach. Feldspars are large and more resistant than the other minerals.
The crystals erode out. Constant erosion breaks other minerals in the granite into the "granitic" sand that is along the beach.

VII. DISSOLUTION OF MINERALS CAN CREATE NEW ROCKS.

A. Calcite
B. Mudstone with fossils
C. Marble

Organisms like bivalves can use elements dissolved in water to make a shell of calcite. When the organism dies it leaves its calcite shell behind. Water percolating through the rock will dissolve the calcite shell over time and it reprecipitates into calcite. If a large area has been deposited with calcite and then changed by increasing temperature and pressure (metamorphism), marble is then created.

ACTIVITIES USING SAMPLES IN KIT

MINERALS

QUARTZ - Quartz is composed of silica dioxide which is usually colorless or white, when pure; with characteristic pencil-shaped (hexagonal dipyramid) crystals. Quartz can scratch steel, meaning that it is a very hard mineral. Quartz is used as a gemstone, in watches, in the manufacture of glass, and as oscillators in radio transmission and reception. Common gem names for quartz include rock crystal, amethyst, rose quartz, adventurine, smoky quartz, cat's eye and tiger's eye.

Have your students count the six sides of the crystal. Remember that this crystal was not cut, this is natural. You can scratch a variety of substances like a penny or knife with the quartz crystal. Also, quartz crystals are used in some cults, because many feel that quartz had magical powers.

COPPER - Crystals are usually malformed in a branching form. Copper is very soft and is very malleable. It is composed only of the element copper, making this a native mineral. This specimen is from Michigan, one of the largest copper deposits in the world. Copper is used as a metal in many different ways, from copper pipes to copper wire.

CALCITE - The name calcite comes from the Latin word, calx, meaning burnt lime, referring to its chemical composition, calcium carbonate. Calcite is usually white, gray or colorless. It is used in the manufacture of steel, cement, and glass.

Calcite's distinguishing characteristics includes calcite fizzes when hydrochloric acid is dropped on it; it's rhombohedral shape; and when an object is viewed through a single, clear crystal of calcite, a double image is seen due to the refraction of light through the crystal.

Have your students identify the shape of calcite. This shape is not because it has grown in a rhombohedral crystal, but because it broke in that form. Cleavage, or the ability of a mineral to break in predetermined shapes is characteristic of many minerals. Calcite will break into this shape. However, it is sometimes very difficult to determine if a mineral is broken or whether it grow in that fashion. If hydrochloric acid is put on calcite it would fizz. We don't recommend you fizzing this specimen, as you will ruin the ability of double refraction.

GYPSUM - The name gypsum is from “gypsos,” Greek for plaster. Gypsum can be white, colorless, gray, yellow, red or brown. Crystals are tabular in shape. Gypsum is a soft mineral that can be scratched by a fingernail. It is a common mineral used for plaster and cement.

Instruct the students observe the tabular nature of the crystals. Demonstrate how soft gypsum is by scratching it with your fingernail.

IGNEOUS

OBSIDIAN - Also known as Volcanic Glass. Most children recognize obsidian as the rock that many Indians used to make arrowheads. The Indians chose obsidian for the very reasons that a geologist can recognize it. It is very hard, but more importantly it breaks into sharp edges that can pierce through many things. The way obsidian breaks resembles broken glass. The piece that is in your kit comes from Clearlake, California. If you notice, it is not a pure black color, this is due to the presence of trace elements that give it color. Obsidian has no visible minerals, it is the one exception to the rule that rocks are made of minerals. It is made of silica dioxide (or glass) that is not in a crystalline order. Obsidian can come in almost any color, depending on the trace elements, but black and brown are the most common. Obsidian is formed when lava is cooled very quickly. Have your students try and figure where in a volcano the lava can cool very quickly, the outer skin of the lava flow. Because it cooled so quickly it did not give the elements time to "hold hands" in a crystalline order, that is why it does not have minerals.

PUMICE - Extremely light weight and blackish gray in color. Easily broken, glassy fibrous texture, no visible minerals and has sharp edges. Pumice is formed when gas charged lava is erupted, the gas "froths" the lava and it is then cooled. The gas escapes leaving numerous holes in the pumice rock. Pumice is used as an ornamental stone and some "pumice rock" is sold in beauty stores for cleaning the dead skin off your body. Children are fascinated by the fact that it floats in water and that pumice is so light.

BASALT - Black in color and has no large visible minerals. Looking with a hand lens you can see very small minerals. Many times gas bubbles are trapped as the lava was cooling. Because the minerals are not large yet, this is a clue that it cooled slower than obsidian but faster than granite. Basalt is a dark color because the minerals in basalt are rich in iron and magnesium, which are dark colored minerals. Have your students figure where the basalt cooled in a volcano (within in the lava flow). Basalt is also used as a building and ornamental stone.

GRANITE - Contains quartz, mica and feldspar minerals. Quartz is the clear mineral; mica is the black, flaky mineral; and feldspar is either a pale pink/orange or white. Because the minerals are large, this gives us a clue that it cooled very slowly. It cooled not on the outside of a volcano but deep inside the earth. Sometimes molten magma does not reach the surface which insulates the magma so it takes a long time to cool; creating large crystals. Ask your students if they think granite is made of the same minerals as basalt (yes, they cooled differently but did come from the same "mother" magma). Have them think if the minerals in the granite were tiny, would it be dark? (No, it would be lighter color.) This gives us a clue that the minerals may be different, and hence have different mothers. Emphasize that many rocks are called granite but they look very different. Granite is used as ornamental and building stone.

GRANITE (Monterey) - The individual minerals in this granite are easily visible. The clear colored minerals are quartz; the white, gray or pink are feldspar; and the black minerals are mica and hornblende. This rock was formed by slow coloring and crystallization of magma at depth in the Earth's crust.

SEDIMENTARY

SANDSTONE - The gritty feel to the surface of sandstone gives us hints that this rock was once sand that has been cemented together. Sandstone can have any kind of rock within its grains. Many of the minerals that make up the individual grains are microscopic. Tell students that Mother Nature has a cement that she sometimes pours onto the beaches of lakes, oceans, and rivers, and when it hardens it becomes a sandstone. In reality, the two most common cementing substances are natural solutions of calcium carbonate and silica dioxide. A sandstone has a very specific size, most students will recognize that size if you refer them to "sand" size by showing them a bag of sand.

DIATOMACEOUS SHALE - Grains are very fine, smaller than sand size. In the case of diatomaceous shale many of the grains are skeletons of one celled plants called diatoms other grains are clays. The particles are so small that they rub off easily. It can be used as chalk to write on the board. Diatomaceous shale (sometimes called diatomite) is used for many purposes because of its fine grained nature. It is used in filters, fertilizers and many manufacturing items.

CHERT - Reddish to brown in color, composed mainly of silica dioxide (different phases of quartz). The red color comes from trace amounts of iron, brownish tinges can be caused by the presence of organic matter. Chert was also used by Indians (the variety called flint) for making tools. Chert has little microscopic one-celled protozoa called radiolarians within the rock. Chert was formed under the oceans where the skeletons of these organisms became trapped. Key characteristics is hardness (cannot be scratched with a nail) and the red color.

MUDSTONE WITH FOSSIL SHELLS - Mudstone is made up of mud size particles that has been cemented together. It can be easily broken because this mudstone has not been compacted very much. You can have your students make their own rock by getting mud from your local puddle and have them observe it dry. Notice that it becomes hard and that the mud will crack when it dries completely. This illustrates that the water takes up space and when the water evaporates there is leftover room, so the mud cracks. Because the size of the particles is so small, they easily get cemented together. You can compare sand when wet versus mud when wet. Sand does not stick together like mud does. Making a mudstone is easy!

In the ancient seas of California, bivalves lived in sandy mud. When the California coast was uplifted, the clams basically got "stuck" in the mud. The mud then turned to rock and the shells became fossils. The shells are composed of calcium carbonate.

MONTEREY SAND - Large grains of sand that have weathered from granite. Feldspar and quartz are the main components. The dark minerals that were present in the granite are not as common in the sand. Feldspar is a very abundant group of minerals in rocks. Feldspars are silicates of aluminum with potassium, sodium, calcium, and rarely barium. The type of feldspar that is in your kit is either plagioclase or orthoclase. Orthoclase may be white, pink, brown, gray, green, colorless or yellowish. Plagioclase is whiter than orthoclase. Both minerals exhibit a prismatic crystal habit.

METAMORPHIC

MARBLE - Composed exclusively of large crystals of calcite. The gray/white bands are due to impurities within calcite, giving it another shade of color. Marble has been used throughout history because of many properties that make it easy to break and to carve. Some marble (especially in Italy) is noted for its smooth, small crystals that make it excellent for carving...many of the statues of Michelangelo were made from marble. Many statues throughout the world are made of marble. Also, marble is used as an ornamental building stone because of its beauty. You can find black, gray, white, and pink varieties of marble throughout the world. If you live near a city, have your students try and figure which buildings are made of marble. If you are in an old school, some of the bathroom stalls or floors may be made of marble. Marble, like all rocks that have calcite in them, fizzes if you put a weak acid on it (usually 10% solution of hydrochloric acid). Marble was formed when rock that had calcite in it (namely a limestone) was put under extreme pressure.

SERPENTINITE - Has a smooth, soapy feeling, green mottled color, and is composed mainly of the mineral serpentine. Serpentinite has that name because of the mottled color which resembles the back of a sea-serpent. The origin of serpentinite is still debated, but many feel that it came from a rock like basalt that was put under high temperature and pressure. Serpentinite is the state rock of California. Serpentinite is used for carving and as an ornamental building stone.

SCHIST - Schist is a good example to illustrate with your students the characteristic "squished" look of metamorphic rocks. Just have them imagine that a heavy Mother Nature sat on some rocks, and look what she did! The flat mica flakes, that are layered are testimony to this pressure. Students will notice that it looks like glitter, and sure enough, these mica flakes can be used for that purpose! Many schists are almost exclusively mica.

SLATE - Slate used to be a mudstone or shale before it was put under high temperature and pressure. Slate is denser than mudstone or shale and has a characteristic "ting" sound when it hits a hard surface. Mudstone and shale will have a "thud" type of sound. This illustrates senses that geologists use other than their sense of sight, they can also use their hearing sense.

PRESENTING KEY CHARACTERISTICS OF MINERALS AND ROCKS TO ELEMENTARY STUDENTS

Rocks and minerals are effective in teaching students how to use observational skills while illustrating using key characteristics. This outline is an inquiry-based method of teaching about rocks and minerals. Part of the material is written like a script, to help you introduce the material in a way that has been successful in thousands of classrooms. The sequence of this presentation can be discussed in 1-2 hours, and has been successfully used with kindergarten aged children to adults. The presentation is especially useful as an introduction to rocks and minerals.

This lesson plan will vary depending on the grade of the students. In the 7th-12th grade you can use the entire sequence to introduce students to a lab, adding more details and more advanced analog. The upper primary grades can tolerate a hour lesson on rocks and minerals, but the lower primary grades attention span will be shorter so you will have to modify the lesson for each grade. The format and procedures you use will be totally up to you. This lesson is designed to give you some key ideas and examples to follow.

I. INTRODUCTION

A. What kind of people are Geologists as scientists? Anyone can become a geologist if they go to college and study about the earth.

B. What makes scientists different from other people? Express to the students that scientists observe things that we see everyday but scientists look at it closely and try to discover new things about them.

C. What does Geology mean? Explain that Geo- means the earth and -ology the study of the usually some kind of science, so Geology means the scientific study of the earth.

D. What do geologists study? Write on the board a list compiled by students (like below) and have students discuss what each of the subjects are about. Pictures or slides can help you illustrate what each of the topics is about.

volcanoes
earthquakes
fossils
minerals
rocks
mudslides, and anything else that has to do with the earth

II. LEARNING OBSERVATIONAL SKILLS: THE PENNY EXERCISE

Let's pretend that we are scientists and observe a penny, something you see everyday. But have you every really looked at a penny? We will describe it after looking at it.

Give the students 10 seconds to look at both sides of the penny. At the end of the

10 seconds have the students place the penny in the palm of their hand and then hide the penny. Ask the following questions about the penny and have students answer during a class discussion.

A. Which side has the words In God We Trust?
B. Which side has the words One Cent?
C. Who is the man on the front?
D. What's the penny made of? (Where does copper come from?)
E. What is on the back side of the penny?
F. What is the name of the building on the back?

Have students describe the building as you draw it on the board. Draw: the pillars, the roof, the stairs in front, the bushes and statue on the stairs, and Lincoln sitting down.

Give the students 5 more seconds to look at Abraham Lincoln and then ask them a specific question. Tell them you will take a show of hands.

A. What kind of tie is Lincoln wearing? A bow tie or a long tie.

You might mention, that even if you did not notice the type of tie Lincoln was wearing, you can figure it out. Many people did not wear ties in 1850's. Explain to the students that:

We have just used observational skills to observe and describe the details of a penny. The penny is logical, just like science, the penny has a picture of Abraham Lincoln and the building that honors him.

What does a penny have to do with learning about rocks and minerals? Well, as we looked at the penny we looked for details that helped us learn. Geologists look at details, to help understand and collect data about the mineral or rock that they are looking at.

III. KEY CHARACTERISTICS - LEARNING WHAT IS IMPORTANT

Scientist observe things and they look for KEY CHARACTERISTICS. What is a key characteristic? Explain what KEY CHARACTERISTICS are by using the following analog.

When you go home today will your mom or dad recognize you? Yes, but how will she/he recognize you? If you take a friend home, will your mom know you from your friend? What is the difference between you and your friend? The difference can be called "characteristics" that an individual possesses. What about 20 years from now, will you look the same? No, but kind of yes? What characteristics about you will never change? These would be key characteristics.

Which of the following are key characteristics? (Ones with *)

1. Eye color*
2. Eye shape and size*
3. Mouth shape and size*
4. Ear shape and size*
5. Finger prints*
6. Age (birth date*)
7. Male/female* (under normal circumstances)
8. Height/weight

9. Voice
10. Complexion/skin color*
11. Birthmarks/scars*
12. Hair (length, color, curly)

Those things that will not change on you, or those that will stay the same are your key characteristics. Key characteristics are features that will rarely change or characteristics that stay the same (something that you can recognize even after a long time has passed).

Now that we know what key characteristics are, let's examine and discuss the key characteristics of some minerals.

IV. MINERALS

Explain to the students that minerals are pure, and make up rocks. Then explain what pure means. PURE can mean several things: all of the same substance; no matter which way you cut something it looks same; composed of the same molecules; or unmixed with any other matter. Salt water, for example is made up of salt and water, if you took out the salt what would you have left? Nothing but pure water. Well, pure means being made of only one thing. Minerals are pure, which means that they are made up of one thing or of one substance. Emphasize that rocks are a mixture of minerals. Minerals are the ingredients that make up rocks. They are like building blocks. A good example is to get three balls of different colors clays, say a red, blue, and yellow. Individual balls represent a red mineral, blue mineral and yellow mineral. If you took some of the red, blue, and yellow ball of clay, you would have a rock.

Some minerals that you may use are listed below. These minerals were chosen because they are more common and have very distinct key characteristics that the students can easily observe.

1. Quartz: Always makes a nice pointed pencil shape in crystal form. It has 6 sides on the terminal ends, resembling a prism. It is very hard (7 on the Mohs hardness scale). Even a steel knife will not scratch quartz. The scientific name for the shape of the quartz crystal is not important. Sometimes quartz is clear, sometimes different colors.

2. Calcite: Rhombohedron crystal shape or simply a "drunken" or tilted 3-dimensional rectangle. When a clear crystal is placed over a word, the word appears to be double. This is called double refraction.

3. Halite: Tastes like salt, because it is salt. Breaks into perfect cubes and has a cubic crystal form. Although taste is an important characteristic, caution students to taste very little, because you are never quite sure what you are tasting.

Since these three minerals can above be clear in color, ask the students if color is a good key characteristics and then ask them how they would tell these minerals apart? How? By their key characteristics of hardness, shape, or taste. Note however, that color is an excellent key characteristic for certain minerals like azurite (blue), pyrite (brassy gold), and malachite (green).

Some others minerals you can use are:

4. Graphite: Writes on paper. Actually, it is not really lead in pencils but graphite. It is also very soft and has greasy feeling.

5. Mica: Very thin. Flakes off into sheets. It is transparent in thin sheets. A characteristic mineral of metamorphic rocks. Used as glitter in some make up.

6. Pyrite: It's metallic luster (very shiny) and gold color, give it it's common name "foolsgold"; can discuss how the miners thought it was real gold, but it was not.

7. Magnetite: Naturally magnetic (sticks to magnet); dark color, and very heavy because it has iron in it.

8. Galena: Silver colored (fool's silver); very shiny breaks into cubes, very dense. Have students hold a large piece, they will be surprised at how heavy it is.

9. Gypsum: Soft enough to scratch with fingernail, used in plaster.

V. ROCKS - IGNEOUS, SEDIMENTARY, AND METAMORPHIC

Remember that minerals make up rocks. There are three different rock groups.
1. Igneous - FIRE or HOT ROCKS (refers to the environments formed.)
2. Sedimentary - WET or COOL or CHILLED ROCKS (refers to the environments formed.)
3. Metamorphic - CHANGED or RHINESTONE ROCKS (refers to what the rocks look like).
NOTE: Have your class nickname the type of rocks by the characteristics that you describe below. It does not matter what their pet name for the rocks are, as long as it helps them to remember the rock groups.

IGNEOUS

What words sound like or start with "ig" like igneous? Ignite, ignition, iguana, ignorant, or igloo. Which of these words have something to do with fire? Ignite and ignition. "Ig" come from the Latin word for fire.

So what kind of rocks do you think are igneous rocks? Hot rocks. Does that mean that the rocks are really hot? No. Igneous rocks need to have been melted and then cooled. The cooling rated and chemical composition of the "Mother Magma" determines what the igneous rock will look like.

You can illustrate cooling in igneous rocks through the following three examples. We suggest that "Mother Magma" be discussed in more details in another lesson.

GRANITE:

Most of you have probably seen granite or at least heard the word before. Granite is a igneous rock that cooled very slow. We know it cooled very slow because the minerals in granite are very large. When rocks cool slowly the minerals have enough time to grow visibly large.

BASALT:

Basalt cooled quicker than granite. Geologists know this because the minerals are not visible with the naked eye, but with a specialized microscope. The quicker an igneous rock cools the smaller the crystals.

OBSIDIAN:

Obsidian, or volcanic glass, cooled very quickly giving the minerals no time to grow (there are no real crystalline minerals in obsidian). Obsidian cooled faster than granite or basalt. The chemical composition is silica dioxide (the same composition as quartz and glass).

What is molten rock called inside the earth? Magma.

What is molten rock called that comes from a volcano? Lava.

Molten rock inside the earth cools very slowly, but when it pushes to the surface it cools quickly. Draw a diagram of a volcano and ask the students where they think each of the rocks were formed. Deep inside the volcano? Granite. The outer skin of the volcano? Obsidian. Under the outer skin? Basalt.(put diagram on the board)

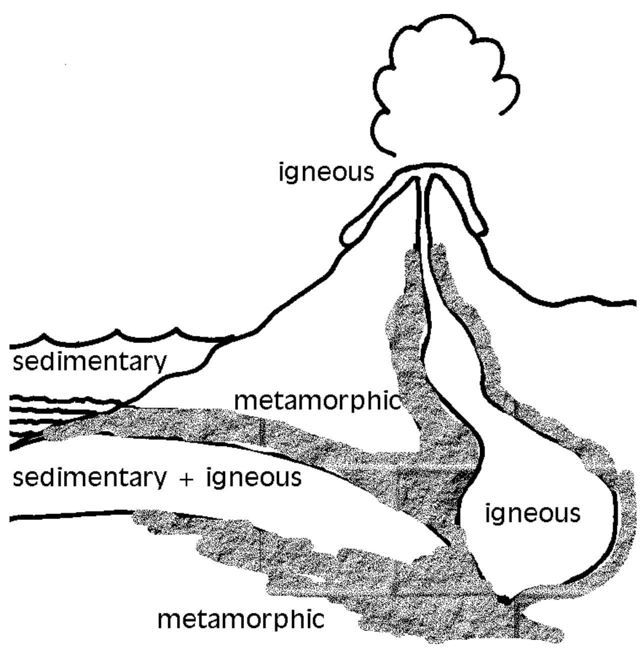
Are there more than three types of igneous rocks? Yes, depending on the Mother Magma and the cooling rate. Let's look at another igneous rock.

Pele's Hair: Imagine a volcano, but instead of magma, it is filled with molten cheese! The cheese began to violently push its way up and out of the volcano. When it reaches the top it squirts out. What does the cheese look like? Is it in chunks or is it stringy? The cheese is stringy. Will it stay in this form? Yes. Think of melted cheese on a pizza. When you take a bite and pull it away, you get long strands of cheese that won't break. This is how Pele's hair if formed, except the lava is the cheese. When the magma shoots out of the volcano what does it look like? It looks stringy like hair. Scientist gathered this up and called it Pele's hair after the Hawaiian Goddess of Volcanoes, Pele. Pele's hair is nothing more than strands of obsidian.

SEDIMENTARY

Where does the name sedimentary come from? What other word sounds like sedimentary? Sediment. Sediment means small particles of matter that settle to the bottom of a liquid. Sedimentary rocks are made up of small rocks, the size of sand, mud or pebbles. Sedimentary rocks are formed in cool or wet areas. Where would you find sedimentary rocks? Near water, beach, lakes, oceans, and rivers. Mother Nature cemented sand, mud and pebbles together to form rocks.

There is also another process that makes sedimentary rocks, unlike the mechanical breaking described above. Chemical reactions that produce rocks are also considered to be sedimentary. Supersaturated solutions that precipitate large amounts of minerals are the main chemical process that produce these rocks.



SANDSTONE:

This is a stone made from Mother Nature cementing sand together.

SHALE:

Mother Nature used even smaller size particles, like mud, to make this rock. It is called shale.

CONGLOMERATE:

This rock was made from pebbles and gravel. Mother Nature used her glue to stick these broken rock pieces together.

CHERT:

This sedimentary rock was formed by the chemical method. The process is so complicated that geologists still argue on how they think chert was formed. It is a common rock, used primarily in the gravel industry. Many cherts have the remains of radiolarians, one celled organism that live in the oceans.

MUDSTONE WITH CLAM SHELLS:

No this is not a new food dish. Where do living clams live. Many in the mud. This rock is the mud (mudstone) with the clam shells that got trapped (fossils).

Fossils are associated with sedimentary rocks because most organisms live near a water environment, and become trapped in the sedimentary rock as it is being formed.

METAMORPHIC

Where have you heard the word metamorphic? Metamorphic comes from a Latin word meaning to change in form. Refer children to the comic book character of the Incredible Hulk. David Banner the hero of the series, metamorphoses into the Incredible Hulk when something hurts him. What happens to David Banner? He changes from David into the Incredible Hulk.

Metamorphic rocks are changed rocks. They are rocks that use to be sedimentary or igneous rocks. These rocks have been sat on by Mother Nature and squished. These rocks are all squashed and squished together inside the earth. They have also been heated up after burial within the earth. However, they have not been heated up hot enough to melt. (They would then be igneous).

SCHIST:

This rock is usually contains a high percentage of the mineral mica. This is called a foliated texture (foliated comes from the German meaning like leaves/foliage). It is a new word to students, so it is important that you have a good sample when illustrating schist.

PHYLLITE and SLATE:

These rocks were probable a mudstone or siltstone before they got squished. The heat and temperature was not as great as schist or gneiss, but enough to compact the small particles of the former rock into a solid flat, dense rock.

GNEISS:

This rock has been chemically changed into bands of different minerals.

REVIEW

The three rocks types are Igneous, Sedimentary, and Metamorphic. Igneous are melted hot rocks or fire rocks, sedimentary are wet or cool rocks, and metamorphic are changed rocks.

Minerals make up rocks. Minerals are pure and have key characteristics. What are key characteristics? Things about an object that always stay the same. Review the key characteristics of quartz, calcite, and halite. Then let the students come up and tough and look at the rocks.

MORE INFORMATION: UNDERSTANDING MINERALS AND ROCKS

MINERALS

Minerals are the basic building blocks of rocks. Chemical compounds or elements with certain physical and chemical properties and whose internal structure is stable with an inorganic crystalline structure defines a mineral. Minerals have to be naturally created. Man-made minerals are not considered true minerals.

Rocks are a combination of minerals. Certain groups of minerals indicate the temperatures and pressures in which they were created, so the history of the rocks may 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 as well as other nations. Wars have been fought over the wealth that minerals bring.

Minerals can be organized by their chemical composition. The following chart shows the major chemical families of minerals.

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        ELEMENTS          COMPOUNDS
          *
          *    +))))))))))))2))))))))))))))),
          *
          *  organic   (no minerals)                    inorganic)),
          .)))))))))))))))))))))0))))))))))))))-       mineraloids
         +))))))0)))))))))0)))))))))0)))))2)))0))))))))0)))))))),
elements      elements      elements      elements      elements elements elements
              O2-           S2-           (SO4)2-       (CO3)2-       (SiO4)4-      F1-
 native        oxide        sulfide       sulfate       carbonate     silicate      halide

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graphite      hematite      galena        gypsum        calcite       quartz        fluorite
copper        magnetite     pyrite        dolomite      feldspar
              limonite      sphalerite    azurite       mica
              chalcopyrite  malachite     kyanite
              bornite       talc
                            serpentine
                            chrysocolla
                            hornblende
```

EXAMPLES OF MINERALS BELONGING TO CHEMICAL FAMILY

The following characteristics can help identify minerals.

1. **CRYSTAL FORM** - the natural growth (shape) of a mineral
   a. based on internal arrangement of atoms
   b. whether it has sufficient room to grow
   c. individual crystals - always bounded by a smooth, plane surfaces called "faces" that meet at characteristics angles (e.g., Halite meets at right angles; quartz meets at 120 degrees).
2. **FRACTURE AND CLEAVAGE** - different minerals have characteristic ways of breaking in one or more directions
   a. fracture is the way a mineral breaks irregularly, for example, quartz is said to have a conchoidal fracture (a hollow and rounded surface)
   b. cleavage is a break that leaves smooth and plane surfaces due to weakness of the atomic structure along certain planes
3. **HARDNESS**
   a. resistance to scratching
   b. related to internal atomic bonding
4. **SPECIFIC GRAVITY**
   a. density of a mineral taken relative to that of water
   b. characteristic of metallic minerals
5. **STREAK**
   a. color of a powdered mineral sample
   b. scratch an unglazed piece of porcelain plate (streak plate) to produce a streak
   c. since most minerals give a white streak, not useful for majority of minerals, but very characteristic for a few minerals like hematite which gives a red streak
6. **LUSTER**
   a. the way that a mineral reflects light
   b. metallic luster versus non metallic luster
   1. metallic or looks like metal
   2. non metallic
      a. glassy
      b. pearly
      c. dull
7. **TASTE** - certain minerals like halite (salty) and sulfur (bitter) have characteristic "flavors".

8. **MAGNETISM** - reaction to a magnet or showing magnetic properties (i.e., loadstone).
9. **REACTION TO ACID** - dilute HCl reacts with carbonate minerals

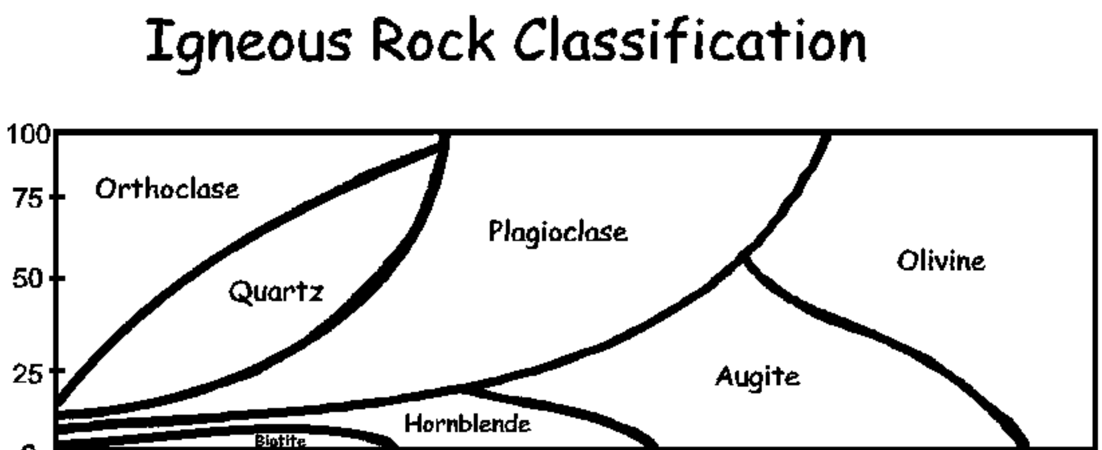
ROCKS

IGNEOUS ROCKS

There are many different types of igneous rocks. However, they all were once melted and have since cooled down. Igneous rocks look different because of two factors: (1) they are cooled at different rates and (2) the "Mother" Magma (original melted rock)was different. These two factors create many different types of igneous rocks. Geologists name igneous rocks according to the cooling rates and the original magma. When the rocks cool at different rates they create different sized minerals. Quick cooling igneous rocks have small minerals (with the exception of obsidian, which technically is made up of SiO_2 with no crystalline structure. Basalt, for example, has small minerals that can be seen under a microscope. Magma that cools slowly creates rocks like granite which have large minerals that can be seen with the naked eye.

Rocks formed from lava (cooled outside a volcano) are called volcanic rocks and have small minerals. Rocks formed from magma that cooled within the earth are called plutonic rocks and have large minerals.

Identification of rocks can be difficult for a novice. There are two ways that we



Aphanitic	Rhyolite	Andesite	Basalt	
Phaneritic	Granite	Diorite	Gabbro	Peritodite
Glassy	Obsidian			
Pyroclastic				

SIAL SIMA

recommend for beginners. First, a flow chart of all the rocks can help distinguish the different rock types by their key characteristics, except this chart tells you nothing about how the rocks were formed. A better approach is to understand how igneous rocks are named. The percentage of certain key minerals and the mineral size are the main factors used to name rocks. The figure above illustrates this method. This chart is read by looking at the vertical column. For example, look at BASALT. Reading horizontally we note that basalt is a fine grained (aphanitic)igneous rock and reading vertically we note that basalt is composed of 30-60% pyroxene, 70-40% plagioclase feldspar, and 0-25% olivine. Notice that these percentages represent RANGES and not specific numbers.

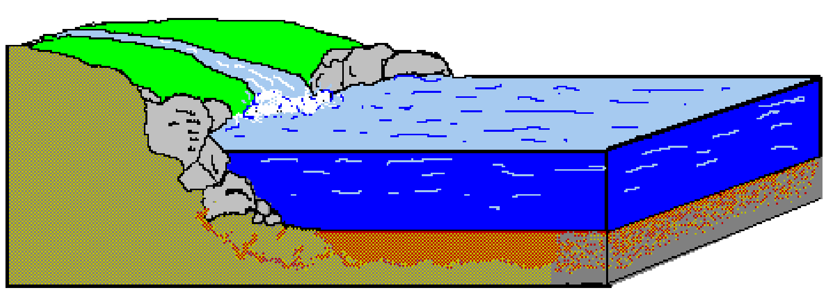
Igneous rocks refer to those rocks formed when magma is cooled. They can form in two ways: VOLCANIC - magma that erupts on the surface of the Earth (called lava) cools which tend to have small minerals (aphanitic), and PLUTONIC - magma that never reaches the surface of the Earth, but cools slowly, deep inside the crust of the Earth which tend to have large minerals (phaneritic).

SEDIMENTARY ROCKS

Sedimentary rocks are formed in 2 major ways: (1) clastic material (pieces of other rocks or fragments of skeletons) cemented together, and (2) chemical means (usually precipitation). Usually sedimentary rocks are associated with water (erosion, settling, and cemented together). However, other sedimentary environments include wind erosion, and glacial movement.

The best way to illustrate sedimentary rocks is to use pictures that show where water is found. The figure below illustrates how sediments are brought to a lake or ocean and settles out. The heaviest grains settle first and as you go away from the source, the finer the particles become. If these sediments become rocks by being cemented together, the gravel and pebbles will be called a CONGLOMERATE, the sand will be called SANDSTONE, the mud size particles will become MUDSTONE, and the silt size particles will become SILTSTONE.

SORTING and ROUNDNESS of the particles helps to understand sedimentary rocks. . Sorting refers to how the agents of erosion have winnowed the particles. Those particles that are all the same size are well sorted, those particles of unequal size are



poorly sorted. Roundness refers to how long particles have been in the system. Particles that are well rounded have been in the system for a long time, and those that are angular have been eroded more recently.

CLASTIC SEDIMENTARY ROCKS

TEXTURE		ROCK NAME	MINERAL COMPOSITION	ROCK NAME WITH FOSSIL REMAINS
finer than sand < 1/16 mm	***SMOOTH***	**SHALE**	**Clay**	**DIATOMITE (diatoms)** **RADIOLARITE (radiolarians)** **FOSSILIFEROUS MUDSTONE or SILTSTONE**
	GRITTY	**SILTSTONE**		
sand size (1/16 to 4 mm)		**SANDSTONE**	**quartz (quartz sandstone)**	**FOSSILIFEROUS SANDSTONE**
			rock fragment, feldspar, quartz, mica (graywacke)	
			quartz, feldspar (arkose)	
coarser than sand (>4mm)	***rounded grains***	**CONGLOMERATE**	**quartz, feldspar, rock fragments**	**FOSSILIFEROUS CONGLOMERATE**
	angular grains	**BRECCIA**		**FOSSILIFEROUS BRECCIA**

CHEMICAL PRECIPITATE SEDIMENTARY ROCKS

TEXTURE	ROCK NAME	MINERAL COMPOSITION	WITH FOSSIL REMAINS
microcrystalline	CHERT	quartz	RADIOLARIAN CHERT
crystalline	GYPSUM	gypsum	
crystalline	ROCK SALT	halite	
crystalline	DOLOMITE	dolomite	
crystalline	LITHOGRAPHIC LIMESTONE	calcite	FOSSILIFEROUS LIMESTONE
spongy	COAL	no true minerals, various stages of diagenesis of plant remains	PEAT
spongy			LIGNITE
hard			BITUMINOUS
hard			ANTHRACITE

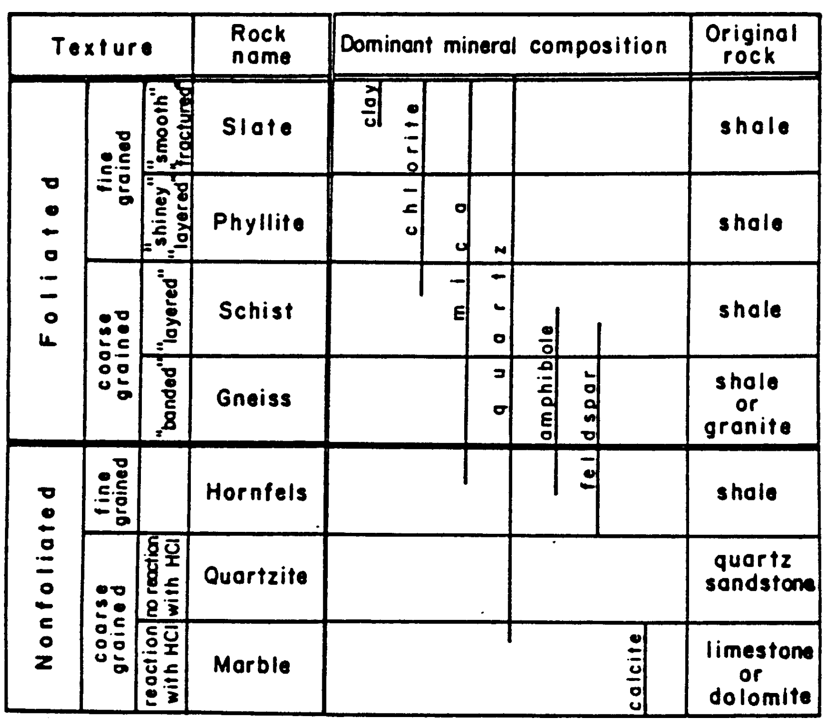
Identification of sedimentary rocks is based on whether they were formed by the breaking of other rocks (clastic or mechanical), by organic matter (bioclastic), or by chemical means (non clastic). Notice on figure 6 that the identification of clastic sedimentary rocks depends on the size of the grains of rocks and the mineral composition. The rock names reflect a combination of both requirements. Sand size particles when cemented together make a sandstone. Smaller than sand size make a shale, siltstone or mudstone. Larger than sand size make a conglomerate or breccia. The classification scheme represented here is a simplified system and some books may use slightly different means of identification.

As long as you teach your students a consistent process, they will have the power to realize different systems. Recognizing the non-clastic system is mainly by getting familiar with those rocks.

METAMORPHIC ROCKS

Metamorphic rocks were either igneous, sedimentary, or other metamorphic rocks that were changed. They were changed by great pressures and temperatures inside the earth. The temperatures were not enough to melt the rock, otherwise it would be igneous. The pressures were not enough to break the rock, otherwise it would be sedimentary. The conditions were just enough to change the chemical make up of the rock by forcing the elements to "exchange partners".

Metamorphic rocks are named by physical appearance and mineral composition. Slate is very dense and smooth; schist has layers of minerals; and gneiss has bands of minerals. Certain minerals like garnets and micas are usually associated with certain metamorphic rocks. If the minerals are abundant in certain rocks, the name of the rock will reflect this. For example, a schist with abundant garnets is called a garnet schist.



ROCKS IN CALIFORNIA BRINGING THE SUBJECT HOME

(NOTE: For teachers using this kit in other states we recommend that you contact your local university or state geological survey for information. If you are having trouble finding information, please contact the staff of the Math/Science Nucleus).

California is a beautiful state. It can boast sights like Yosemite Valley, the Sierra Nevada, and the high sea cliffs along the coast. Many people notice the beauty but fail to see the connection between the beauty and the rocks that create these breathless sights. Are rocks just anywhere? Are the rocks all the same or are there areas where just one rock can be found? Why are rocks where they are? Are rocks important to our lives?

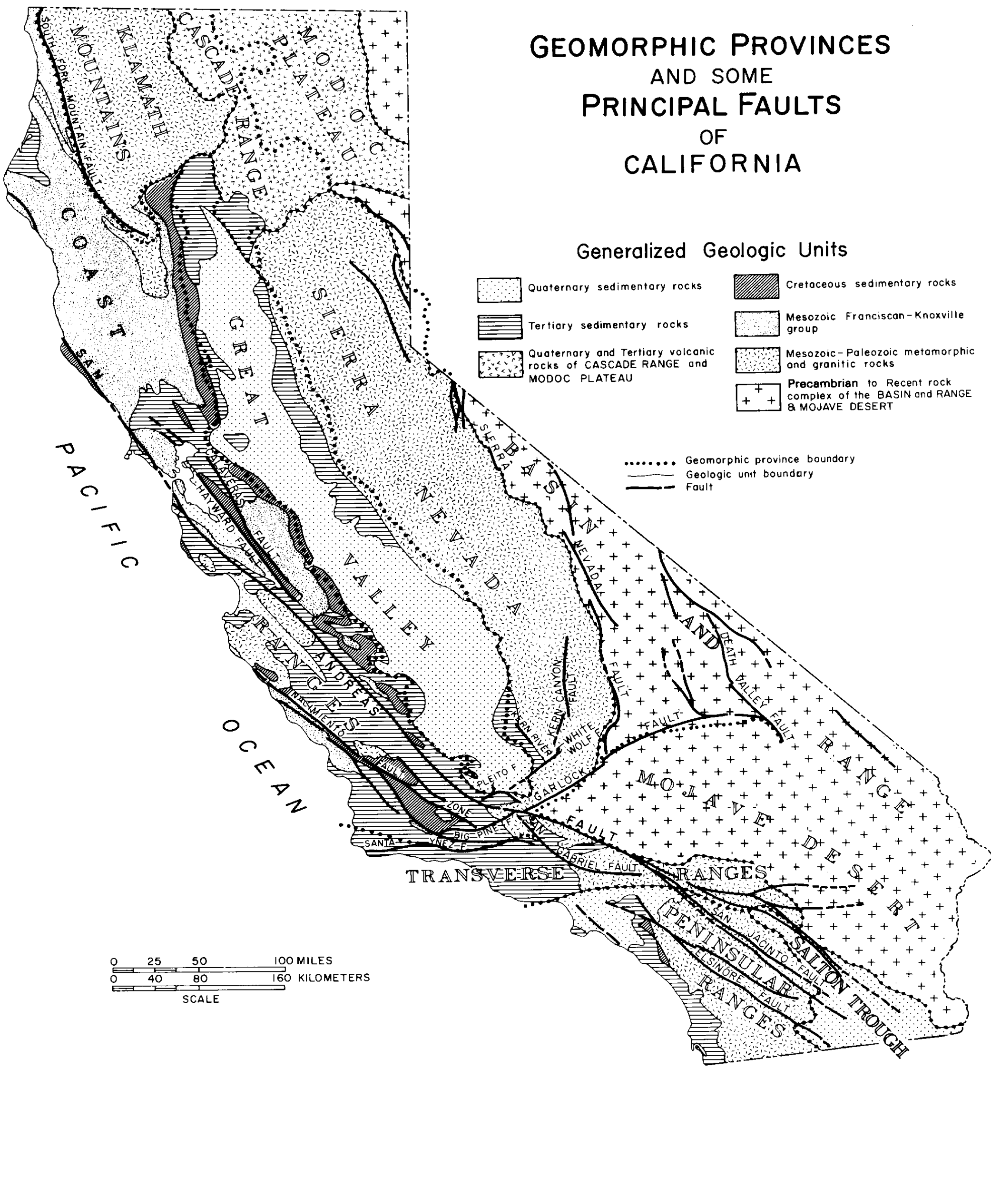
Geologists give the rocks they study names to help identify them and to communicate certain characteristics to other geologists. These names however do not tell you their characteristics if you are introduced to them for the first time. Its like meeting a person for the first time, you now know the persons' name, but you do not know anything about that person. If you pick up a rock and do not know what it is, you can begin to look and find clues that might suggest what the rock is. You slowly become a friend to that rock. Let's start to explore the types of rocks that California has.

California is geologically a very complex area. It has all three kinds of rocks, in different combinations, all around the state. Many of these rocks are mined either to extract the mineral wealth (remember minerals make up rocks) or to use rocks as ingredients for building materials (cement, gravel, etc). On the map of California you can see the areas and the overall rock ingredient of that area. These geomorphic areas (areas with different landscapes, representing different types of rocks) however, have many different variations and sometimes exceptions. The legend on this map has words like Quaternary, Tertiary, Mesozoic, Paleozoic and Pre-Cambrian. These refer to time: Quaternary is up to 10 thousands years ago; Tertiary is up to 65 million years ago; Mesozoic is up to 225 million years ago: Paleozoic is up to 600 million years ago; and Pre-Cambrian is anything older than Paleozoic. This is getting complicated...so let's try and recognize some of the rocks in a few of these geomorphic regions.

Let's start with the Sierra Nevada. Driving to Yosemite or Lake Tahoe you can't help but see the white and black rock along the side of the road. Much of this rock is a type of granite, a rock made up of large crystals of black and white minerals (mainly quartz, feldspar, hornblende and biotite). This area was once magma under the earth over 65 million years ago. It cooled and has slowly moved up, and the rock above it slowly eroded to expose what you see today.

Another prominent geomorphic region is the Great Valley, a flat area in the middle of the state. Many travelers down Highway 5 complain about the lack of scenery. True, it is very flat, but the exciting rocks lie underneath. This area used to be under very deep marine water, so they type of rocks found here are sedimentary. Trapped in the layers are large deposits of oil and gas, which add to the wealth of our state.

In northern California you have a very complicated area. The areas that stand are the Cascade range because it noted for its "sleeping volcanoes." Mt. Shasta and Mt. Lassen are also in these ranges. The major type of rocks found here are igneous. The Coast Range or the mountains that hug the central coast is geologically very complex. The types of rocks range from igneous, sedimentary to metamorphic. The San Andreas fault and the movement associated with it has made an added "mess" of these rocks...commonly called a melange. California is complex geologically, but for students to realize that within each rock, there is a story that unravels the geologic history of their state, is awesome indeed.


GEOMORPHIC PROVINCES
AND SOME
PRINCIPAL FAULTS
OF
CALIFORNIA
Generalized Geologic Units
Quaternary sedimentary rocks
Tertiary sedimentary rocks
Quaternary and Tertiary volcanic rocks of CASCADE RANGE and MODOC PLATEAU
Cretaceous sedimentary rocks
Mesozoic Franciscan-Knoxville group
Mesozoic-Paleozoic metamorphic and granitic rocks
Precambrian to Recent rock complex of the BASIN and RANGE & MOJAVE DESERT
Geomorphic province boundary
Geologic unit boundary
Fault
KLAMATH MOUNTAINS
CASCADE RANGE
MODOC PLATEAU
COAST RANGES
GREAT VALLEY
SIERRA NEVADA
BASIN AND RANGE
MOJAVE DESERT
TRANSVERSE RANGES
PENINSULAR RANGES
SALTON TROUGH
PACIFIC OCEAN
SAN ANDREAS FAULT
HAYWARD FAULT
GARLOCK FAULT
DEATH VALLEY FAULT
KERN CANYON FAULT
WHITE WOLF
SAN GABRIEL FAULT
SAN JACINTO FAULT
ELSINORE FAULT
BIG PINE
0 25 50 100 MILES
0 40 80 160 KILOMETERS
SCALE

EXERCISES TO HELP ILLUSTRATE CONCEPTS

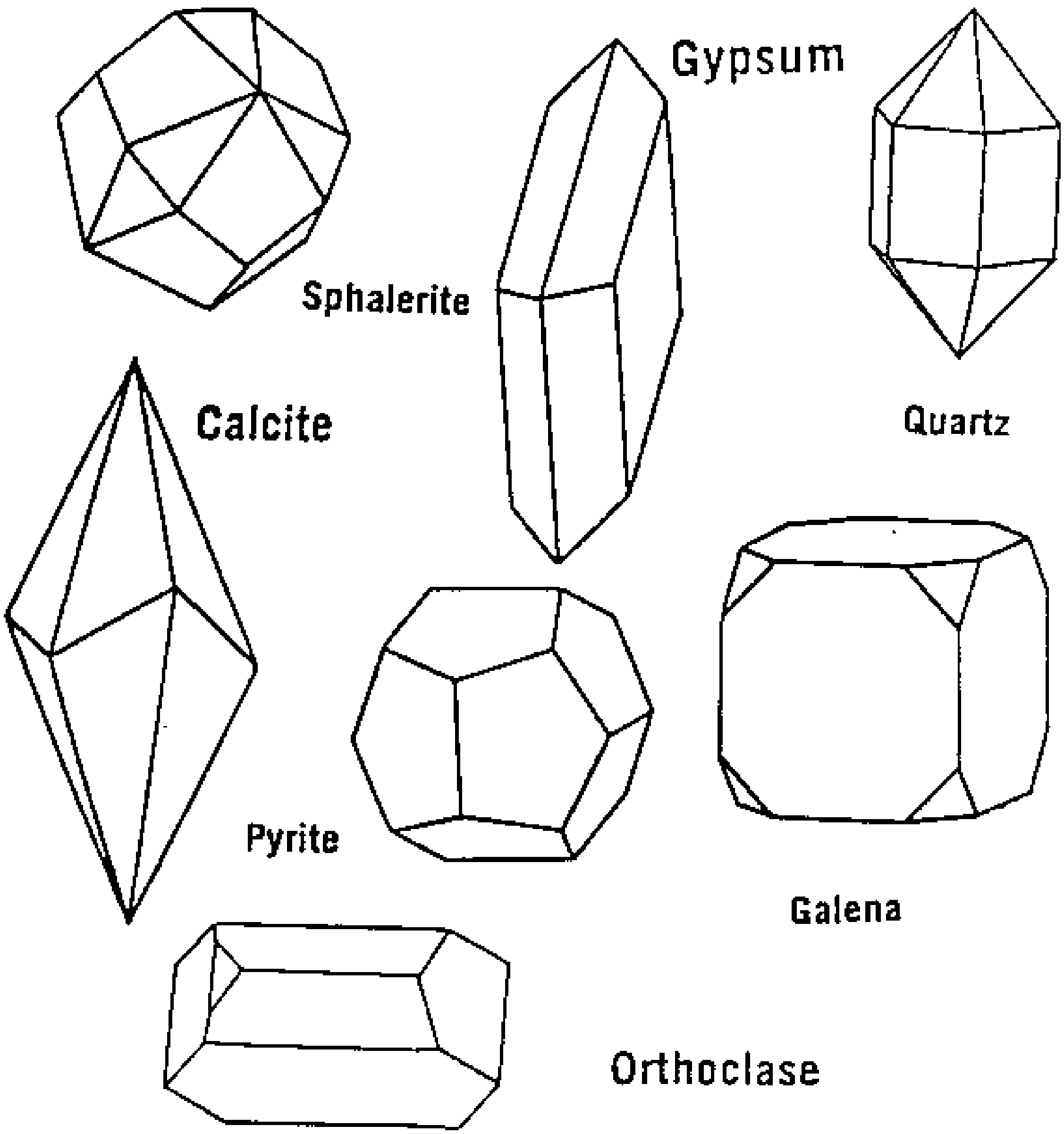
The following are examples of activities from the ROCK CYCLE that have been successful used in the Integrating Science, Math, and Technology (I. Science MaTe) program developed by the Math/Science Nucleus. If you wish further information on grade specific hands on activities please visit the Math/Science Nucleus website http://msnucleus.org. The complete volume of the ROCK CYCLE - UNDERSTANDING THE EARTH'S CRUST, there are 6 weeks of lessons plans per grade level. Three activities per week, or a total of 126 a activities for kindergarten through the sixth grade. The activities are completely written out. The activities included here do not represent the entire activity. If interested in learning more about minerals and rocks, we urge you to view the complete volume.

Minerals and rocks are hard to teach without hands-on materials. The following sheets illustrate some techniques on how to use some of these specimens. We don't include an answer sheet, because that depends on what samples you use. You can use some of the samples in the kit, but you can also get local samples. Stores that sell landscape supplies, might have rocks that can be used. Listed below are the labs included and a brief summary.

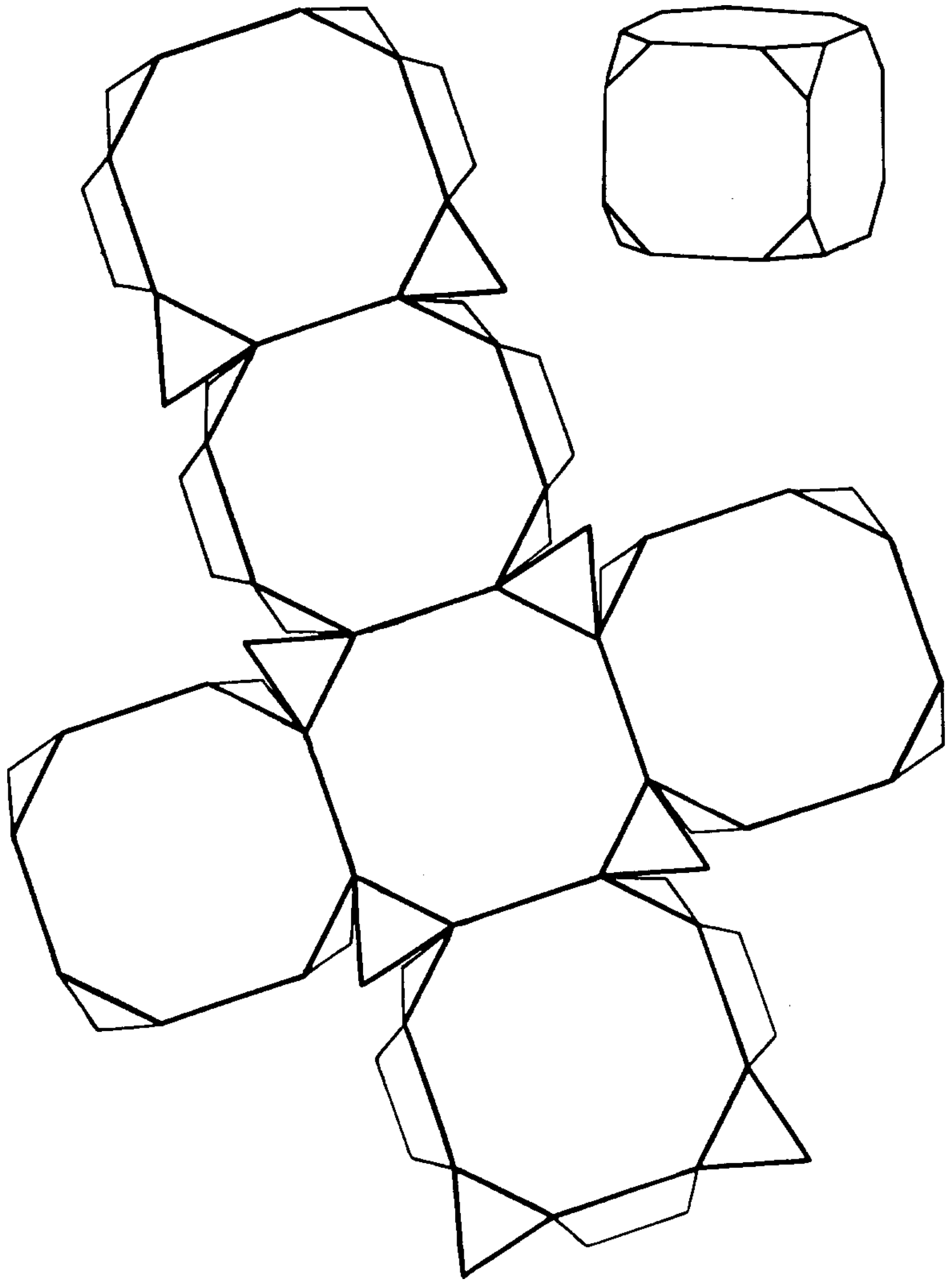
1. MAKE A MINERAL PERSON
2. MINERAL MOBILE
1. How We Use Minerals - If you are not sure of the answer, consult the encyclopedia or read the labels of the items in the store.
3. GROWING A CRYSTAL GARDEN
4. A CLOSER LOOK - This emphasizes that Key Characteristics of a mineral are very important to identifying a mineral.
5. MINERAL SHAPE - This lab looks at the different shapes of crystals that grow naturally. You may want to compare crystal shapes to the shapes that are made when minerals are broken (cleavage).
6. HARDNESS (1 AND 2) - Included are 2 sheets that make the students create their own hardness scale.
7. MINERALS MAKE UP ROCKS - Exercise takes 3 good samples and guides the students into finding those minerals. You should also note, that in many rocks, the minerals are not obvious. However, if you look under a microscope, you can see them.
8. ROCK KIT - This is only an example of a lab sheet that you can develop with your student. This is difficult and boring for many students, but easy to make for the teacher. You decide whether or not to use it.
9. ROCK CYCLE - This exercise tries to make the rock cycle alive for the students by trying to figure out where the rocks of the lab belong. This depends on the samples you have on display for the students to use.
10. SEDIMENTARY ROCKS - There are two types of sedimentary rocks - those that are cemented together and those that have a chemical bonding. This exercise tries to show students that sedimentary rocks with a chemical bonding are difficult to determine.

MAKE A MINERAL PERSON

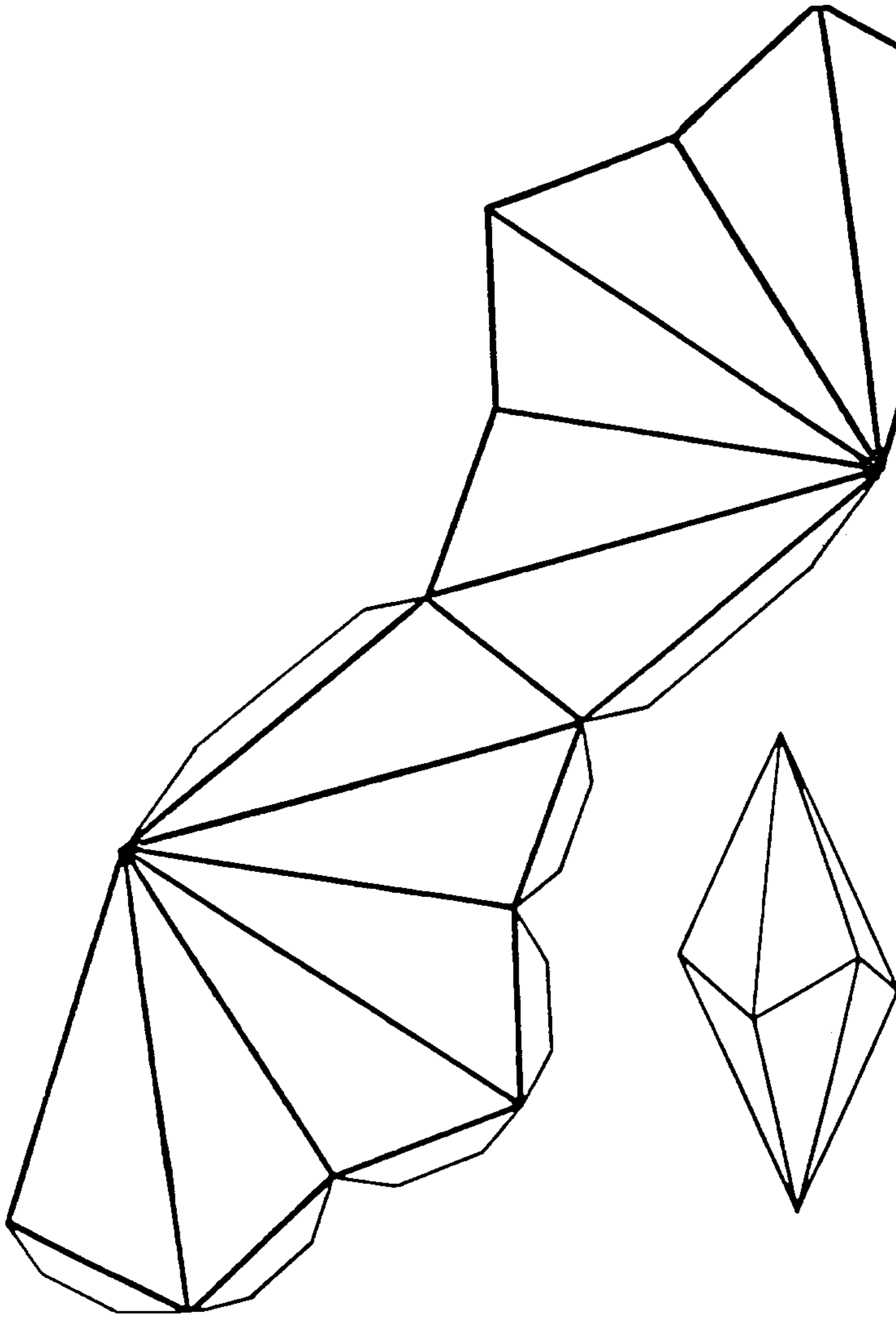
HAVE STUDENTS COLOR AND CUT OUT THESE DIFFERENT MINERAL SHAPES. HAVE STUDENTS ARRANGE THEM INTO THE SHAPE OF EITHER A MAN OR WOMAN, OR ANY OTHER ORGANISM OR THING. THIS REINFORCES THAT MINERALS HAVE MANY SHAPES.



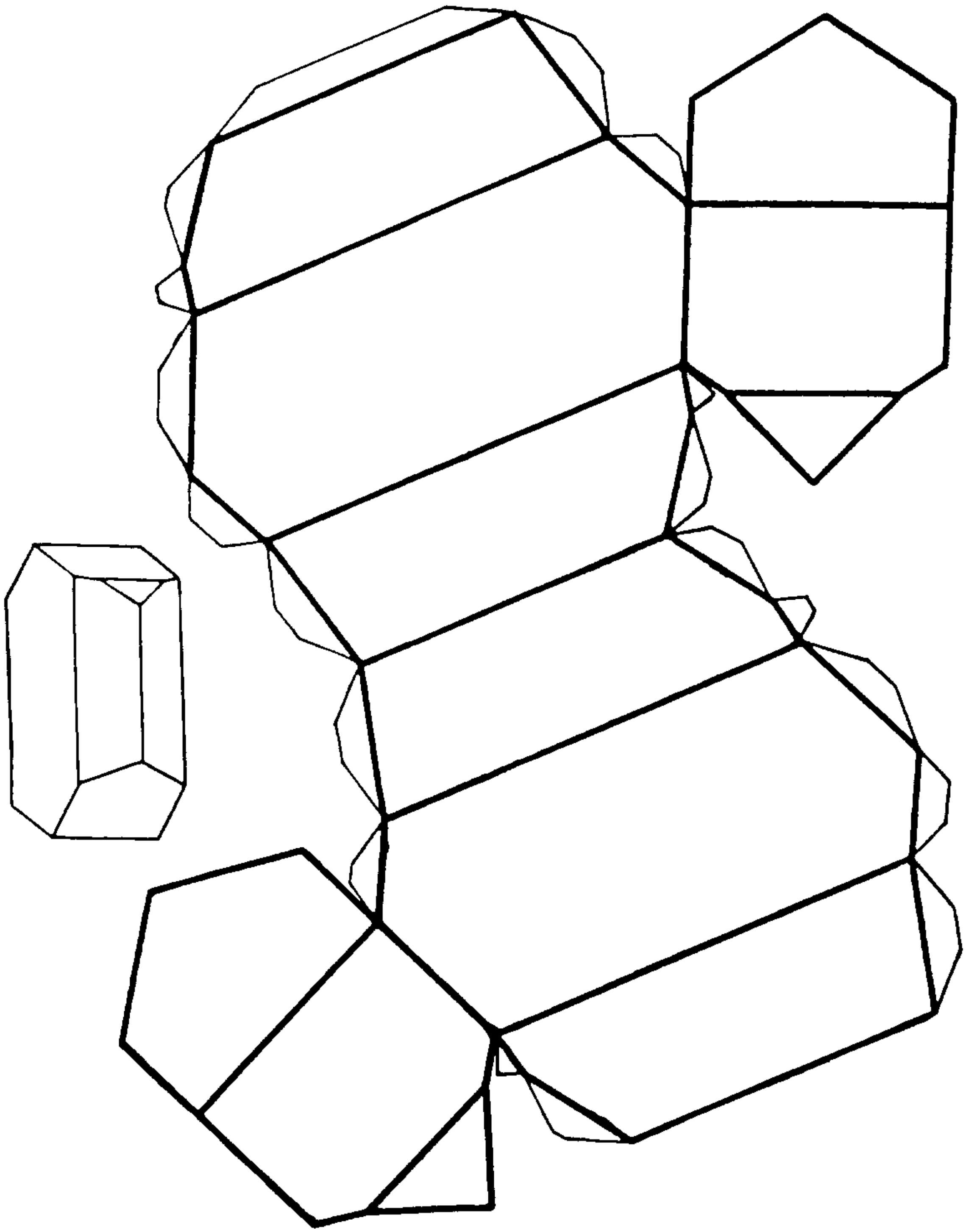
MINERAL MOBILE - GALENA



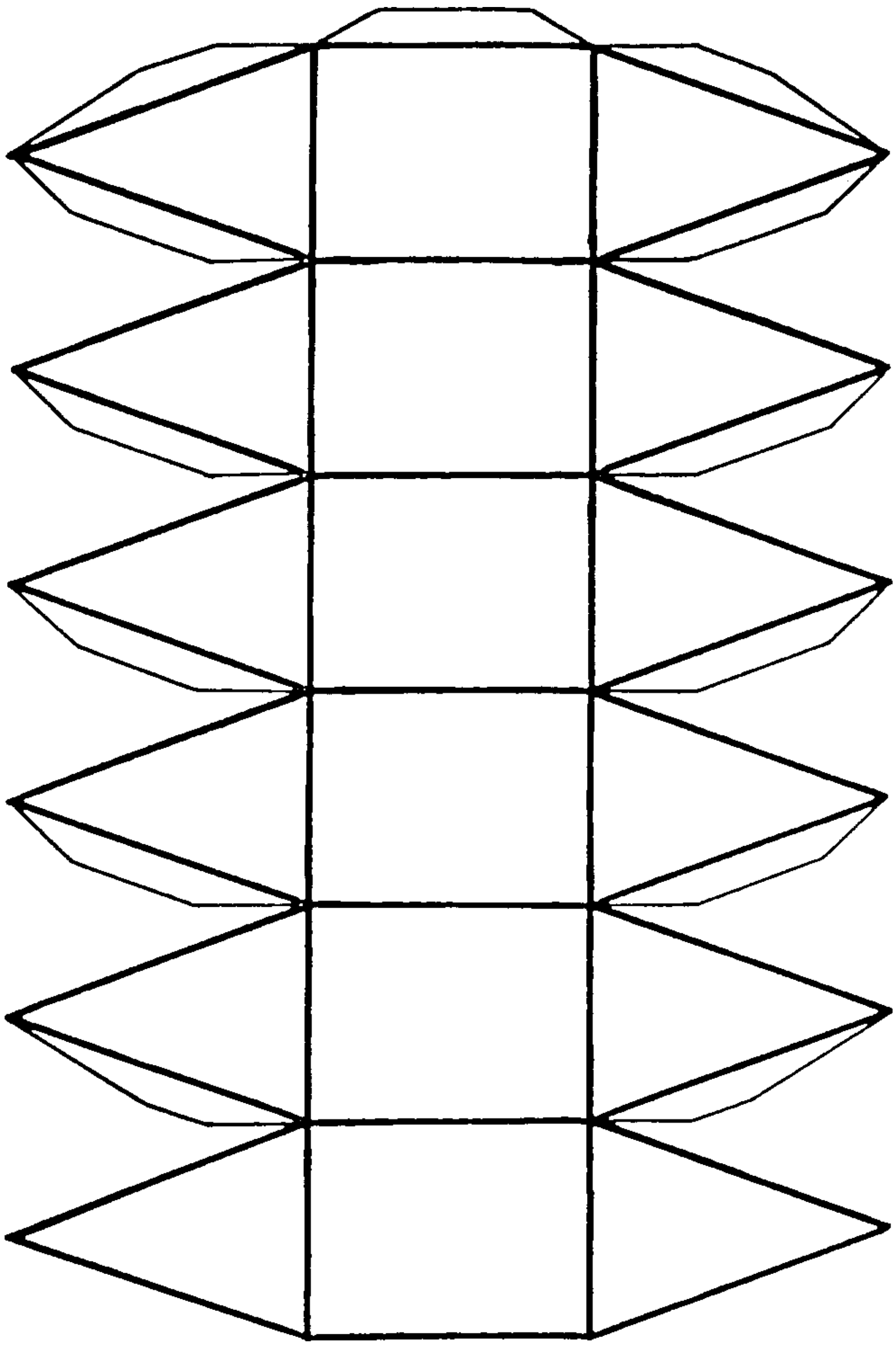
MINERAL MOBILE - CALCITE

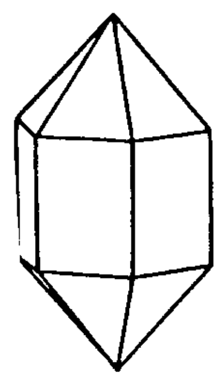


MINERAL MOBILE - ORTHOCLASE



MINERAL MOBILE - QUARTZ





GROWING CRYSTAL GARDENS

RECIPE

- 4 Teaspoons water
- 2 Teaspoons ammonia
- 2 Teaspoons laundry bluing
- 4 Teaspoons salt

Mix ingredients together. On the bottom of a small jar (baby food jar size) place either charcoal or perlite (can buy at a garden shop). Pour the ingredients on the charcoal or perlite, just enough to barely cover them. Drop food coloring to give desired color.

TEACHERS: Growing the crystals can illustrate to students how crystal "grow." Emphasize that not only people and other living things grow, but non-living as well. Grow means to get larger, as these crystal gardens illustrate.

MINERALS
HOW WE USE MINERALS

1. Name three things in the classroom made from a mineral, and name the mineral.

item	mineral
____________________	________________
____________________	________________
____________________	________________

You have several household items, pictures, and labels from other items. Match each one with the mineral or minerals from which it was made. Fill in the chart below. Under "Properties" list the properties of that mineral that make it ideal for a specific product.

PRODUCT	MINERAL(S)	PROPERTIES

List at least two uses for each of these common minerals:

QUARTZ	
CALCITE	
GYPSUM	

MINERALS - A CLOSER LOOK

DIGGING DEEPER INTO THE CHARACTERISTICS OF SOME COMMON MINERALS
We have studied how to identify minerals by recognizing their key characteristics. Today we will examine more closely, the common minerals quartz, calcite, and gypsum. Each of these minerals comes in many forms and varieties.

1. How can the same mineral appear in so many different forms?

____

____

2. Do all minerals appear in so many forms? ________________________________

mineral name	characteristics
calcite	
quartz	
gypsum	

How can we be sure to recognize a mineral that commonly has so many form?

____

MINERAL SHAPE

What does the shape of a mineral crystal tell you?
____
____ Do minerals always have that same crystal shape? ________ Why? __________________

You have different mineral crystals at your lab table. Draw the shape and then look at the associated rocks on the display table and try to match the mineral with the rock by using other key characteristics.

mineral name	shape (draw)	describe rock that is related
QUARTZ		
GYPSUM		
CALCITE		
COPPER		

CHARACTERISTICS
HARDNESS (1)

How can you tell if a mineral is hard or not?______________________________________

What does the hardness or the softness of a mineral tell you?

____

Let's try and figure out how hard or soft the minerals in your collection are, by comparing them to each other. We will start to make a hardness scale by using the following objects: Fingernail, a steel nail, and a penny. State whether the following are softer than or harder than the fingernail, nail or penny.

	softer than	harder than
gypsum		
copper		
calcite		
quartz		

Now make a scale of the softest minerals to the hardest.

1. ________
2. ________
3. ________
4. ________
5. ________
6. ___________
7. ___________
8. ___________
9. ___________
10. ___________

HARDNESS (2)

Every mineral has a given hardness. Geologists use what is called the Mohs Hardness Scale to assign minerals a hardness. The minerals that make up the Moh's Scale are listed below, other familiar items are also included in their appropriate hardness.

1	TALC	5 1/2	WINDOW GLASS
2	GYPSUM	6	FELDSPAR
2 1/2	FINGERNAIL	7	QUARTZ
3	CALCITE OR COPPER PENNY	8	TOPAZ
4	FLUORITE	9	CORUNDUM
5	APATITE OR STEEL KNIFE	10	DIAMOND

****

TEST FOR THE HARDNESS

DIRECTIONS: USING SOME OF THE ITEMS IN THE ABOVE SCALE, TRY TO FIGURE WHAT THE HARDNESS IS OF THE ITEMS PROVIDED.

ITEM	HARDNESS	HOW YOU DETERMINED THE HARDNESS

ROCKS
MINERALS MAKE UP ROCKS

Minerals make up rocks. Different minerals can be distinguished by different characteristics in a rock. In this exercise you have three different types of rocks. Describe and draw what each of the minerals in each of the rocks look like.

name	number of minerals in rocks	describe and draw
granite		
schist		
marble		

ROCKS - ROCK KIT

There are three basic type of rocks. Igneous Rocks are rocks that were once melted and have cooled down. Sedimentary Rocks are rocks that are pieces of other rocks that are glued together. Metamorphic Rocks are those rocks that used to be Igneous or Sedimentary, that under temperature and pressure and changed to what those rocks look like. Below are a list of different types of rocks, list whether they are Igneous, Sedimentary or Metamorphic and list the characteristics of each rock.

name	type of rock	characteristics
obsidian		
basalt		
granite		
pumice		
sandstone		
conglomerate		
diatomite		
shale		
chert		
marble		
serpentinite		
schist		
slate		

ROCK CYCLE

Where are igneous rocks made?____

Where are sedimentary rocks made? ____________________________________

Where are metamorphic rocks made? ___________________________________

The rock cycle refers to the notions that rocks can become other types of rocks by erosion, temperature or pressures in or on the earth. Look at the rocks at the different stations around the room. Try and place the rocks in the correct position in this rock cycle. Use their given code on the diagram.

MELTS

EROSION

SEDIMENTARY **IGNEOUS**

TEMPERATURE PRESSURE

EROSION

TEMPERATURE PRESSURE

MELTS

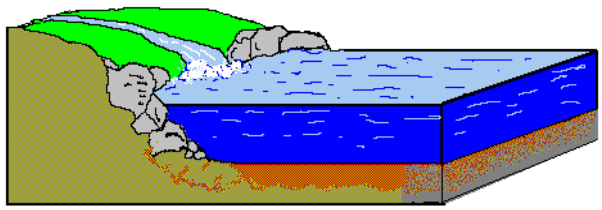
METAMORPHIC

SEDIMENTARY ROCKS

What is another name for sedimentary rocks? ________________________________

Where are they usually found? ____

Below is a diagram of where sediments in the ocean settle out. At your table you have several samples of sedimentary rocks. Place on the diagram where you think each of these samples are from and describe these rocks.



sand	
sandstone	
diatomite	
conglomerate	
mudstone	

Chert and salt rock are also sedimentary rocks? How do they differ from the samples above.

	description	how does it differ
chert		
rock salt		