KANSAS 4-H

Geology

Kansas State University Agricultural Experiment Station and Cooperative Extension Service ■ Manhattan

Kansas 4-H Geology Leader Notebook

Chapter 1 — Geologic Processes

The Crusty Earth

Geologic Processes — Geology, Level I

What members will learn . . .

About the Project:

- Minerals and rocks in the Earth's crust are in a solid state because they have cooled.
- The Earth's crust floats on the mantle.
- The mantle and core are liquid or semi-liquid material because they are hot.

About Themselves:

- Science concepts are an important part of everyday life.
- Observation skills in their changing environment.

Materials: (2 to 3 members per group)

- 1 bag Plaster of Paris
- 6 tin foil pie pans, 6 paper plates, paper and pencils, or enough for one set per group
- 1 large bowl
- 2 quarts water (do not use soft water)
- 3 ice trays with frozen cubes
- Paper and pencil for each group

Activity Time Needed: 20 minutes

Activity

All matter must be either a solid, liquid, or gas. A solid is hard. Liquid pours, and a gas is generally an invisible vapor. Matter changes from one state to another because of the loss or gain of heat.

Observe the temperature by touching the bottom of the pie plate and lightly touching the top of the plaster. Is it cold, warm, or hot when you touch it? Record this information.

- Give each group a paper plate with an ice cube on it.
- Have each group select someone to record what you observe during this experiment.
- What state is the ice in? Solid, liquid or gas? (*Solid*) Your group recorder should write this information on the paper that was provided. Record date, time and state of ice cube.
- What was the state of Plaster of Paris when you poured it into the pie plate? (*Liquid*) Record date and time, also.

Leader's Notes

Pass out the pie pans to the group, mix the Plaster of Paris in the large bowl by slowly adding water. After mixing, allow each group to get enough plaster to cover the bottom of the pie pan at least one inch deep. To ensure the plaster will set up, do not use soft water. Each group should have a pencil and piece of paper to record data.

Review the following information about the crust, mantle and core while the ice continues to melt and the plaster hardens.

Do some other distance comparisons.

Make this observation at least 10 minutes after pouring the plaster and putting the ice cube on the plate.

The crust, or the outside of the Earth, is solid, because it has cooled. The mantle, which is the section below the crust, and the core, are at much higher temperatures, causing rocks and minerals to be in a liquid or partially liquid stage.

The diameter of the Earth is 12,740 kilometers, or about 7,900 miles. The crust ranges from 0-28 miles deep, or about 0-45 km. The mantle is 28-1,800 miles deep, or 45-2,900 km. 1,800 miles is about the same distance from New York City to Denver, Colorado. The Earth's core ranges from 2,900 to 6,370 km, or 1,800-3,950 miles deep.

Now, let's look at our experiment again. What has happened to the ice? What has happened to the plaster? Have the group recorder write what has happened on your data sheet.

Dialogue for Critical Thinking

Share:

1. What did we do to create this experiment?
2. What happened to the ice as it became warmer?
3. What happened to the plaster when it was mixed with water?

Process:

4. How is the Earth's crust like the plaster?
5. How is the Earth's mantle and core like water?
6. How is the Earth's mantle and core different from this water?

Generalize:

7. Can you think of examples where the Earth's crust is warmer or colder than other areas?
8. When you are conducting experiments like this, why is it important to write down what you see?

Apply:

9. If you could have changed this experiment, what would you have done differently, and why?
10. What have you learned about the Earth's crust that will help you as you think about collecting or identifying rocks and minerals?

Going Further:

1. Build a cross-section model of the Earth to scale and label the parts by name, identifying each state as solid, liquid, or gas.
2. Light a candle and allow the wax to become a liquid or semi-liquid and pour onto wax paper.-As it cools, explain the change from liquid to a solid and also note how the wax is flexible in its semi-liquid stage. The Earth's rocks and minerals react similarly when heated or cooled.

Author: Alan DeGood, Kansas 4-H Geology Curriculum Team
Reviewed by: Dr. James Underwood, KSU Department of Geology
Steven D. Fisher, Extension Specialist (Retired), 4-H Youth Development
James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

The Floating Earth

Geologic Processes — Geology, Level I

What members will learn...

About the Project:

- The earth is hotter in the center.
- What causes a volcano to erupt.

About Themselves:

- How daily observation helps them understand scientific principles.

Materials Needed: One set for each 3 members

- 1 empty, clear, 2-liter bottle
- 1 quart jar
- 1 bottle food coloring
- 1 basting tube with 8-inch plastic tube attached
- 1 Tbsp. cooking oil
- Supply of hot and cold water

Activity Time Required: 20 Minutes

Activity

Fill your clear, 2-liter bottle with cold water. Next, place some very hot tap water in the quart jar and add ½ teaspoon of food coloring. What happened?

Now, take the basting tube and draw the hot colored water into it. Place the end of the basting tube in the bottle containing clear water. Gently squeeze the basting tube.

What happened?

Repeat the experiment using the cooking oil instead of the hot, colored water.

What happened?

Now we can see that not only material of a lighter density floats on the top of a more dense material, but that material of the same density when heated will rise to the top of a similar material.

What does this tell us about the Earth? We know that the interior (inside) of the Earth is very hot, so the material (rocks and minerals that compose them) is more dense than those in the crust of the Earth?

Leader's Notes

Explain to the members that the concentrated food coloring is diluted and that the water changed the color because of the dilution.

Heated material (air, water, etc.) of the same type will rise in a similar material.

Material of lighter density will rise or float in a more dense material.

More dense.

Dialogue for Critical Thinking

Share:

1. What did we do?
2. What happened when the hot and cold water were mixed?
3. What happended when the oil was added to the water?

Process:

4. How does this experiment help us understand that the earth's crust floats?
5. How does this explain the temperature of the inside of the earth?

Generalize:

6. What foods or drinks can you think of that react like this experiment?

Apply:

7. Can you think of some examples in your community where heated materials rise? (*Ex.: Hot air ballons, hot air, steam*)
8. On the planet Earth can you think of any evidence that the interior (mantle and core) of the Earth is warmer than the outside (crust)?
9. Why do volcanos and geysers erupt?

The Earth's interior is very hot and it heats the fluids and material in the mantle and crust which then turns into gases or less dense material that rises in similar fluids.

Going Further:

Examine several similar rocks or minerals and explain the color variation. Using a large dish pan, fill it with water and let the members place objects into the water and determine which item is the least dense and the most dense. Items you need are a balloon, wood, plastic, and steel.

Author: Alan DeGood, Kansas 4-H Geology Curriculum Team

Reviewed by: Dr. James Underwood, Professor (retired), KSU Department of Geology

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

The Earth's Makeup

Geologic Processes — Geology, Level I

What members will learn...

About the Project:

- The Earth is not solid.
- The Earth can be divided into three parts.
- The center of the Earth (core) is made of elements which are heavier (more dense) than the elements in the mantle or crust.

About Themselves:

- How observation skills will help to understand their surroundings.

Materials Needed:

- Raw eggs
- Water
- Vegetable oil (¼ cup per 2 or 3 members)
- Pencils and paper
- Clear plastic glasses

Activity Time Needed: 20 Minutes

Activity

The Earth is similar to an egg in that it has a hard outer layer called the crust, a middle inner layer called the mantle which is semi-liquid, and a center layer called the core that is dense liquid.

When you broke the egg in the bowl, why did the yolk go to the bottom and the white and shell go to the top? Was it because the yolk was heavier (more dense)?

Let's do another experiment:

Take ¼ cup of vegetable oil and mix it with one cup of water and let it settle.

The oil floats to the top because it is lighter (less dense) than the water, therefore it floats on top of the water. Similar to the egg shell and egg white above the egg yolk.

A similar reaction occurs in the Earth, the heaviest or most dense minerals are found in the center of the Earth (core). The mantle is made up of less dense minerals and the crust has the lightest minerals.

Leader's Notes

Have the members gather into small groups (2-3). Each group needs a plastic glass and a raw egg. Let the members describe the egg (*shape, color and shell*). Now have the members break the egg into the glass, have the members describe what they see (*shell which is hard, liquid or the egg white and a dense yellow part called the yolk*).

Have the members explain what happens before telling them.

Now have the members draw a circle that represents the Earth's crust. In the center of their first circle have the members draw a small circle and color it solid. The members are now ready to label the parts of the Earth that are the crust, mantle and core.

The members should now be instructed to go back to their cross section of the Earth and label the three parts, from lightest to most dense using the following terms: lightest, light and heavy.

Dialogue for Critical Thinking

Share:

1. What happened to the shape of the egg when it was broken?
2. What part of the egg is similar to the vegetable oil? Why?

Process:

3. How are the earth and an egg alike? Different?
4. What are the three main layers of the Earth?
5. Which parts of the Earth are heaviest? Lightest?

Generalize:

6. Where else do you observe layers?
7. What other items have different weights? How do you know?

Apply:

8. How will what you learned help you understand other things in nature?

Going Further:

Gather samples of soil, sand and gravel. Take one cup of each sample and place them into a quart jar, finish filling the jar with water. Gently shake the jar for about two minutes and allow the jar to set on a table for five minutes. What happens?

Author: Alan DeGood, Member Kansas 4-H Geology Curriculum Team

Reviewed by: James R. Underwood, Professor (retired), KSU Department of Geology

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Dusty Rocks

Geologic Processes — Geology, Level I

What members will learn...

About the Project:

- How to define mechanical or physical weathering.
- The definition of erosion.
- Erosion and weathering are slow processes.

About Themselves:

- Discoveries through observation
- Value of cooperation

Materials Needed:

- Soft rocks such as limestones, sandstone and chalk. Four or more pieces should be several inches in diameter. The rest should be a cup or more of small pieces.
- Coffee can (will be loud) or plastic jar such as peanut butter jar (preferred).
- Pieces of white paper
- Measuring spoons
- Soil samples of mineral and plant material
- Magnifying glass

Activity Time Needed: 15 Minutes

Activity

Did you ever wonder what rocks become when they break up? Well, today we are going to find out. We are using soft rocks today, so we can see the results faster, but it works the same for hard rocks also. What kind of rock is this? We are going to rub these two rocks together until some pieces break off. I'll show you how to do it and then you can each try it. Here is a sheet of paper to catch the pieces and then we can put all that we rub off together and see if we can make a spoonful. Put your paper on the desk (or table) and hold the rock above it and rub them like this until you see some tiny pieces come off. See how small they are? Now, we'll pass these rocks around while we are talking and you can each rub them and try to get some rock dust.

Now, I am going to start another experiment.

What do I have in this jar? (*A. Some rocks.*) What kind are they? Do you see any dirt or dust? No. As we pass this jar around, I want each of you to shake it a little while. Try not to be too loud so that we can keep on talking. What do you think will happen?

Leader's Notes

Try your rocks ahead of time to see how they work. If they are not soft enough or if you cannot find appropriate natural rocks, you may use chalk. The sidewalk chalk would make a good size. Chalk is a "real" rock.

Hold up a piece of rock.

Set time limits on each person if necessary. Have several sets, if possible.

Predicting is a valuable exercise that improves thinking skills.

Large events often occur in nature, but this lesson focuses on the gradual ones.

Ties into the rock cycle. Learn more about that in the rock section.

Look at it with a magnifying glass.

Every person should get a chance before you finish.

Carefully! If anybody spills, use a piece of paper like a dustpan and collect what you can

What would be rubbing rocks together in nature, if people weren't there? (*A. Wind could be hitting the rocks together. Also water and ice could do that.*)

Would ice break off very much at a time? (*A. Sometimes, but usually it would only break off small pieces.*)

What happens to the little pieces of rock? (*A. Sometimes they get washed into the ocean.*) When rocks are broken apart and moved to a different place, it is called erosion. Sometimes they get squashed or melted back into rocks, called magma, but most of the time, they become part of the dirt or soil. Let's look at this sample of soil that I brought from outside.

What do you see in it? Do you see any little pieces that could be rock? What else do you see? Could some of that be plant materials? All that stuff combines to make soil. The decayed plant materials, called humus, help to hold the water in the soil and to make it loose and easy to work with.

What do you think the rock pieces do? (*A. They contribute minerals, or nutrients, that the plant needs to grow.*)

If each of you has had a chance to rub off some rock pieces, let's look at the results. Did anybody get a lot? Well, you all did pretty good, but nobody got a whole lot by themselve. Let's carefully pour it all together on this piece of paper and see if we get a teaspoonful together. (Measure). If each person does a little and puts it all together, then we get enough to make a difference. Weathering works the same way. Each piece isn't much, but all together, over several years, it is enough to make a big difference.

Now let's look at the jar. What do you see? Any dust or dirt yet? Where did that come from? (*A. From the little pieces of rock that have broken up.*)

Dialogue for Critical Thinking

Share:

1. Which created the most dust, rubbing rocks together or shaking the jar? Why?
2. What rocks made the most dust? Why?

Process:

3. What problems did you have making dust? What is this process called? (*Weathering*)
4. What is it called when rocks are broken apart and move to a different place? (*Erosion*)
5. What is soil? (*Rocks and plant material*)

Generalize:

6. How much dust did you make compared to that of the total group? How did cooperation help?
7. What are some other times when you need help (cooperation) to get something done?

Apply:

8. How important is each small part when cooperating on a big job? Why?

Going Further

1. Go for a walk, or on your next field trip, look for examples of weathering and erosion.
2. Compare soil samples from different places. What makes them different?

References:

Schlesener, Norman E., Plant Science, 4-H Curriculum Material, Level IV, Cooperative Extension Service, Kansas State University, Manhattan KS.

VanCleave, Janice, *Earth Science for Every Kid.* 1991, John Wiley & Sons, Inc., New York.

Author: Pat Gililand, member, Kansas 4-H Geology Curriculum Team.

Reviewed by: James R. Underwood, Jr., Professor (retired), KSU Department of Geology

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

The Mighty Plates

Geologic Processes — Geology, Level II

What members will learn...

About the Project:

- The members will learn about Pangea (Pan-JEE-uh).
- Continental drift and continental plates.
- Plates are pieces of the Earth's crust, most of which contain a continent.

About Themselves:

- Why change is often slow.

Materials Needed:

- Copies of Activity Sheet 1, *Continental Plates* for each member
- Scissors
- Tape
- Pencils
- Globe or world map

Activity Time Needed: 20 Minutes

Activity

The word Pangea is the name given to the large land mass on the Earth before it began breaking into the continents that we presently recognize. Pangea was subdivided into two smaller continents about 200 million years ago during the Jurassic Period. Laurasia represented the northern hemisphere continent and Gondwanaland was the continent located in the southern hemisphere. Laurasia and Gondwanaland began breaking up into the continents as we recognize them today about 135 million years ago. The heated material from the Earth's core and mantle provide the energy necessary to move the plates on the Earth's crust.

Pass the map of the continents out and have each member carefully cut out each of the continents. Once they have cut out the continents, they are ready to assemble into one large continent that geologists call Pangea. Each large continent is called a continental plate. To assemble them into one large continent, simply move the continental plates around until you have a good fit. When you get a good fit, tape them together. Keep adding continental plates until all are taped together. Now they should fit on the Pangea continent.

Once you have taped all the tectonic plates back together, you can see how the Earth looked 200 million years ago.

Leader's Notes

This was the time the Rocky Mountains were beginning to form.

Does this help explain why there were dinosaurs on all continents?

Distribute Activity Sheet 1, *Continental Plates*.

Dialogue for Critical Thinking

Share:

1. How did you feel when you were trying to match the continents to Pangaea?
2. Did all the plates fit together or are there some holes? Why?

Process:

3. When the hot material of the mantle reached the surface of the Earth, what happened?
4. Are there any areas on the Earth today that have active earthquakes and volcanoes?
5. Why would the crust of the Earth be the youngest and thinnest near the earthquakes and volcanoes?
6. What force might have caused Pangea to break apart?

Generalize:

7. What other things can you think of that have changed shape over time? What caused that change?

Apply:

8. Name or describe some natural or man-made disasters that have changed the face of the earth?
9. What can you do to affect change?

Going Further:

Research Continental Drift and do a project talk on what other evidence supports this theory.

References:

Physical Geology, Fifth Edition, Publisher William C. Brown

Author: Alan DeGood and Bill Dymacek, Kansas 4-H Geology Curriculum Team

Reviewed by: James R. Underwood, Jr., Professor (retired), KSU Department of Geology

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Some possible answers:

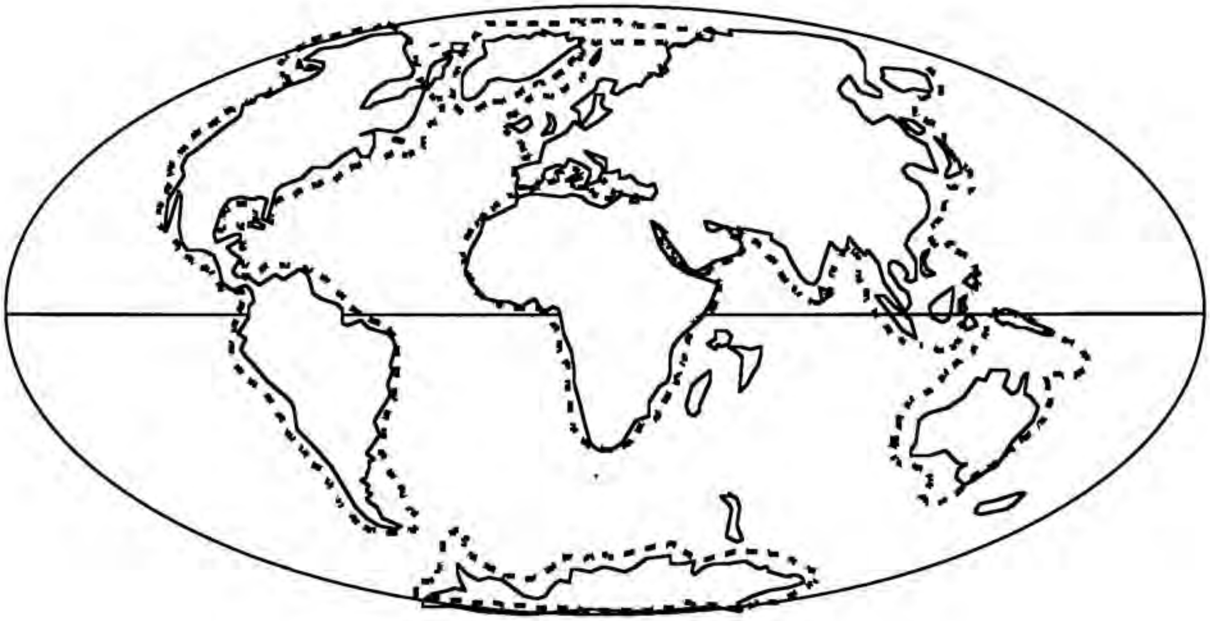
2. The holes are present because most of the continents have a continental shelf, which are underwater extensions of the continents.
3. Volcanoes and earthquakes occur.
4. Yes, show them the globe or world map and point the active areas out.
5. Yes, because this is where the rocks are solidifying and forming.
6. Remember how the mantle and core have semi-liquid material present and the crust is a brittle solid; as the material in the mantle worked its way toward the surface it broke up Pangea and began forcing the land masses apart, forming the continents as we know them presently.

The Mighty Plates

Activity Sheet 1, Continental Plates

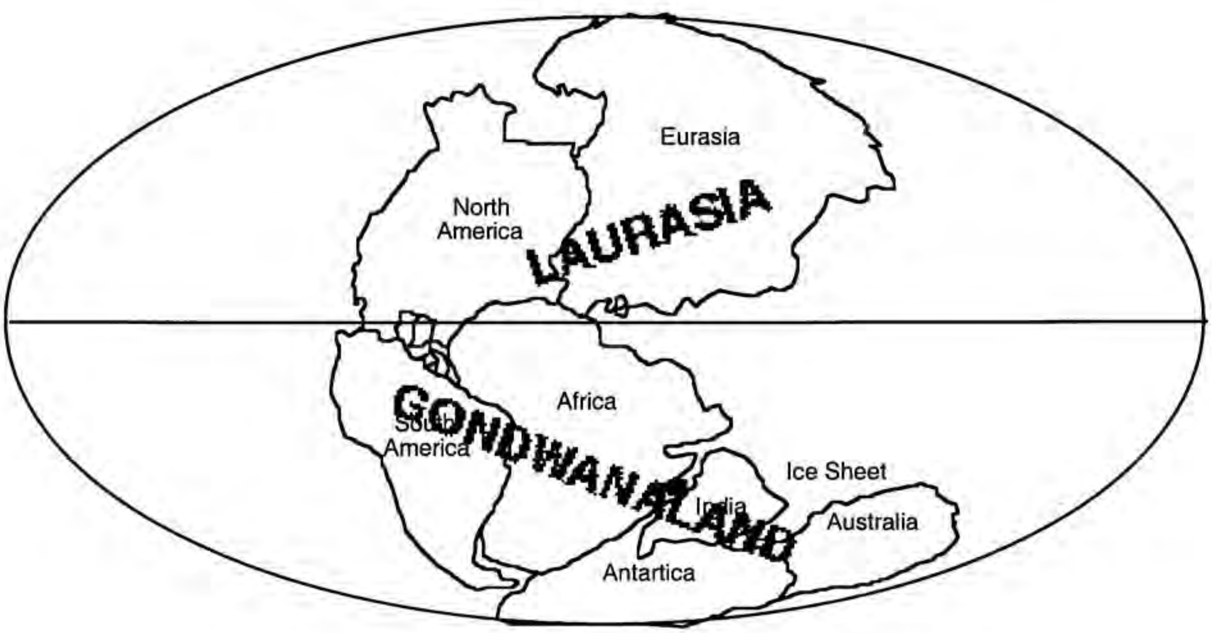
Geological Processes — Geology, Level II

Cut the continental plates around the dashed line.



Pangaea

This is what the earth's landmasses looked like before the breakup of Pangaea.



Making Mountains

Geologic Processes — Geology, Level II

What members will learn...

About the Project:

- Things happen inside the earth that help form mountains.
- New geological terms and processes.

About Themselves:

- Small changes can make big changes over long periods of time.
- Patience is important when working with others.

Materials Needed:

- A sample of igneous, metamorphic, and sedimentary rocks (see Leader Notes)
- Activity Sheet 2, *Major Tectonic Plates of Earth*
- Activity Sheet 3, *Major Tectonic Plates of Earth, Leader's Key*
- Member Handout 1, *Glossary of Geological Terms*

Activity Time Needed: 30 Minutes

Activity

The Earth's crust is made up of large and small pieces called plates that move around on the mantle of the Earth. Sometimes these plates run into each other forming mountains. In some places, one plate is forced under the other and the second plate is forced up and over the first, forming mountains. In other places, the plates collide head on and mountains are erected. A mountain can be defined as any rock body that rises 2,000 feet or more above the surrounding land mass. Kansas is part of the North American Plate.

The North American Plate is moving west at the rate similar to that of your fingernails growing.

Mountains that are formed by plates colliding or large structural uplifts are called structural mountains. Structural mountains are usually very large. One such mountain system runs from Alaska to the tip of South America. It includes the Andes of South America, the Rockies of North America and the Alaskan Mountains. These mountains have a core area made of igneous rocks, which are surrounded by metamorphic rocks and further out by sedimentary rocks. These structural mountains are usually highly folded and faulted.

Another type of mountain is formed by erosion. These mountains have a simple structure in which rock layers are horizontal or folded. These mountains are called dissected mountains. They formed as a result of a river or drainage system that erodes a channel and removes the material or

Leader's Notes

Show your members a piece of granite for an igneous rock, which is commonly found in mountains. A piece of gneiss or schist is a good example of a metamorphic rock found in the mountains. A piece of sandstone, limestone or shale, which is found in the foothills around a mountain range is an example of a sedimentary rock.

Distribute Activity Sheet 2, *Major Tectonic Plates of Earth*. Have members label the continents. Use the *Leader's Key* to check answers.

Show sample of granite for an igneous rock.

sediments. Over millions of years, the valley widens and the river continues to cut down into the land mass. These mountains continue to stay at the original elevation and are higher than the surrounding land area only because the river and stream have cut the land area away.

Show your members a piece of shale and limestone to represent a common sedimentary rock.

The Ozark Mountains are an example of dissected mountains.

The third type of mountains are volcanoes that may have any type of rock. They always have some igneous rocks. Mount St. Helens, Washington; Mount Shasta, California, and Kaplan Mountain in New Mexico are examples of volcanic mountains.

Show your members a piece of basalt and obsidian for examples igneous rocks you would find around a volcanic mountain.

Distribute Member Handout 1, *Glossary of Geological Terms*, to each member.

Now we are going to review some definitions of geological terms which we have talked about. (You might ask for volunteers to take turns reading a different definition, or you can read them, depending on reading skills of your members.)

Dialogue for Critical Thinking

Share:

1. What happens when the plates of the earth run into each other?
2 How do the different kinds of rocks feel? Which ones are smooth? Chalky? Gritty?

Process:

3. What role did weather have in forming dissected mountains?
4. Why do dissected mountains take a long time to form?
5. What type of mountain might will be most likely to occur in our lifetime? Why?

Generalize:

6. Do you like to wait on things that seem to take a long time? Why or why not?
7. What do you think about the old saying, "Good things come to those who wait."
8. Have you had something good happen because you were patient? How can you learn to be more patient when working with others?

Apply:

9. Have you ever visited a mountain range? What kind of rocks did you find?
10. What other recent natural forces have significantly changed the earth's landscape?

Author: Alan DeGood, Kansas 4-H Geology Curriculum Team

Reviewed by: Dr. James Underwood, Professor (retired), KSU Department of Geology

Steven D. Fisher, Extension Specialist (retired), 4-H Youth Development

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Making Mountains

Member Handout 1, Glossary of Terms

Geological Processes — Geology, Level II

MANTLE The zone of the earth below the crust and above the core. It can be divided into the upper mantle and lower mantle.

PLATE A rigid, thin segment of the earth's crust that moves horizontally on the mantle.

MOUNTAIN Any part of the earth's crust higher than a hill. It can occur as a single land form, or in chains such as ranges. There are three types: structural, dissected and volcanic cones. Each are formed differently and have different types of rock.

STRUCTURAL MOUNTAINS A result of the uplift segment of the earth's crust, they usually cover a large area. The center part or core is made up of igneous rocks. As you travel away from the core, metamorphic rocks are found that are usually highly faulted and folded. The foothills adjacent to mountains have sedimentary rocks present and can also be faulted or folded.

DISSECTED MOUNTAINS Formed by erosion that results in the surrounding area being cut away by wind and water. The rocks in the mountains are sedimentary and may be gently folded.

VOLCANIC MOUNTAINS Formed by volcanoes and can be single cone or in ranges. They are always made up of igneous rocks.

Making Mountains

Activity Sheet 2, Major Tectonic Plates of Earth

Geologic Processes — Geology, Level II

Below is a map with the major continents and oceans. Name the oceans and continents.

A. North America
B. South America
C. Atlantic Ocean
D. Pacific Ocean
E. Africa
F. Europe & Asia

The black lines represent major tectonic plates that are moving on the earth's mantle.

Making Mountains

Activity Sheet 3, Major Tectonic Plates of Earth, Leader's Key

Geological Processes — Geology, Level II

Below is a map with the major continents and oceans shown. Name the oceans and continents.

A. North America
B. South America
C. Atlantic Ocean
D. Pacific Ocean
E. Africa
F. Europe & Asia

The black lines represent major tectonic plates that are moving on the earth's mantle.

Understanding Earth's Forces

Geologic Processes — Geology, Level II

What members will learn...

About the Project:

- An understanding of the tectonic forces that affect the Earth.
- Long term processes occur over millions of years and affect us and our environment.

About Themselves:

- Things are not always what they seem to be.
- How to explore options before drawing conclusions.

Materials Needed:

- 2 to 3 members per group
- 3 large rubber bands per group
- 1 12-inch ruler per group
- 1 pair of gloves per group
- 1 pencil and paper per group
- 1 large rock per group
- masking tape

Activity Time Needed: 20 Minutes (plus one month for long-term experiment)

Activity

Look at the rock and take a couple of minutes to describe it on paper. Look at one of the rubber bands, given the choice between solid, liquid or gas, what states of matter are the rubber band and rock in? Being a solid, the rubber band shares many characteristics of the rock. Do you agree? Name some of the similar characteristics.

Take a rubber band and stretch it as far as you can without breaking it. Release the stress on the rubber band. What happens to the rubber band? When an object returns to its original shape after being subjected to tension or pressure it is said to have elastic behavior. Do you think rocks have elastic behaviors?

A familiar substance that exhibits the same behavior is the elastic in your waistband or socks.

Now put on the gloves. Take the rubber band in both hands and give it a very sudden and big pull. If the rubber band did not break, try it again. In terms of the amount of stress and how long that stress was applied, what were the differences in the two experiments? Did the rubber band behave

Leader's Notes

Divide into small groups and give each group a rubber band, ruler, gloves, pencil paper, and rock. Have a recorder make notes about the experiment.

Is the rock round, hard, soft, colorless, heavy, etc.?

Does the rubber band return to its original size and shape?

Take a piece of gyp-board or sheetrock (6″x 2″), lay it over two bricks and place a third on top of it. Next dampen it with water and let it sit until the end of the meeting. What happened to the gyp-board? Was it altered?

The leader can also show a piece of mica and show its elastic behavior by flexing the piece.

differently in each example?

Glass responds like the rubber band did in the last example. A large stress over a very short period of time results in the glass breaking as did the rubber band. The term "brittle" is applied to this type of breakage that occurs when a large amount of stress occurs over a short period of time, resulting in broken or fractured material.

The leader may do this one month earlier, so that members can see the effect or change.

Now, try a long term experiment. First, measure a rubber band by laying it on a ruler. Don't stretch it, but take the slack out. On a small piece of tape put the day's date and how long the rubber band is. Tape this information to the rubber band. Now carefully stretch it without breaking, around an object and let it stay there for at least a month. Think what happens to the elastic in your waistband and socks after they have been stretched many times.

Predict what will happen to the rubber band as it is continually being stretched by the object it surrounds. Check the rubber band in one month and measure to see if any change has taken place. Measure it the same way as you did the first time. Has there been any increase in length? If so how much?

If the rubber band lengthened, it exhibited what is called a plastic behavior. It deforms as a redult of tension. The tension can't be great enough to exceed its brittle limits or it breaks. However, when the tension is released, it doesn't snap back to its original shape (elastic limit). It is said to have exceeded its elastic limit. Is this what happened with the gypboard?

With enough time, moisture, and weight, the gyp-board should be bent, but not broken.

Now back to your original description of the rock. Did you say a rock can bend or that it can be squeezed and then pop back? Be honest! If you did you are a better geologist than most. The first time doing this activity, most assume rocks should behave in one particular way. That way is what we are accustomed to on the surface of the earth. Rock is an aggregate or mass of mineral matter that has solidified. Most descriptions of rocks would characterize them as hard, solid, rigid, jagged, etc., but not what we just saw above. In studying the earth, keep in mind that rocks behave differently because of the amount of stress (tensional and comprehensional) applied to the rocks, and the rate at which it was applied and the duration of the stress.

Dialogue For Critical Thinking

Share:

1. What happened when you compared a rock to a rubber band?
2. Were you surprised with the final comparison? Why or why not?

Process:

3. What areas on the Earth's surface do you think the most stress is put on the bedrock?
4. Do the rocks in areas that have mountains and volcanoes have stress on them?
5. How do you think metamorphic rocks are formed?

Generalize:

6. What other items do you think have elastic, brittle or plastic behavior?

Apply:

7. How does this activity relate to the continually occurring forces on Earth?
8. Can you think of a time when you have jumped to a conclusion without first getting all of the facts? What did you learn from this?

Going Further:

- Members could make reports on plate tectonics, the mountain building process or volcanoes.
- Can you think of a local example of the change in rocks because of pressure or tension?
- Review Peanut Butter and Jelly Lesson plan in the Geologic History Section.

Authors: Bill Dymacek and Alan DeGood, Kansas 4-H Geology Curriculum Team

Reviewed by: Dr. James Underwood, Professor (retired), KSU Department of Geology

Steven D. Fisher, Extension Specialist (retired), 4-H Youth Development

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

The Earth's Changing Looks

Geologic Processes — Geology, Level II

What members will learn...

About the Project:

- Stress or pressure can easily modify and change rocks.
- Faults occur when the rock layers can no longer bend. They simply break or fracture to relieve the stress or pressure being applied to them.
- Folds occur when the stress being applied to the rock layers causes the rock layers to bend without breaking.

About Themselves:

- How models help us understand.
- The effect of physical and emotional forces.
- How observations of the present impact the future and help us to understand the past.

Material Needed:

- Four colors modeling clay or play dough (per group of 3) recipe in Going Further section
- 2 pine boards, 8" x 4" x 1" (per group of 3)

Activity Time Needed: 35 Minutes

Activity

We are going to construct a model of a fold and a fault. A model actually has three purposes:

A. It helps explain what we see.

B. It allows us to predict and imagine the past.

C. It may suggest experiments.

A fold in strata or rocks is any bend away from a flat surface. A bend upward results in an anticline, and a downward bend in the strata or rock results in a syncline.

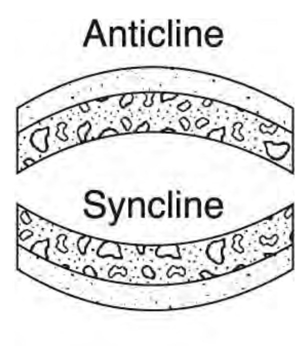
A fault is a break in the bedrock or rock layer forming the earth's crust. The bedrock must have some movement or displacement, either up or down or right or left.

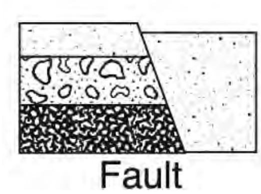
To begin, roll out different colored layers of clay or play dough in 6"x 6" x 6" sections. Now, stack one layer on the other, alternating colors in three or four layers. These layers will represent different rock layers.

Leader's Notes

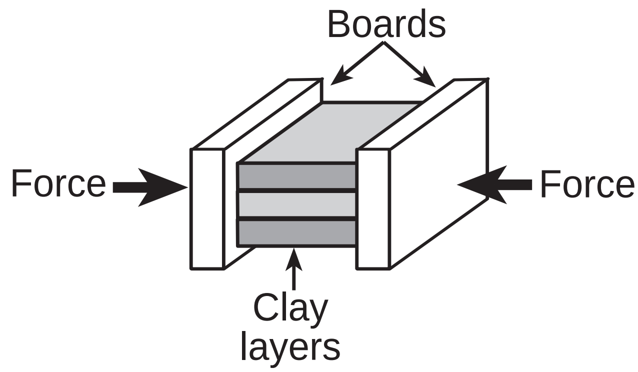
Divide the members into groups of 2 to 3.

You may want to build a poster showing a fold and fault, an anticline and syncline.





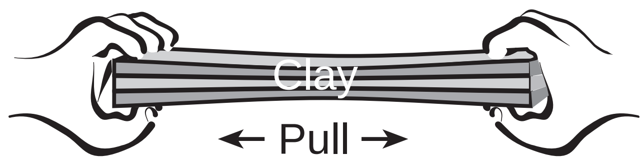
Put the play dough in between the two boards and squeeze. The force presented on the play dough is compression. Compression is caused by the squeezing of the Earth's crust. Describe or draw what the layers look like now.



Yes, because you have exceeded the elastic behavior of the rocks that result in a fault or earthquake.

If you continue the compression, what eventually will happen to the folds? Could you use this model to explain a type of earthquake or mountain building process?

Next, flatten out the layer of clay, or use a fresh supply of clay or dough. Rather than squeezing the layers, pull them instead. This force is called tension. Some places on the earth are subjected to tension and being pulled apart. Describe what happens to the layers as you continue to pull. If these were rock layers, would they finally break and cause an earthquake or a fault?



Dialogue for Critical Thinking

Share:

1. What happened when the clay layers were pressed together? Why?
2. What happened when the clay layers were pulled from each end? Why?
3. What happened when the clay layers were squeezed at angles?

Process:

4. What are the differences between an anticline, a syncline, and a fault?
5. What are the differences in the forces of compression, tension and a shearing force? What might each cause? Why?

Generalize:

6. How well did the models help explain the various forces?
7. Do you ever feel compressed or tense? When?

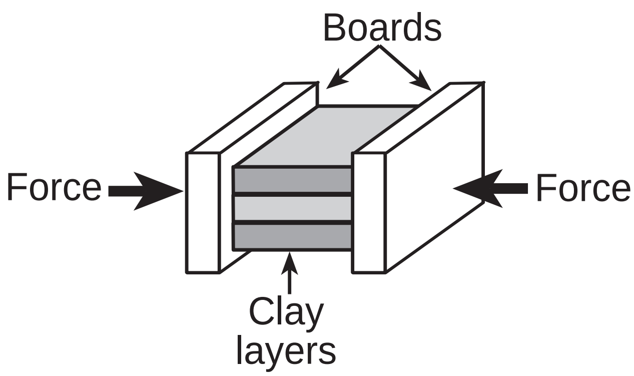
Apply:

8. How can you tell when others feel tense?
9. What can you do to help relieve or understand tense feelings?

Going Further:

- Visit a faulted area and make a cross section of the rock layers.
- Make models of the different types of faults.

Re-stack and flatten the clay. Try squeezing the clay again, but this time offset the boards so the force is not equal, or bring the boards toward each other on a diagonal line. See what happens to the clay when the forces are not applied directly opposite each other. This is a shearing force. Right now it is happening in Southern California. Does this give you any idea what it may produce over time?



A Better Play Dough

1 cup flour
2tsp. Cream of tartar
1 cup water
1 Tbls. Cooking oil
1 cup salt
food coloring

Mix the dry ingredients in sauce pan, add oil, water and food coloring to dry ingredients. Cook until the mixture pulls away from the sides of the pan. You may want to add a few drops of wintergreen, cloves or cinnamon to give the dough a more pleasant aroma. Knead the dough slightly almost immediately. Store it in an air tight container. I will keep several weeks.

Authors: Bill Dymacek and Alan DeGood, Kansas 4-H Geology Curriculum Team

Reviewed by: James R. Underwood, Professor (retired), KSU Department of Geology

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Changing Landscapes

Geologic Processes — Geology, Level II

What members will learn...

About the Project:

- Our land has been altered by many processes into its present shape.
- The weathering processes can be classified into mechanical and chemical.
- Freezing and thawing, the work of plants, and acid dissolution are three ways to shape the land.

About Themselves:

- Better understanding and appreciation of change.
- Observation and categorization skills.
- Learning how to use general, then specific questions.

Materials Needed:

- Pad of small sticky notes.
- Pencils
- Colored markers, highlighters, crayons or colored pencils (See Landforms" activity sheet to have the right colors)
- Small glass jar with lid (glass should be thin and not to strong)
- Dried beans, water, plate or pie pan
- Cake pan or other large pan. Fine dry dust or flour. Drinking straw.
- Piece of chalk and vinegar. Small dish or jar.
- Activity Sheet 4, *Landforms*
- Activity Sheet 5, *Erosion Types*
- Activity Sheet 6, *Landforms, Erosion Types, Leader's Key*

Time: Approximately 45 minutes

Activity/Game

Each person gets a sticky note put on his or her back without knowing what it says. They then ask others questions to figure out what landform they have on their sticky note. Only yes or no questions are allowed. Example: "Am I tall?" "Am I a water feature or a land feature?" Then, when they have some idea of what they might be, they can ask more specific questions like "Am I a mountain?" Allow some time until most or all have discovered their identity, gather up the sticky notes, shuffle them and play another round.

Remember when we made a peanut butter sandwich to show how the layers of the earth work? Were the layers flat or hilly? (*A. Yes, they were flat.*) New

Leader's Notes

Ahead of time, write a landform type on enough sticky notes to have one for each person. Suggestions include: plains, mountain, hill, delta, valley, cliff, volcano, island, butte, mesa, trench, continental shelf, etc. This game can be played at the beginning of the session as a mixer, or preferably at the end after they have studied the lesson.

If you haven’t done that lesson, just remind them that the layers start out flat.

land is laid down in fairly flat layers, but it doesn’t stay that way. Pretty soon weathering and erosion start to wear it down. These processes are not even all over, so more dirt and rocks get worn away, or built up, at different places making the land into different shapes. Soon we have the different land forms that make our Earth so pretty. What are some of the different land shapes, and what do they look like?

Some of these terms your 4-H'ers will know well, others not at all. Discuss other terms also, that relate to field trips, local features, etc., if you wish. See the leader’s key for the *Landform* member activity sheet in this lesson for terms.

What is the difference between a mountain and a hill? The mountain is much larger, of course. Mountains are usually formed when they are being pushed up by forces deep within the earth. Newer mountain ranges tend to stand higher and have sharper ridges than older ones that have had lots of time to wear down. Have you heard of foothills? What are those? (*A. Hills that form near mountains from material eroded from the mountains.*) What is a plain? (*A. Yes, very flat area without mountains.*) What are buttes and mesas? (*A. Both are landforms that have flat tops where a hard rock layer has kept the softer material under it from washing away.*) Here is an activity sheet on different land shapes or landforms.

Hand out Activity Sheet 4, *Landforms*, and colored pencils, markers or crayons.

Let’s read the instructions and see what we need to do. When you are done, you can put it in your geology notebook for a reference.

Weathering and erosion must be very effective processes to do all this. What do you think would wear down a mountain? It sounds very hard to do doesn’t it? Erosion works just a little at a time, but after a while, it can make big changes.

See materials needed at the beginning of this lesson.

We are going to start an experiment now so it can work while we do other things. Here is a glass jar. Fill it full of beans. Another person can fill it almost to the top with water and put the lid on tightly.

This a good time to talk about slow changes adding up over time also. Can you see it changing?

What do you think will happen? (*A.Expanding beans will break the glass.*)

Have you ever watched your mother cook beans? What happens when she does? (*A. Soaks the beans; they get softer; they get bigger etc.*) Put the jar on this plate and we will check it once in a while.

Some kinds of erosion are mechanical. That means, it is just a simple act of moving the material around.

Put the fine dust or flour on the cake pan or cookie sheet. You may also add a larger piece if you like, and see which are more resistent to being blown around by the straw.

What might move dirt around? (*A. Wind, glaciers, water, gravity, etc.*) Could I have a volunteer to try blowing this dirt with this straw. Did the dirt move? Now I will sprinkle a little water on the dirt and you can try again. What happened to the places where the dirt was wet?

A long time ago, the middle of the United States didn’t get as much rain as usual. Then, when the wind blew, what do you think happened? Right, the dirt blew. A lot of dust blew around and made the sky dark. It was called a dust bowl. Farmers could not raise as many crops, and it was even hard to see. The same thing happened when the glaciers retreated a very long time ago. Wind carried dry glacial silt and deposited it in other areas as loess, a fine, wind blown soil.

River water can carry even more dirt. Sometimes the water even looks muddy. A heavy rain can wash new gullies in a field.Can you think of any examples of this kind of erosion locally?

Place chalk in small dish or jar. Watch closely. This mild but safe combination will not put on a big show.

Another kind of weathering is called chemical. For this, the materials have to change to another material entirely. This experiment is a little harder to see, so watch closely. Here is some chalk and vinegar. Vinegar is a weak acid and chalk is made of calcium carbonate, as is limestone. I need another volunteer to put a little of the vinegar on the chalk, and then observe what happens.

What did you see? (*A. Gas bubbles coming from the chalk.*) Where is the gas coming from? Was there that much air in the chalk? The gas is coming from a chemical change between the chalk and the vinegar. It is changing some of the rock into carbon dioxide (the bubbles) and calcium. These are entirely different materials, so it is a chemical change. Can you see much difference in the chalk, except for being wet? Chemical change usually is a slow process. Over time, it can dissolve large caves in limestone the same way it is dissolving this chalk. We can put the chalk in the rest of the vinegar and come back later to see what has happened.

In nature, we can get acid from plants and from pollution. One kind of pollution is even called acid rain.

Here is a worksheet on different kinds of erosion. Let's read the directions and do the sheet. Then you may keep it in your geology folder.

Hand out Activity Sheet 5, *Erosion Types* and pencils.

When we are done with the activity sheet. it is time to check our experiments. What happened? How do you explain the results?

Dialogue for Critical Thinking

Share:

1. What happened (or do you think will happen) to the glass jar with beans?
2. Where did the dust go from the dust blowing experiment?
3. What new landforms did you learn?

Process:

4. Why did the glass with the beans break?
5. What is chemical weathering?

Generalize:

6. What landmarks or national parks have been carved by erosion? (*Grand Canyon, Badlands, Chimney Rock etc.*)
7. Can you think of other slow changes in your life?

Apply:

8. If you were a farmer, why would you **not** want your field to blow around?
9. If you were a farmer and your field was blowing, what could you do?

Going Further:

1. Look for examples of erosion and landforms on your next field trip.
2. Find some area that is endangered by erosion. Try to think of ways to stop the erosion.
3. Do some other erosion experiment. Books have a lot of them.

Reference:

VanCleave, Janice, *Earth Science for Every Kid*, John Wiley & Sons, New York 1991.

Written by: Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by: Dr. James Underwood, Professor (retired), KSU Department of Geology

Steven D. Fisher, Extension Specialist (retired), 4-H Youth Development

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

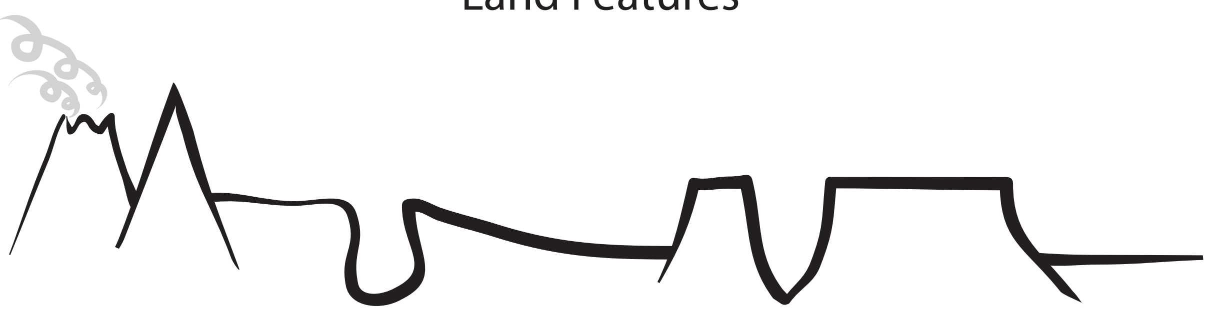
Changing Landscapes

Activity Sheet 4, Landforms

Geological Processes — Geology, Level II

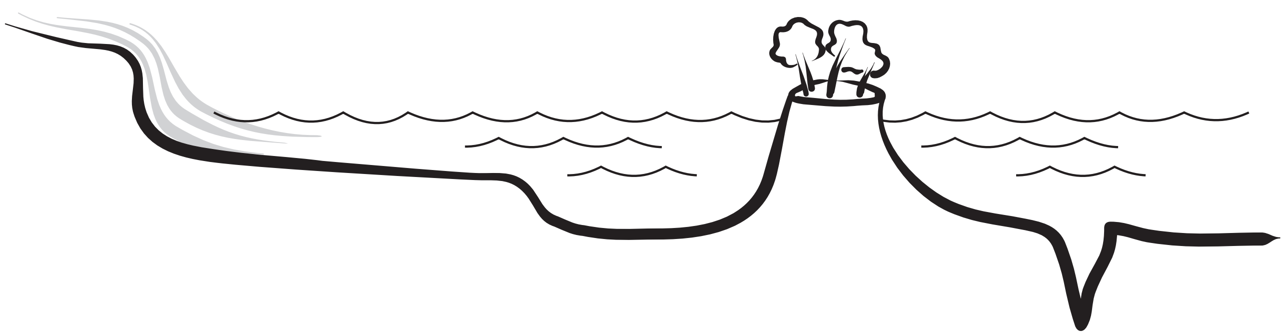
Here is a picture showing some different landforms. Color each with the color by its description.

Land Features



Volcano (red) Where magma has burst to the surface and formed a cone
Mountain (purple) A much higher area that has land around it
Plateau (yellow) Large, high flat area near mountains
Valley (blue) A low area where water does, or has, run
Butte (tan) Flat-topped hill
Canyon(orange) Deep, steep gorge
Cliff (black) Steep drop
Mesa (gray) Flat-topped larger area
Plain (green) A flat area

Water Features



Waterfalls (blue) River where it goes over a steep drop
Delta (tan) Triangle-shaped area made of sediment deposited at the mouth of the river where it enters the ocean.
Continental Shelf (brown) Level area near the edge of the ocean
Ocean (blue-green) Large areas of water where water is salty, also called a marine area.
Island (orange) Small area of land with water around it
Trench (black) Deeper valley in the ocean bed

Changing Landscapes

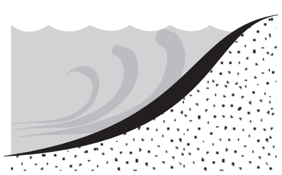
Activity Sheet 5, Erosion Types

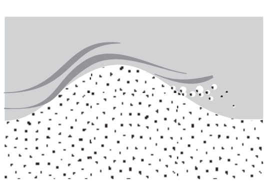
Geological Processes — Geology, Level II

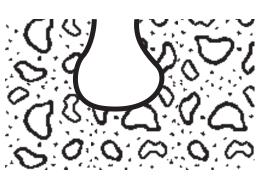
Draw a line from each picture of erosion to the picture for either mechanical or chemical erosion.

Mechanical Erosion
Physical breaking,wearing away, etc.

Chemical Erosion
Changes in the kinds of matter involved





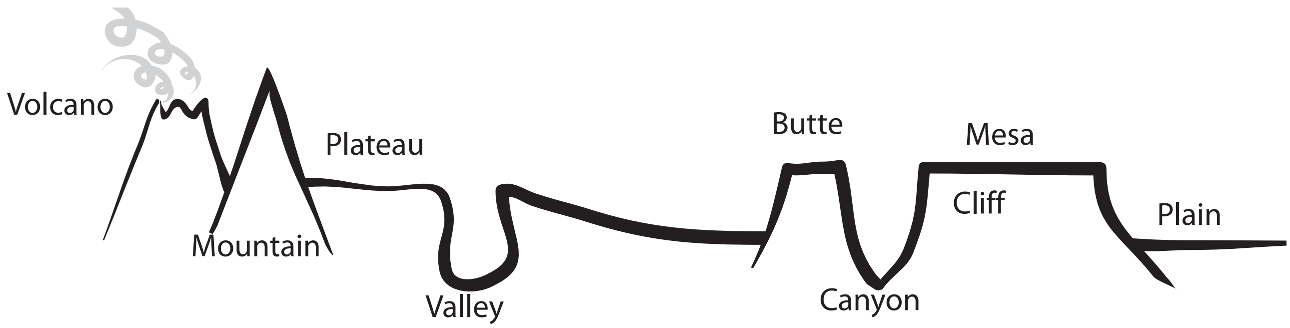


Changing Land-scapes

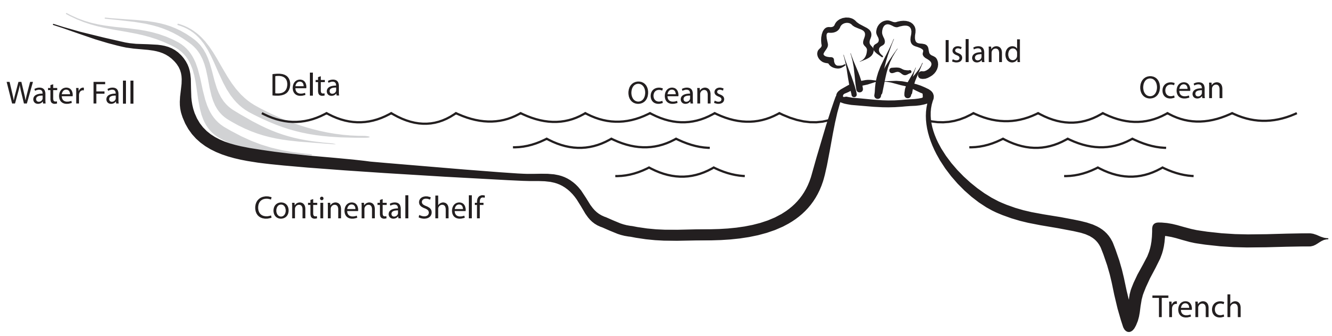
Activity Sheet 6, Landforms, Erosion Types, Leader's Key

Geological Processes — Geology, Level II

Land Features



Water Features



Key Erosion Types

Mechanical – Plants growing, wave action, sand dunes blowing
Chemical – Acid rain, cave dissolved out of rock

The Break Down

Geologic Processes — Geology, Level III

What members will learn...

About the Project:

- How water naturally forms stream patterns.
- Effect of alternate freezing and thawing.
- Effect of glaciers.

About Themselves:

- Value of observation
- Value of comparisons

Materials Needed:

For Freeze-Thaw Activity:

- Small jar without sloping sides (expendable)
- Cold water
- Plate or pie pan
- Freezer

For Glacier Activity:

- Deep dish, like a loaf pan, or larger
- Damp sand
- Spoons
- Newspaper
- Frozen "glacier" – yogurt cup or similar container with sloped sides
- Fill with water, add one tablespoon of sand and a few rocks
- Glass pane
- Large and small foil pie plates
- Ice chest or freezer

For Stream Table Activity:

- Map showing meandering pattern of streams
- Blue marker or highlighter
- Jelly roll pan (preferred) or other shallow large pan
- Dirt or sand, small rocks or clods
- Water hose connected to water, or two large pitchers or milk jug with water
- 2 to 4 bricks, or equivalent items, to elevate end of pan

Leader's Notes

Stream table needs to be set up outdoors in an area where water can drain, and sand washed out of the stream table will not harm anything.

Time Needed: 30-40 Minutes.

It may take hours to freeze first experiment, and "glacier" will take advance preparation.

Activity

Freeze-Thaw:

What do you think is the greatest force in erosion? We'll look at some different ways of erosion and then compare them when we are done. First, we'll look at how something as simple as freezing water breaks up rocks. Then, we'll look at glaciers and how they work. The last force we'll look at is water and how it shapes the landscape.

Leader's Notes

We are going to start this experiment first, but even then, it may not be finished by the end of the meeting. Would someone volunteer to fill this jar with water and put the lid on tightly. Now we'll put it in the freezer on this plate. What do you predict will happen? Does water contract or expand when it freezes? If it expands, where will this water go? The jar doesn't have slanted sides that let the ice just push up as it gets bigger. How is this similar to water freezing in a small crack in a rock?

You could also freeze it ahead of time and bring it frozen to the meeting.

Glacier:

What is a glacier made of? Ice. What else? They usually carry debris such as rocks and dirt they have picked up. They form in high areas of a mountain and flow down into a valley. These are called valley glaciers, or mountain glaciers. Glaciers can also be very large and cover vast areas, even as large as states, and those are called continental glaciers, or ice sheets. At different times, they have reached down into the United States as far as the northeastern part of Kansas.

Here is a big ice cube I have frozen to be somewhat like a glacier.

What have I done to make it like a glacier? (*A. Added sand and rocks. Glaciers can stretch with the materials they carry.*)

Who would like to try to scratch this glass plate with it? Oh, yes, it made a nice scratch. Sometimes, we can still see where a glacier scratched another rock a long time ago. In fact, a glacier scraped off part of the area where New York City now stands. Skyscrapers can be built very tall where it scraped off all the loose rock, leaving firm bedrock. You can still see the grooves and scratches they made in the famous New York Park called Central Park.

Glaciers carve a river valley into a very characteristic shape also. First, would someone shape a river valley in this pan of sand, going the long way? Slope it down gradually, have the riverbed down, about 1 or 2 inches above the bottom of the pan, and have the valley sides slope up wider than the frozen glacier.

It may take a bit of coaching to get the right shapes

If we were to cut a cross section across this valley, what shape would the valley look like? (*A. V-shaped.*) Now let's add a side stream coming into it, sloping down also.

Time for the glacier! Here it comes down the valley! (Push the glacier firmly down the valley in an upright position. The bottom of it should just scrape the bottom of the river.) What is happening to the sand? Yes, it is being pushed ahead of it. Eventually, it should push some to the side also. This debris will make the moraines. The glacier has receded. What happened to the side valley? (*A. It was cut off.*)

What will happen to the water that flows along it? (*A. Form a waterfall.*) This is called a hanging valley.

What shape is the river valley now? (*A. U-shaped, or flat-bottomed.*)

Now we can put the glacier on this upside down pan and the other panwill catch the water and let it melt.

What will happen to the sand and rocks in it? (*A. They will stay in a pile while the ice melts away.*) This is called a glacial till. Is anything else brought along by the glacier? (*A. It is unsorted.*) That means all different sizes are left jumbled together.

Stream Table:

It's almost time to go outside for the last experiment about stream valleys. But first, look at this map. Do you see any stream valleys? Take turns marking in the valleys with this marker. How can you tell if it is just a low place or if it really has water? What do you see about the patterns that the streams make? Are they straight?

Outside:

We are going to pretend this pan and sand is a river valley. Do we have a volunteer to spread the sand out evenly over the top ¾ of the pan, about 1-inch thick? Trace a small stream in the sand, straight down the middle.

Does this look natural, like streams usually look? [*A. No, streams are usually crooked, or meander (weave from side to side).*]

This pitcher (or jug) is going to be water running down the valley. I am going to pour it into the stream at the top of the pan, slowly and steadily. Look carefully to see what happens to the shape of the stream, where the sand goes, etc. Now add a few rocks in the stream bed. What happened? Build a dam and spillway. What happened to the washed out sediments?

Time to check your other experiments. Did what you think would happen, occur? We can also check them later, or I can tell you what happened the next time we meet.

Do this yourself unless some 4-H'er is very responsible.

"Lake" should form at the bottom, with a "delta."

A brick makes a good dam. Sediments should settle out in lake before water goes over spillway.

Dialogue for Critical Thinking

Share:

1. Which of the three activities did you like the best? Why?
2. Which activity was easiest to understand? Most difficult? Why?

Process:

3. Which of the three erosion forces are most prominent in your area?
4. Which of the erosion forces carry the most material?
5. Which erosion force breaks up most large rocks?

Generalize:

6. What is the value of erosion, and why is there so much concern about controlling erosion? (Discuss the positive and negative effects of erosion.)
7. How does erosion affect the quality of your life?

Apply:

8. How will you act differently the next time you observe the result of erosion. Why?

Going Further:

1. Investigate how far debris has been carried by glaciers.
2. Get pictures of Yosemite National Park, which was shaped by glaciers. What evidences that it was glacier sculpted do you observe? (*A. U-Shaped valley, half of a mountain scraped away, hanging valleys and water falls.*)
3. Investigate local examples of anything we studied. Where did the rocks originally come?
4. Investigate local examples of glacial deposits, and types of features, such as horns, cirques, drumlins.
5. Build a permanent stream table. You could make a model of a stream valley of your choice, or of one near where you live, and try it out.

References:

Beckway, Gregory, *Stream Table Investigations,* Hubbard, P.O. Box 104, Northbrook, IL 60062 (Ph. 312-272-7810) (Advanced stream table and erosion exercises)

Kansas Geological Survey, *Geologic History of Kansas*

Lasca, Norman P., *Build Me a River*, Earth, Jan. 1991, Vol. 1, No. 1, pp 59-65 (Good article on building your own stream table)

Matthews, William H. *Geology Made Simple,* Doubleday & Company, Inc., Garden City, New York, 1967. (Good information on erosion, and glaciers)

Van Cleave, Janice. *Earth Science for Every Kid*, John Wiley & Sons, New York, 1991. (Simple erosion experiments)

Written by: Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by: James R. Underwood, Jr., Professor (retired), KSU Department of Geology

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Weathering Forces

Geologic Processes — Geology Level IV

What Members Will Learn...

About the Project:

- Wind and water are potent weathering processes and can sort materials.
- Streams meander and produce different shaped channels as they mature, and have different branching patterns.
- Chemical weathering is a strong force under certain conditions.

About Themselves:

- Observation is a good way to learn.
- Decision making skills.

Materials Needed:

- Fan and garage or other large area where dust can be blown.
- Flat pan of dry dirt containing different size particles.
- Map or pictures showing caves and /or karst topography.
- Copies of Member Handout 2, *Weathering Forces*, to each member.
- Copies of Activity Sheet 7, *Valley Cycle*,to each member.
- Pencils
- Limestone piece and hydrochloric acid (10%) in dropper bottle.

Time Needed: Approximately 30 minutes

Activity:

Weathering and erosion are powerful processes. What examples can you think of around your area that show the power of wind and water? Tuttle Creek Spillway Canyon near Manhattan, Kansas, is a very striking example of erosion. Geologists believe that in prehistoric times, even greater erosion took place. We are going to learn about some different forces of weathering and the way they share the land.

Wind

One powerful force is the wind. Ask your grandparents or great-grandparents for stories of the dust storms if you want some evidence. Sand dunes tend to form characteristic mounds, and if the material blown has different size particles, the wind will sort them. We will try this with a fan and some dry dirt. We'll start it now so it can be blowing as we do the rest of the lesson, then come back later to see what happened. What do you think will happen? Where will the larger particles be? The smaller particles?

Leader's Notes

Set up the fan at one end of a garage or other place where a cross wind will not interfere. A large, smooth surface should be in front of the fan. Then put a shallow pan with the dirt in front of the fan and turn on the fan and let it blow for awhile. Send someone out to turn off the fan about 5 minutes before the end of the lesson so the dust will settle before you observe patterns.

Hand out Activity Sheet 7, *Valley Cycle*.

Provide Member Handout 2, *Weathering Forces*.

This concept often confuses people. There are also 5, 10 and 500 year floods, etc.

Consider doing stream table if you haven't already done it.

Have a member do this common test for carbonates that also shows how chemical weathering takes place.

Water

Water can be a very powerful weathering process. Have you seen a gully? They are formed by water. Water also erodes stream banks. A combination of erosion and deposition shapes stream patterns. The *Valley Cycle* activity sheet has a chart to fill out about stream formations and illustrations of the different land forms. You can keep it as a reference sheet when you are done.

Do you remember when we did the stream table? Did the water run in straight lines in the stream table? (*A. No, it swerved around, or meandered.*) The water erodes the bank of the river on the side that is flowing fastest. When a stream is new, it runs mostly straight, and carves a v-shaped valley, eroding the valley floor. As it gets older, it meanders over a broad area, and has a wider flood plain.

The flood plain is the broad area that is covered by water when the river floods. Flooding waters slow down when they are out of their channel and drop some of the dirt they are carrying, eroding less. More drops near the bank of the river sometimes form a natural levee, or dike, along the edge of the river, and the sediments deposited make the flood plain even more fertile and flat. Sometimes people are tempted to build in this area, especially if it has been several years since a flood. They are now unable to get federal funding for such building, so fewer houses are being built in flood plains. Flood plains are classified by how often they would flood (on the average). A flood might be classified as a hundred year flood, but that doesn't mean you couldn't have similar floods several years in a row, and then none for several hundred years.

A very old river meanders and flows slow as it cut itself into a stream bed with less drop. Sometimes the meander loops will get so close that the river just cuts across and leaves the loop stranded. If the loop is deep enough to hold water, it is called an oxbow lake.

An old river might have several flood plains on different levels. If the earlier ones were when the river was bigger, it can form a stepped arrangement on both sides of the stream. These are called terraces. This is more likely to happen if the area is being lifted up so that the stream continues to have enough energy to cut downward.

Various stream patterns develop depending on geologic conditions. The usual pattern is a tree or branching pattern with smaller streams joining together irregularly to form one bigger stream. A lattice or a rectangular pattern develops when the area is fractured in large blocks, and it is easier to erode along the fractures. A drainage system is the area that one stream drains. Sometimes a more rapidly growing stream will erode back into another stream's area until it captures part or all of the other stream's drainage system. This is called "pirating."

Chemical

There are several kinds of weathering. Chemical weathering is often overlooked, but is important in many places. It can be on a grand scale, or as simple as the chemicals produced by one plant. Kansas has a lot of limestone that is very susceptible to being dissolved by acid. As rain falls, it collects any acid that may be in the air from air pollution, and forms a weak acid solution. Let's do the acid test for limestone.

What happens? As the acid is neutralized by the basic nature of the limestone, bubbles are released. A very small amount of the limestone is dissolved. Of course, this would have to be repeated over a long period of time, for the results to show. Over millions of years, great caves can be formed. If the caves are small and near the surface collapse, the result is a pocked, lumpy landscape known as karst topography. How can this reaction also have results for water contamination? (*A. limestone neutralizes the acid and acts as a stabilizing force in nature.*)

(See "Karst Topography" in the 1995 Kansas State 4-H Geology Field Trip Guide for more on this subject).

Let's go look at the wind experiment. It will be dusty so bring a tissue to cover your nose. Can you tell that different sizes have fallen in a different place? Which went the farthest? (*A. A stream can also sort its material.*) What shape are the deposits? (*A. Drifts, or dune shapes.*)

Compare to sand dune shape on reference sheet.

Dialogue for Critical Thinking

Share:

1. Which experiment did you find the most interesting? Why?
2. Did the blowing dirt bother us all? What do you think it was like to live in the dust bowl days?

Process:

3. Which form of weathering do you think moves the most material?
4. What are the other kinds of weathering and erosion?

Generalize:

5. Did you learn or understand better, or think you will remember better by doing the experiments than if you just read them in a book? How can you use this information in the future?

Apply:

6. What would be good things to do with a flood plain?
7. What examples of weathering do we have in this area? What kind of stream valleys do we have?

Going Further:

1. Observe old and new road cuts or a quarry. What evidence of weathering do you see?
2. Observe an erosion area over time, several years if possible. What changes do you see over the years?
3. Collect two samples of limestone as similar as possible. Arrange to have a weak acid slowly drip on one. An empty milk jug with a small pin or nail hole, and filled with a strong solution of vinegar and water, works for this experiment. Observe and compare the samples periodically. Remember, it usually takes a long time for results to show from acid solutioning. Collect the acid solution and drip it on the rock several times to dissolve more limestone.
4. Study other forms of weathering and erosion.

References:

Plant Science Book, Kansas 4-H Curriculum

Matthews, William H. III; *Geology Made Simple*, Doubleday & Company, Inc., Garden City, New York.

Written by: Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

Steven D. Fisher, Extension Specialist (retired), 4-H Youth Development

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

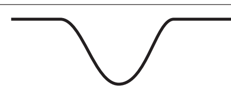
Weathering Forces

Activity Sheet 7, Valley Cycle

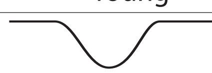
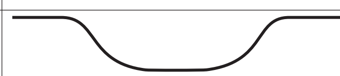
Geological Processes — Geology, Level IV

Valley Cycle

Valleys change as they age. Fill in the blanks to show what the valley would be like at that stage. When you have checked this sheet with the answers at the bottom, and made changes, you may keep it as a reference sheet.

	Young	Mature	Old
Cross-Section View			
Drop	Steep		Low, gentle
Stage	Valley Deepening		Widening and Flattening
Channel Shape		Beginning to Meander	Broad Meanders
Flood Plain	Little or No Flood Plain	Definite Flood Plain	
Tributaries		Many	Few and Large
Features	Rapid and/or Waterfalls		Many Oxbow Lakes Marshy Areas/Natural Levees

ANSWERS: (fold under until you are ready to check answers)

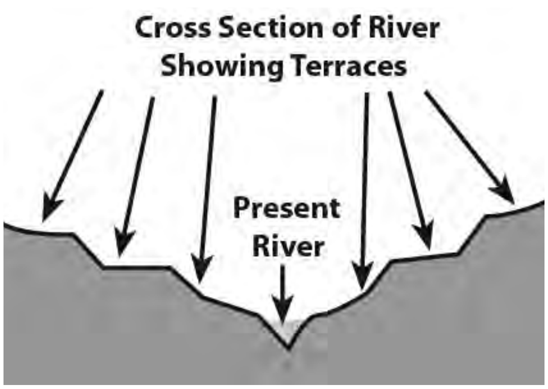
	Young	Mature	Old
Cross-Section View			
Drop	Steep	Moderate	Low, gentle
Stage	Valley Deepening	Cutting Wider and Deeper	Widening and Flattening
Channel Shape	Straight	Beginning to Meander	Broad Meanders
Flood Plain	Little or no Flood Plain	Definite Flood Plain	Broad Flood Plain
Tributaries	Few and Small	Many	Few and Large
Features	Rapid and/or Waterfalls	May Have Oxbow Lakes	Many Oxbow Lakes Marshy Areas/Levees

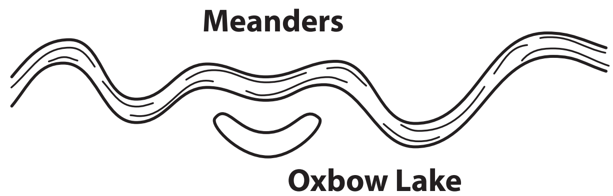
Weathering Forces

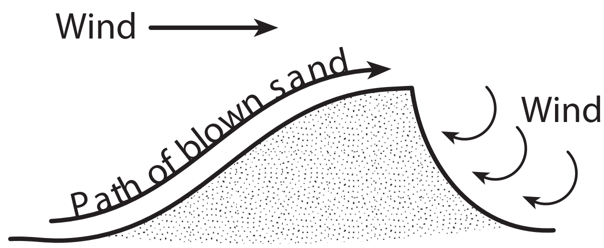
Member Handout 2, Weathering Forces

Geological Processes — Geology, Level IV

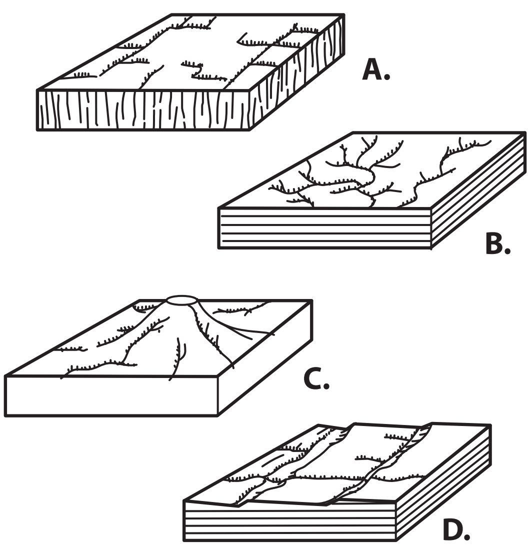
Illustrations of different stream patterns and sand dune shapes to use with this lesson and on your own.







Cross-section of sand dune



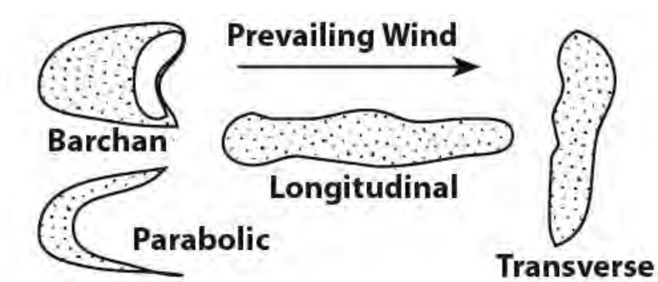
Some typical drainage patterns.

A – Rectangular

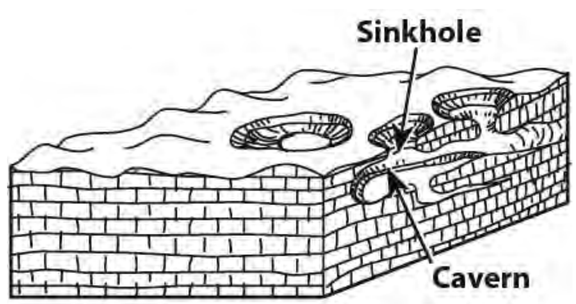
B – Dendritic

C – Radial

D – Trellis



Types of Sand Dunes



Caverns and sinkholes developed in an area of karst topography.

Kansas 4-H Geology Leader Notebook

Chapter 2 — Geologic History

Peanut Butter Geology

Geologic Processes — Geology, Level I

What members will learn:

About the Project

- Much of the earth's history can be interpreted by studying the layers of sedimentary rock.
- The geologic law of Original Horizontality.
- The geologic law of Superposition.

About Themselves

- I can use examples I see in the present to learn about the past.
- Hands-on learning is more fun and helps me remember longer.
- Being neat helps.

Materials Needed:

- 2 kinds of bread
- Crunchy peanut butter and jelly (dark preferred)
- Table knives or plastic knives
- Two plastic spoons
- Napkins

Activity Time Needed: 20 Minutes

Activity

Demonstrate each step while you talk, and have the members follow along.

The dirt and rocks that make up the earth were laid down in layers of sedimentary rock. We are going to make peanut butter sandwiches to show how the earth's layers are made.

First we need to open a napkin and lay it down to protect the table and the sandwich. Then, put down a piece of whole wheat bread and spread peanut butter on it. Did everybody get theirs exactly the same? No? Some have lumps or are thicker or thinner than others. Well, sometimes the earth's layers are thicker in some places, too.

Now, let's add jelly and a top layer of white bread. Let's think about how we made the sandwich. When we were making the sandwich, was it easier to lay it flat or hold it on edge? *(Flat)*

That's also the way the earth is made. Layers start out flat like the horizon; that's called the "Law of Original Horizontality." Horizontal means flat, like the horizon. Layers sometimes get rearranged afterwards, but they

Leader's Note

You will need to demonstrate this yourself, and it would be even better if each person or team of two members could make their own sandwich. It is wise to have members wash their hands first, and then they can eat their sandwiches when you are done for refreshments; or, you could give the sandwiches away or put them out for the birds. NOTE: Some people are allergic to peanuts, so check with your group members before they eat the sandwiches.

Specially colored "rainbow" bread can add interest when used as some of the layers.

If you have done the experiment in the Rocks chapter where you shake up a jar of water and sediments and let it settle out in layers, remind members of the flat flayers it formed.

start out flat.

Now, which piece did we put down first? *(The bottom or whole wheat bread)* That's also the way the earth is made. The bottom layer is put down before the layer on top of it. Then, the next lowest layer until you get to the top. Geologists call this principle the "Law of Superposition."

Before we eat our sandwiches, let's think about it some more.

Dialogue for Critical Thinking:

Share:

1. Why did you make a peanut butter and jelly sandwich?
2. What happens if you hurry too fast?

Process:

3. How is the sandwich like the earth's layers? What geologic law says the layers are laid flat?
4. Which layer is the oldest or put down first? What do geologists call this?
5. What could the chunks in the peanut better represent in the earth? *(Rocks or conglomerates)*
6. What might eating or slicing off part of the sandwich be compared to on the earth? *(Erosion of various kinds)*

Generalize:

7. How does doing an illustration (like the bread) help you learn or remember better?
8. Why is it important to be neat and careful?

Apply:

9. Where else might you find layers of things? What is the same or different from the Geology layers?
10. What are some other ways to show the effect of erosion?

Going Further

1. Add raisins or M&Ms to the sandwich. What might those be compared to? Boulders in isolated pockets? For example, a small pond or pothole could leave an area that is different from the rest of the layer.
2. Make a sandwich a little differently. It could have two of one kind of bread, or honey instead of jelly. Is this sandwich the same as the others? Why not? *(Layers are not the same.)* That's also how you can match up layers from place to place. If they don't match up, they are usually from different ages. *(This is correlation of layers.)*
3. Look for layers on you next field trip, or when you are driving or walking near a road cut. Which layers are the oldest? Can you match them up on the other side?

Author: Pat Gilliland, Kansas 4-H Geology Curriculum Team.

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey
James P. Adams, Associate Professor, 4-H Youth Development

Era Dioramas

Geologic History — Geology, Level II

What members will learn:

About The Project:

- The earth has been around for a long time.
- The earth is changing.
- Some kinds of plants and animals are extinct.
- Geologic time is divided into four main eras.
- Each era has its own distinctive plants and animals.
- Plant and animal life has developed from simple to complex.
- Dinosaurs are only a small part of the earth's history.
- Vertebrates are animals with backbones.

About Themselves:

- To appreciate our world and its long and interesting history.
- We live in a logical world.
- We can learn through careful observation skills.
- Visual displays help us learn.
- Creative learning is fun.

Materials Needed:

- Four or more boxes — like shoe boxes or boxes from a store — for bases for the dioramas.
- Member Handout 3, Instructions for Dioramas
- Member Handout 4, *Archeozoic*
- Member Handout 5, *Paleozoic*
- Member Handouts 6 and 7, *Mesozoic* (2 pages)
- Member Handouts 8 and 9, *Cenozoic* (2 pages)
- Art materials: felt tip markers, highlighters and/or crayons and paints
- Scissors, glue, construction paper, etc.
- Blue plastic food wrap, or plastic bags (optional)
- Rocks, dirt and sand as desired
- Newspapers to protect tables

Activity Time Needed: 1 hour, or may be continued at the next meeting to complete the diorama.

Leader's Notes

It would be good to do the peanut butter geology lesson first, so members know a few basic geology concepts.

Activity

Divide into small groups of one to four. For large groups, make two or more series of dioramas. The Precambrian group should be small, or assign the first two eras to one group, as it is simpler than the rest. (Use a smaller box.) Hand each group member a handout of the appropriate era figures.

The earth started a very long time ago — way before I was born and even before your great grandparents were born. In fact, there were no people at all. There were no plants and no animals at all for a long time until a few things got started. First, there were little things like algae and bacteria, some too little to see. We call this time the Archeozoic or Precambrian and we don't know a lot about it because it was so long ago. Then, slowly, more things started to grow until now where we have lots of different plants and animals.

The earth's history can be divided into four large amounts of time called eras. In a little while, we are going to make dioramas—which are boxes with a model of the scene built into it — to show each era, or long amount of time. We'll need to divide into four groups, and each group will make one era diorama.

Who has the Precambrian or Archeozoic era? What is on it? You may want to use some of these rocks in your diorama to show what it was like. Most of the life forms shown started in this era.

These answers may not come exactly in this form. Expand as you like. Reptiles also are cold-blooded. Expand on that if you would like.

Next was the time of ancient life called the Paleozoic. What figures do you have most of on your pages? Do they look like sea or land animals? *(Sea)*. That's because during some of that time, large areas were covered by seas. You can use this blue plastic wrap (or blue highlighters or paint) to make the sea. What else do you have? *(Sharks, bony fish, amphibians)* Some of these things were also on land. They are some of the earlier and simplest animals and plants. Some of the items in this diorama were earlier in the era, while the amphibians were in the later part of the era.

If they ask, Jurassic is a period within the Mesozioc.

Who has the Mesozoic, the age of the reptiles? What are reptiles? *(A large group of scaly animals with backbones like lizards, alligators, etc.)* What animals do you have on your sheet? *(Dinosaurs)*. Yes, this era included the age of the dinosaurs.

There were also many other animals. What were some of them? *(Sharks, turtles, fish; a big variety)*. Are all these kinds of animals still around today? *(No, but some are)*. What do we call it when all types of an animal dies out? *(They are extinct)*. What were these plants like? *(Almost like a tropical forest; lots of large ferns and palm trees)*. What does that make you think the climate, or weather, must have been like? *(Warm and wet)*.

Go into more detail if members seem interested in what differentiates mammals, reptiles, etc. More information on both plants and animals can be found in the fossil

Now, we are ready to look at the last era: the one we are still in. It is called the Cenozoic, the Age of Mammals. What are mammals? *(Animals that feed their babies milk)*. They are also warm-blooded, have hair somewhere on their bodies and have backbones. People are mammals. Why? *(They have milk for their babies, hair, backbones, etc.)*. There were also many other animals. What were some of them? *(Fish, turtles, mammals that are a little like some we have today, a big variety, most of which are still around today)*. Quite a few animals are still alive from earlier eras, and these new ones were added to them, so now we have many kinds.

Hand out Member Handout 3, *Instructions for Dioramas*. Read or summarize the instructions before members start. They will likely need to take turns and share the supplies. Suggest appropriate backgrounds, etc., as needed. Praise their efforts and comment specifically and favorably on any creative or special efforts.

Now, we need each group to make a little museum-type display about your era, and then we'll see what we can learn from them. You can use these supplies to color your boxes and make them attractive. Don't put anything in your box that wasn't in your era. You can cut out the pieces on the sheet after you color them, and then fold the tab back and glue it down to the bottom of the box. Use your imagination to make your box look nice. If you have a partner, you will need to plan how to make the diorama together. Let's read the instructions before we start.

Now that we are pretty much done, let's take a look at your boxes and talk about the eras. They all look great, and I'm pleased with all the good work and ideas you put into them. You can look at the dioramas to answer these questions.

Dialogue for Critical Thinking:

Share:

1. How did you feel when you tried to say these new geology words?
2. What did you find most interesting about building your diorama? Why?

Process:

3. What eras might have had volcanoes? (*Any, but especially Precambrian and Mesozoic.*)
4. What kinds of animals do we still have today that used to live in earlier eras? (*Sharks, shellfish, etc.*)
   What kinds don't we have anymore because they all died? *(Trilobites, dinosaurs, etc.)*
   What kinds do we have now that we didn't have earlier? *(Elephants, tigers, etc.)*
5. What kind of plants do we have now that we didn't have in earlier eras? (*Plants with flowers*)

   What kinds of plants still live from earlier eras? *(We have palms, algae, bushes)*
6. Which era has the most complicated (fanciest) and the most kinds of animals and plants? *(Cenozoic)* Least? *(Precambrian)*

Generalize:

7. Do you think the dioramas helped you to understand how things have changed? Where else could you use models or dioramas?
8. Can we depend on a species being around if we don't protect its living space?

Apply:

9. Which era is exposed at the surface in the area where you live? How can you tell? *(Fossils you find.)* What might have happened to any layers that are missing? *(They might have eroded away or weathered until they were gone.)*
10. Where else might visual displays like dioramas help you learn?

Going Further

1. Display your dioramas at the fair, club meetings, school, nursing homes, etc. Make a fancier display. Use purchased animals or animals molded from clay. Add more plants and animals. You could make a poster about each era to go with it.
2. Read about the era you find the most interesting, and write a report or a small book to share with someone.
3. Study about plants and animals that are extinct and tell what you find out. What caused it? How does today's rate of extinction compare with those in the geologic past? How do we know?

References

Dinosaurs Alive! Teacher guide by Dinamation International Corporation

Many books available at your local library. Choose more factual books, like ones by Ailki, Osborne books, Eyewitness books, etc.

Murals at the Peabody Museum as printed in Time-Life books are a good source of ideas for dioramas.

National Geographic, June 1989 issue (extinctions)

Author: Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Kansas Geological Survey

Steven D. Fisher, Professor and Extension Specialist, 4-H Youth Development (Retired)

James P. Adams, Associate Professor, 4-H Youth Development

Era Dioramas

Member Handout 3, Instructions for Dioramas

Geologic History — Geology, Level II

Instructions for Dioramas

Each diorama is about a different era, so each should be different. You may add more items to the dioramas, but they should be appropriate to that era. Many animals continued into other eras, but you should first decide if the animal really did live then. Some are still living today, so it would be safe to add them to any dioramas between when they appeared and now.

Appropriate items to add to each era are these:

Archeozoic: Dirt, rocks and slimy things to look like molds or other simple life forms. Most life was in the water. No big plants, just algae.

Paleozoic: Some rocks, dirt, shell fish, fern type plants and large fern-looking trees. Much animal life still in water.

Mesozoic: Volcanoes molded from play dough or glue mixed with sand. Evergreen trees (conifers) and trees that looked like palm trees, but few flowering plants. Shallow seas in some areas.

Cenozoic: Trees and plants like today. Any animals still alive today. Dirt and mountains and/or glaciers in the background.

Steps To Make Dioramas:

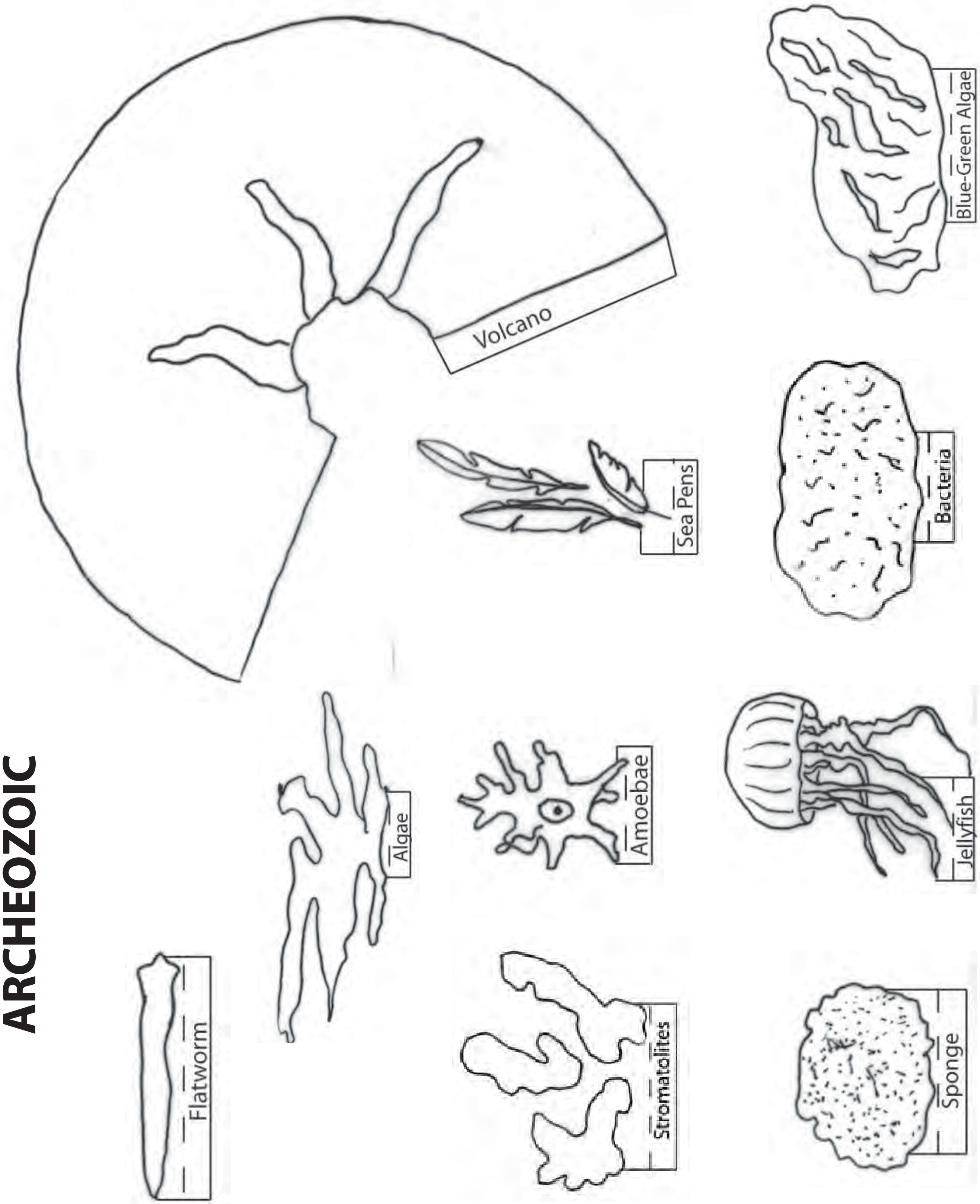
1. Plan how you will work. If you have a partner, decide if one of you can work on the box and the other on the parts to go in it, etc.
2. Keep items for each diorama separate from the others.
3. Prepare the box. Place it on the side. Remove the top. Paint, or leave the bottom brown or tan, for dirt. Paint the sky. Paint the sides appropriately for each diorama. Should it be blue for sky or water? Should part of it be brown for dirt? Should it be green with trees? What kind of plants should you paint on it? Should part be for water, a lake or sea? Could you use plastic wrap to look like water?
4. Color the items to go in the box. Try to think of appropriate colors.
5. Cut out the items. Fold tabs on the dotted lines. Do you want all the tabs folded back so they don't show, or forward so people can read them?
6. Put them in the box and move them around until they look right. Is each in the right environment?
7. Glue the items in place, or lean them against something.
8. Find a good place to put the sign. You could also look up each era and write down some information so other people could learn about it .
9. Look at all the dioramas. What can you learn?
10. Find a good place to display your diorama? The fair? school?

Era Dioramas

Member Handout 4, Archezoic

Geologic History — Geology, Level II

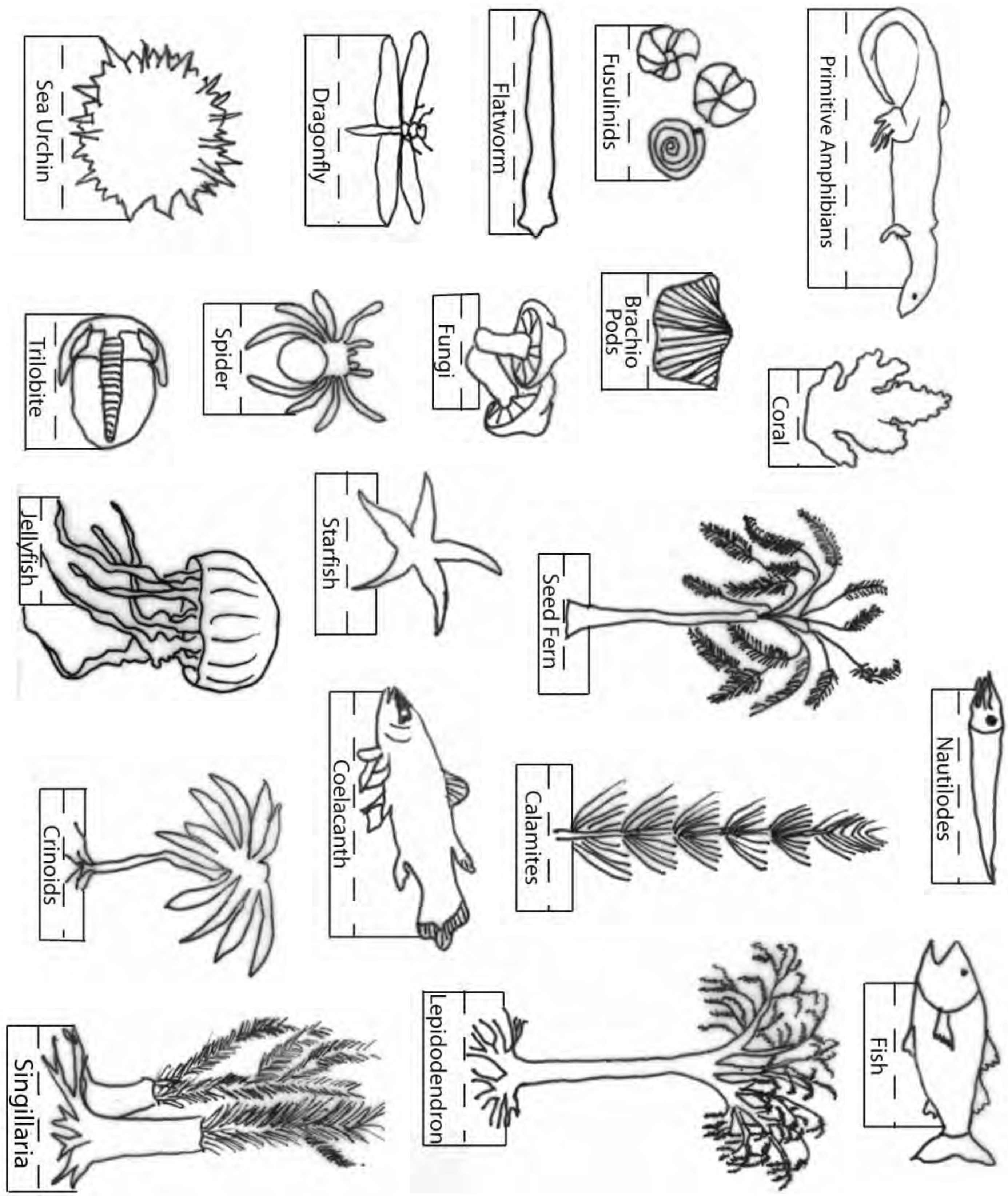
ARCHEOZOIC



Era Dioramas

Member Handout 5, Paleozoic

Geologic History — Geology, Level II

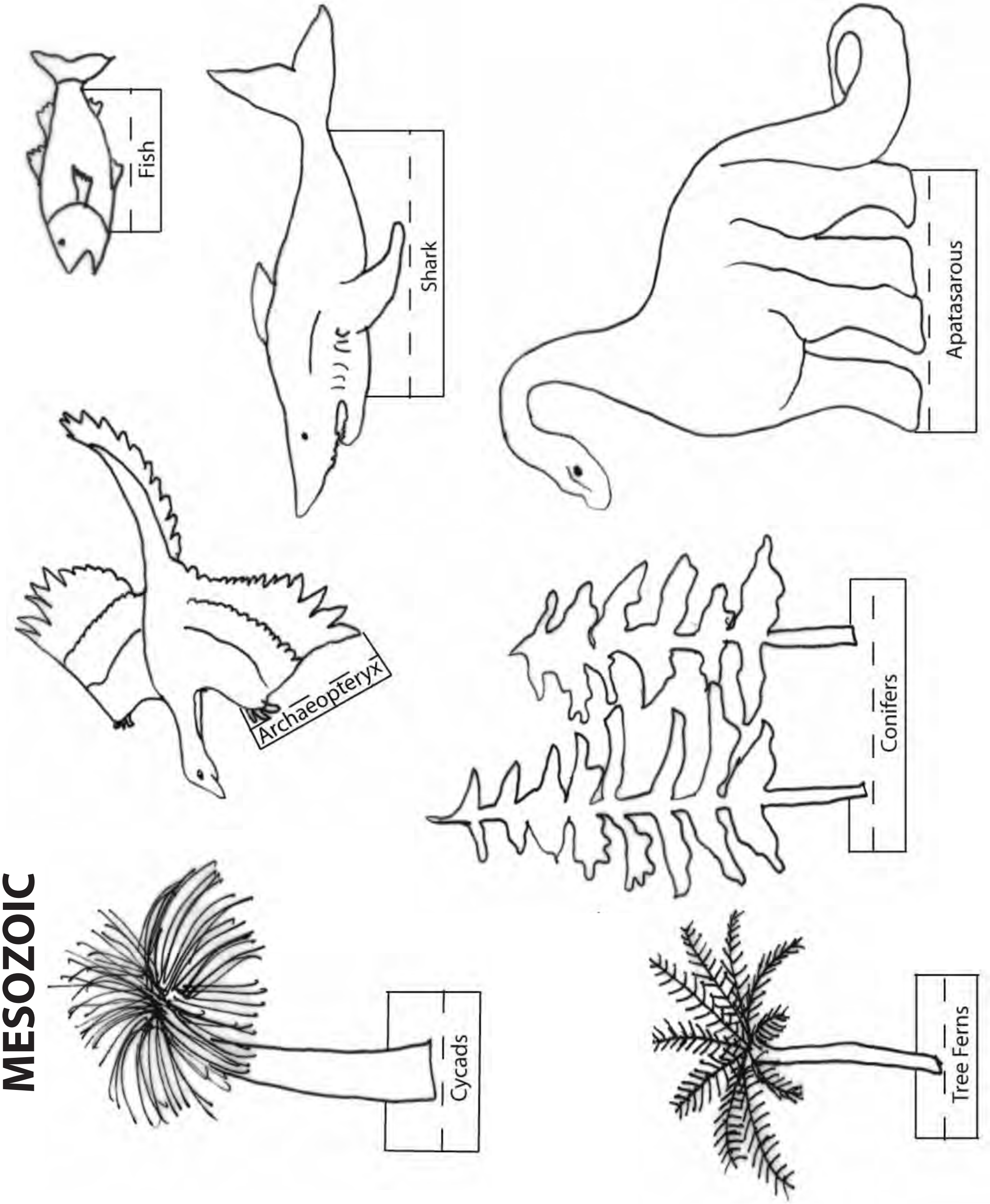


PALEOZOIC

Era Dioramas

Member Handout 6, Mesozoic 1

Geologic History — Geology, Level II

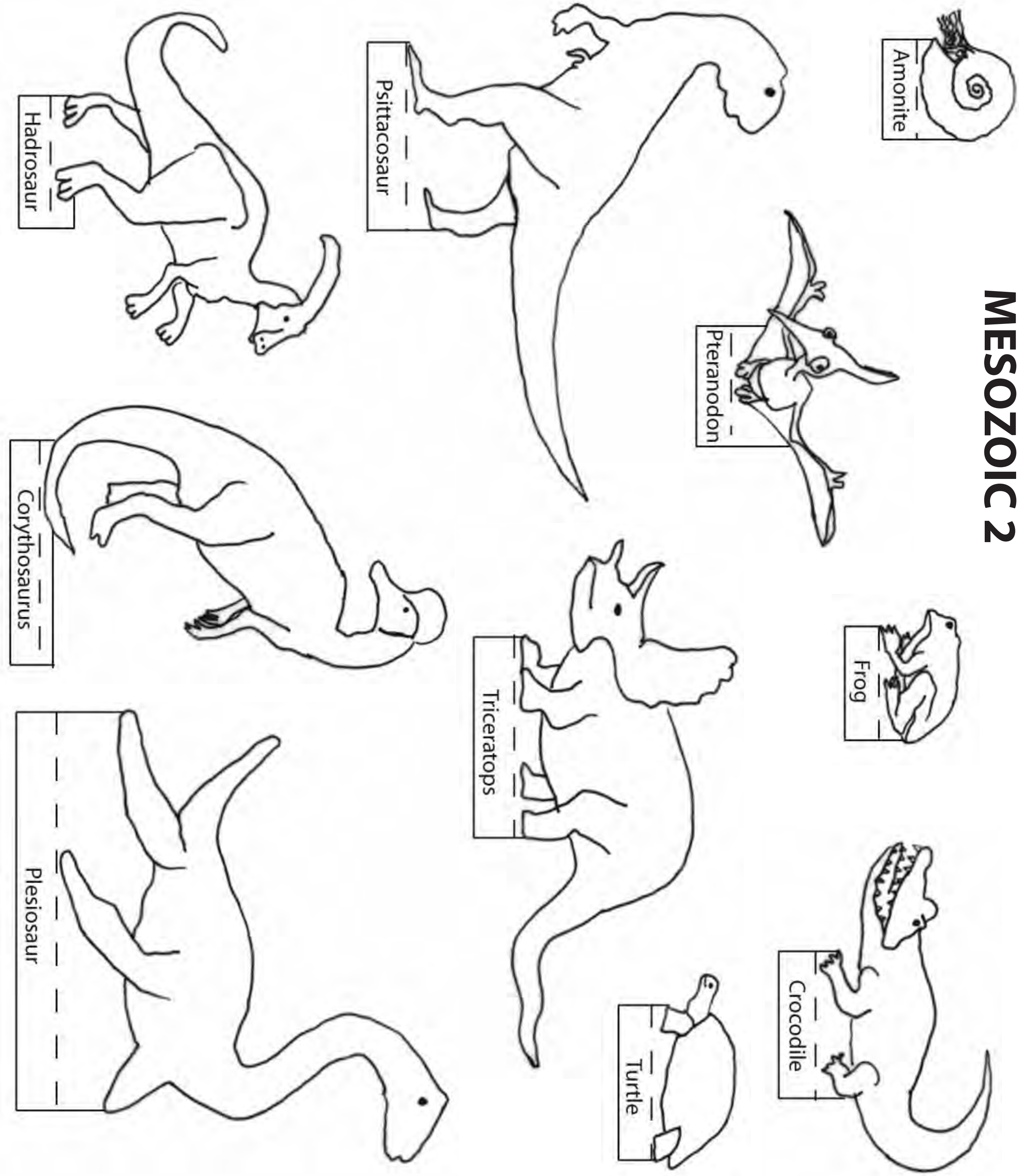


MESOZOIC

Era Dioramas

Member Handout 7, Mesozoic 2

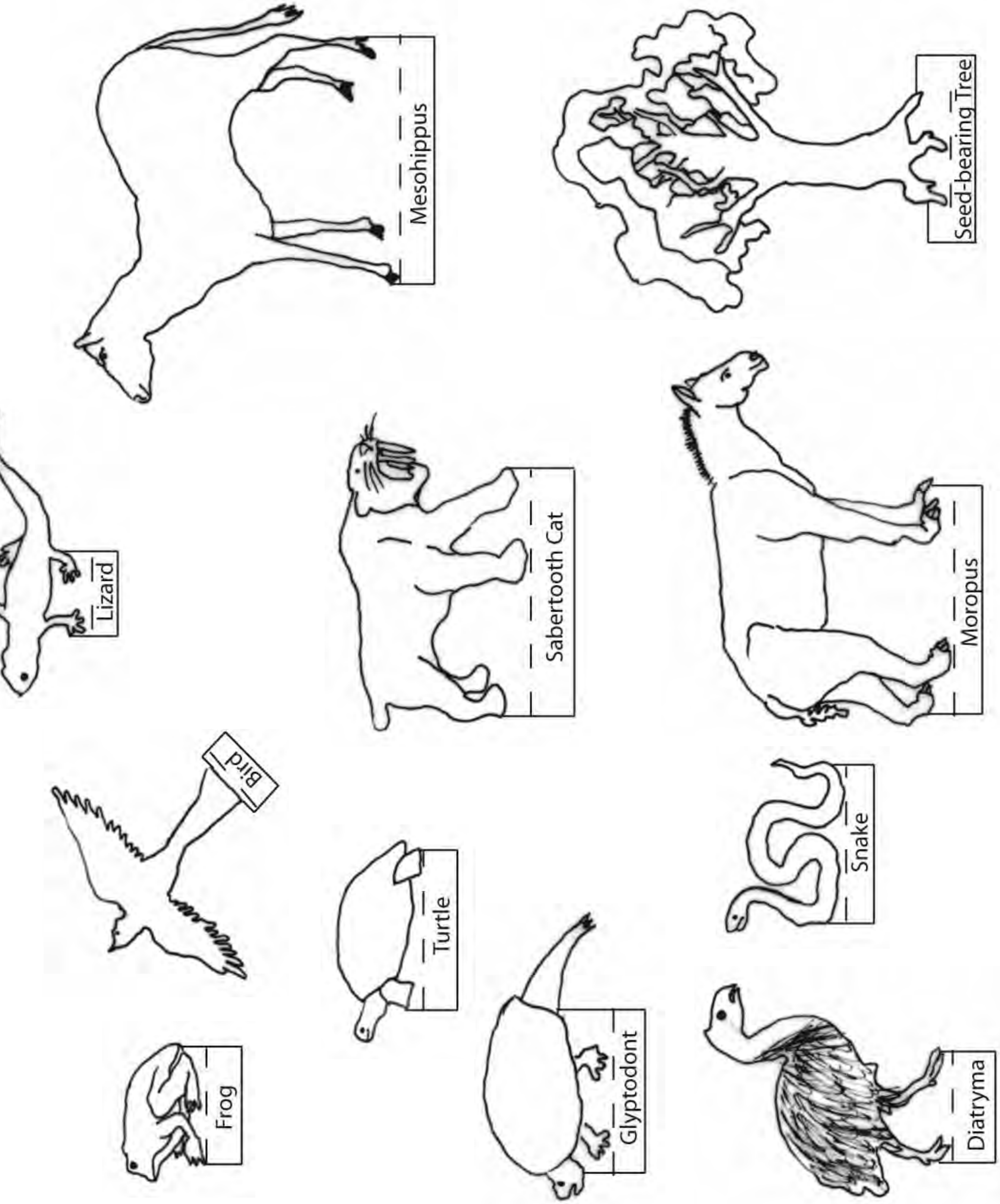
Geologic History — Geology, Level II



Era Dioramas

Member Handout 8, Cenozoic 1

Geologic History — Geology, Level II

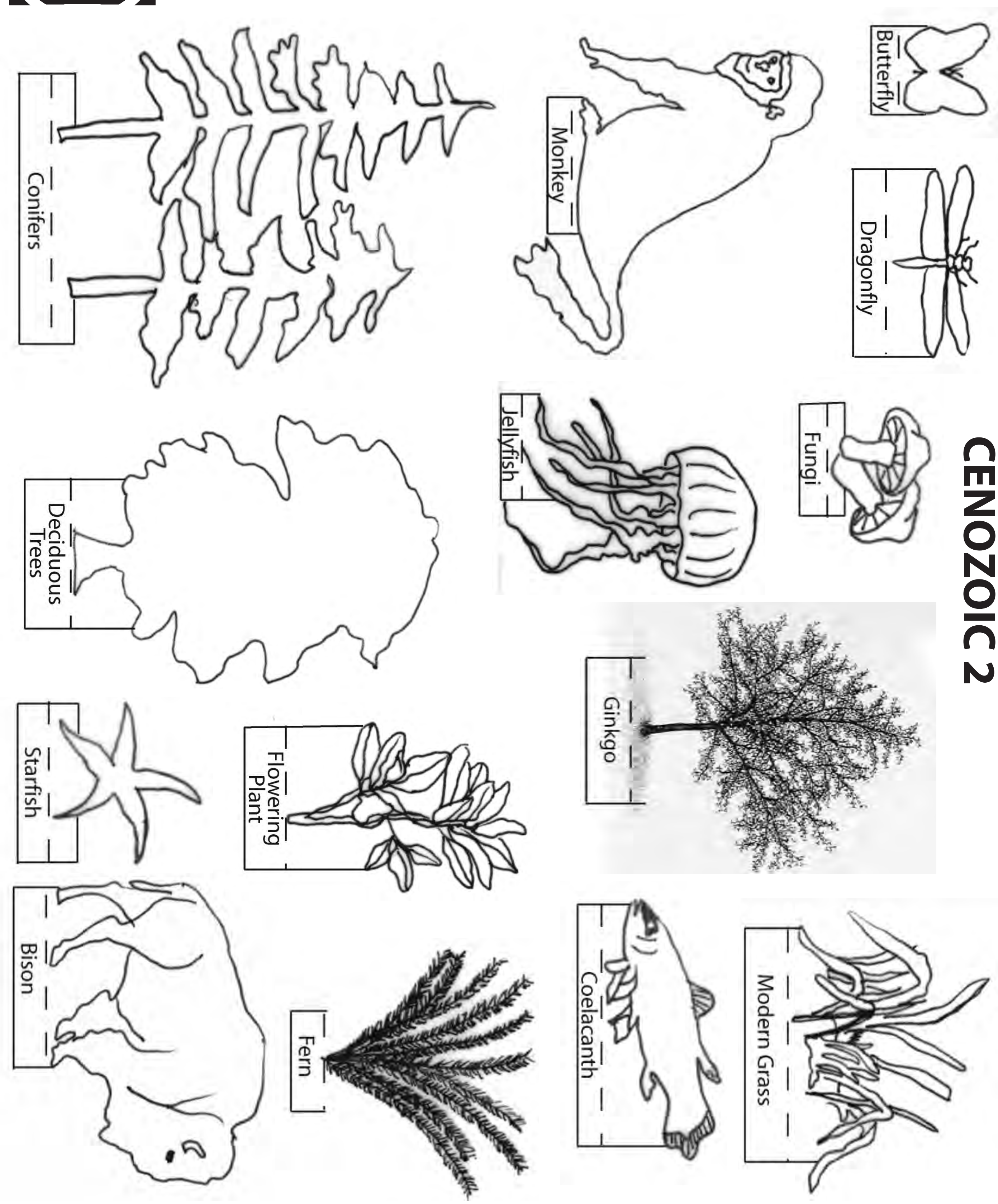


CENOZOIC

Era Dioramas

Member Handout 9, Cenozoic 2

Geologic History — Geology, Level II



Dinosaur Ancestors

Geologic History — Geology, Level II

What members will learn:

About The Project:

- A niche is the place where animals fit into nature.
- A theory is a guess about a principle that is based on fact.
- Extinction is when all animals of a species die.
- Geologists can tell things about how an animal lived by studying its bones.
- The inside of an animal is more important than the outside for deciding were it fits into families.

About Themselves:

- I can make a better guess if I first gather information.
- I can divide things into categories by looking at their common characteristics.
- I have my own niche where I fit in nature.
- What I am inside is more important than what I look like on the outside.

Materials Needed:

- Activity Sheets: 8 *Niche*; 9 *Niche, Leader's Key*; 10 *Dinosaur Dig*; 11 *Dinosaur Hips*; and 12 *Dinosaur Family Tree*
- Pencils and markers or crayons (optional)
- Scissors, paper, stapler and glue
- Library reference materials as desired (e.g. dinosaur pictures, models, books).
- Dinosaur bones, gastroliths, etc. as available.

Activity Time Needed: 50 Minutes (longer if doing additional activities)

Activity:

How many of you like dinosaurs? What are your favorite kinds of dinosaurs? Today, we are going to learn some things that apply to dinosaurs and also other prehistoric animals. All dinosaurs and many other prehistoric animals are extinct. What does that mean? Yes, they all died, and there are no more of that kind of animal left. What are some more recent animals that have become extinct? (*Auks, mammoths, passenger pigeons, etc.*)

Leader's Notes:

Allow a little discussion, and then move into the lesson.

When an animal becomes extinct, another animal usually replaces it to fill the place it held in the animal and plant community. The place that it has is called a niche. For example, if all of a species of an animal that ate grass died out, some other animal that could digest grass would come along to fill its niche. If you don't know what some of those animals are, you can ask or look it up before you match them up.

Hand out the Activity Sheet 8, *Niche*.

People have long wondered about dinosaurs. Long ago, when people found dinosaur bones, they thought they were maybe monsters or dragons. Even though we know more about them, we still are not sure why they all died. How many theories for dinosaur extinction do you think there are? (*Over the years, more than 80 theories or guesses have been suggested for why they died.*) A theory is a reasonable explanation for why something happened. People who think of theories first study what is known. Then, they think about how it could have happened. If their theory still makes sense, they tell people about and publish articles about it. It usually takes a long time before a major theory is accepted as fact. Dinosaur extinction theories are still in the early stages. In fact, there are still several theories that could explain what happened. Which ones have you heard? (*e.g. comet stirred up dust blocking sunshine, environment changed, etc.*) Maybe there is more than one reason for it. If you are especially interested, you can study and report back to us the next time we meet, or do an educational project on it.

Expect them to know almost as much about these theories as you do.

Geologists can tell a lot by studying the fossils they find. By studying the leg bones and the places where the muscles were attached, geologists can tell how the animal stood and ran. They can tell what an animal ate by studying its teeth. If a dinosaur had sharp, steak knife-type teeth, what did they probably eat? (*meat, other animals*) If they had flat grinding teeth, what did they probably eat? (*Plants that needed grinding up.*) Grass is so hard to digest that many animals store it in a separate compartment called a gizzard to allow a longer time to digest. Round stones — that geologists think were inside the gizzards of dinosaurs to help grind up the grass — have been found. These stones are called gastroliths.

Dinosaurs can be divided into two main kinds depending on the way their hips are shaped. One is called "Lizard-hipped" or Saurischian, because its hip bone is shaped like a lizard's hip. This makes sense because dinosaurs are closely related to reptiles like lizards, and some people think they are a kind of reptile. Reptiles have their legs sticking out of the sides of their body. Dinosaurs, however, were thought to walk more upright than reptiles, and had their legs straighter under their bodies.

Hand out:
Activity Sheet 10, *Dinosaur Dig*
Activity Sheet 11, *Dinosaur Hips*
Activity Sheet 12, *Dinosaur Family Tree*

The other main type of dinosaur is "Bird-hipped" or Ornithiscian. This also makes sense because birds are thought to be descendants or near relatives of dinosaurs. By using the hipbone type to separate the two categories, you can tell which dinosaurs are more closely related to each other. Using the *Dinosaur Dig* worksheet, you may first color the outside of the dinosaur if you wish. Then, cut out the pieces and use the *Dinosaur Hips* worksheet to match the hip bones to the outside of the dinosaur by the shape. Staple matching pieces together at the top. Now, sort them into lizard-hipped and bird-hipped categories. Can you always tell from the outside what kind of hip it will have?

Glue your pictures to the *Dinosaur Family Tree* worksheet. The trunk of the tree shows that they all started from animals called Thecodonts. Pterosaurs and crocodiles also came from them. Many geologists now think birds descended from dinosaurs, or that they branched off about the same place dinosaurs did. They think birds might have come from the lizard-hipped dinosaurs, with feathers being the distinguishing feature for birds. Some geologists also think some dinosaurs might have had feathers. It is very interesting. Glue the back layer of the animal picture to the *Dinosaur Family Tree* worksheet to show how they were related.

The activity sheets can be added to their geology notebooks when finished. You may want to do one of the hands-on activities from the "Going Further" section to complete this lesson. Measuring the length of the longest and shortest dinosaurs is easy to do. The references with worksheets also have good activities.

Dialogue For Critical Thinking

Share:

1. What part of this activity did you enjoy the most? Why?
2. What was the most difficult thing to do?

Process:

3. How many dinosaurs could you match up without looking at their hip type?
4. What would have happened if dinosaurs hadn't become extinct?
5. Which dinosaur extinction theory do you like and why?
6. Which is more important in deciding what an animal is related to; its inside structure or its outside appearance? *(Inside)*

Generalize:

7. Do you think your inside (your thoughts and feelings) or your outside (your appearance) is more important? Why?
8. What is your niche in biological terms? *(Both meat and plant eater)* What is your niche in social terms? *(You have an important place in your family and community — e.g. son or daughter, student, helper, team member)*

Apply:

9. How does dividing items into categories help you learn?
10. Why are so many reptiles confused for dinosaurs? (*Because they are closely related, have many of the same characteristics and look alike.*)
11. How would you check out a theory explaining something new?

Going Further:

1. Look up length and height for the biggest and smallest dinosaurs. Then, measure out in a long room or hall how long they were. Compare the largest one to a blue whale, the largest living thing.
2. Investigate teeth types in detail. There are many more kinds. How did they relate to the dinosaur's diet? Draw pictures of the types of teeth, tell what diet they probably ate and which dinosaurs had that type of teeth.
3. Birds may be descended from dinosaurs. Find out what the early birds looked like, and what the justification is for calling them either birds or reptiles. Compare the skeleton of a modern bird, a flying reptile, and Archaeopteryx. How are they alike? Different? Make a chart.
4. Make a mobile of ancient flying reptiles and early birds. Separate them by putting the reptiles and the birds in different areas of the mobile to make it easier to compare. Make a sign telling the differences.

5. Make a diorama of the dinosaurs in the different periods. Make sure the plants are also right for each period. How do dinosaurs differ in the periods, and can you see a connection between the plants available and the dinosaur's adaptations?

References

Braden, Evelyn M., *Prehistoric Life*, 1987, Milliken Publishing Company, St. Louis, Missouri. (Reproducible pages and good info on Dinosaurs and prehistoric life.)

"Digging into Dinosaurs" issue, *Naturescope*, National Wildlife Federation, 1400 Sixteenth St., N.W. Washington, D.C. 20036-2266. Reproducible worksheets and lots of good activities.)

Lucas, Spencer G., Dinosaurs, *The Textbook*, 1994, William C. Brown Publishers, Dubuque, Iowa. (Excellent in depth book.)

McLaughlin, John C., *Tree of Animal Life*, 1981, Dodd, Mead & Company, New York, NY. (Good book on evolution and pressure to fill niche. (Leaders and teenagers)

Gore, Rick. 1989. "Extinctions," *National Geographic*, June 1989, pp. 663-699. Good article on extinctions.

Unwin, Mike, *Where did Dinosaurs Go*, 1991, Usborne Publishing Ltd, Usborn House, 83-85 Saffron Hill, London EC 1n 8RT, England. (Children's book on dinosaur extinction)

West, Linda, *Dinosaurs and Dinosaur National Monument*, 1988, Dinosaur National Monument, Box 128, Jensen Utah 84035. (Leaders and older 4-Hers. Very good information and reproducible pages for a range of ages.)

"When Dinosaurs Shook the Earth," *Topeka Capital-Journal*, March 21, 1993, pgs. 1 & 2F. (Newspaper article on dinosaurs found in Kansas.)

Many good children's books are available. Look for ones that are readable and attractive. Also look for a depth of understanding of principles, not just a listing of facts about dinosaurs.

Author: Pat Gilliland, Kansas 4-H Geology Curriculum Committee.

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

Steven D. Fisher, Professor and Extension Specialist, 4-H Youth Development (Retired)

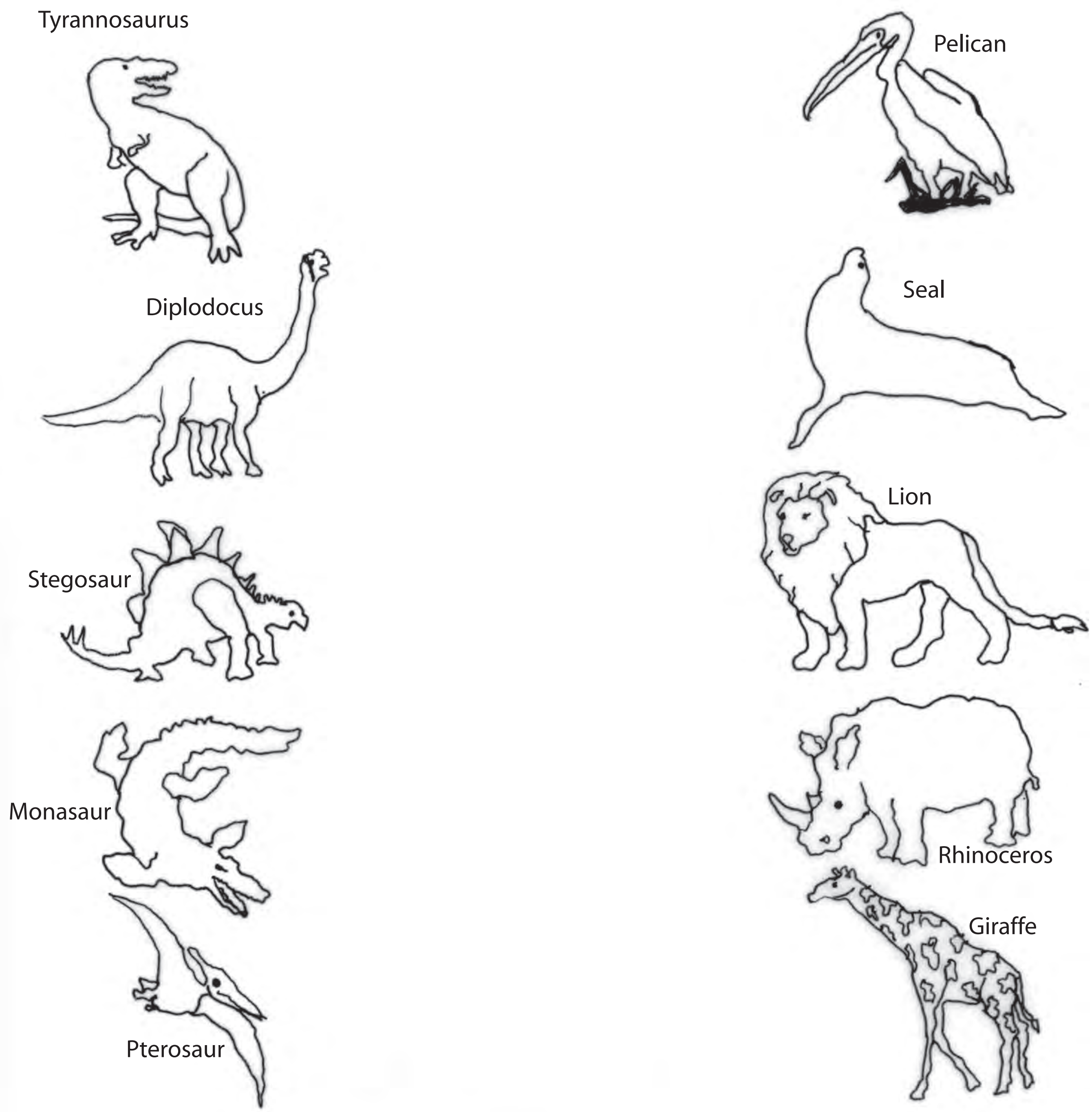
James P. Adams; Associate Professor, 4-H Youth Development

Dinosaur Ancestors

Activity Sheet 8, Niche

Geologic History — Geology, Level II

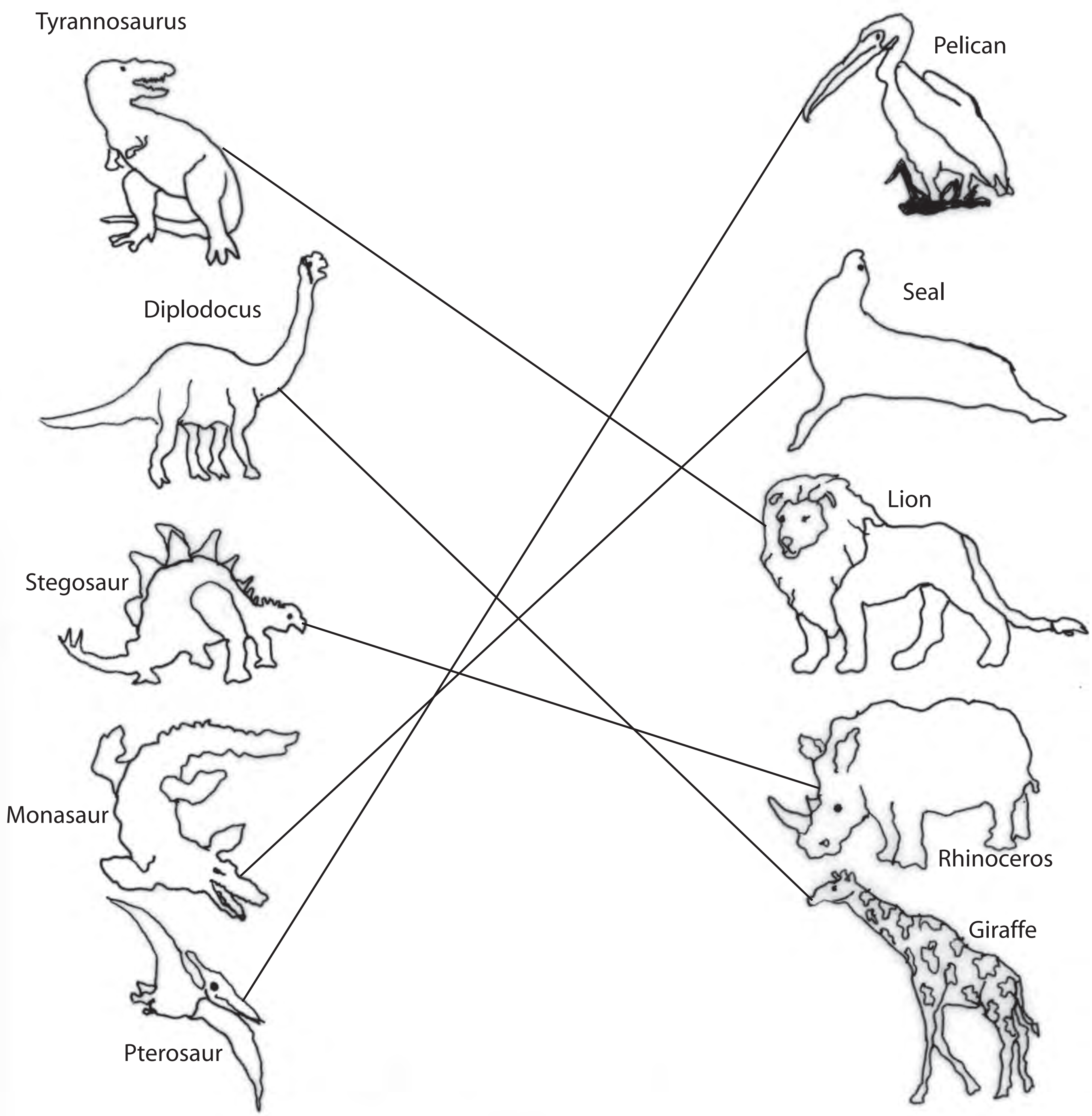
A living thing has a certain place where it belongs. A monkey's niche is in the tops of trees eating fruits and things like that. A fish has a far different niche, and it depends on what that fish eats. Each kind of animal that lived long ago also had its own niche. Think about what the animal eats, its size and where it lives. Draw a line from the prehistoric animal to the modern animal that fills the same niche.



Dinosaur Ancestors

Activity Sheet 9, Niche, Leader's Key

Geologic History — Geology, Level II

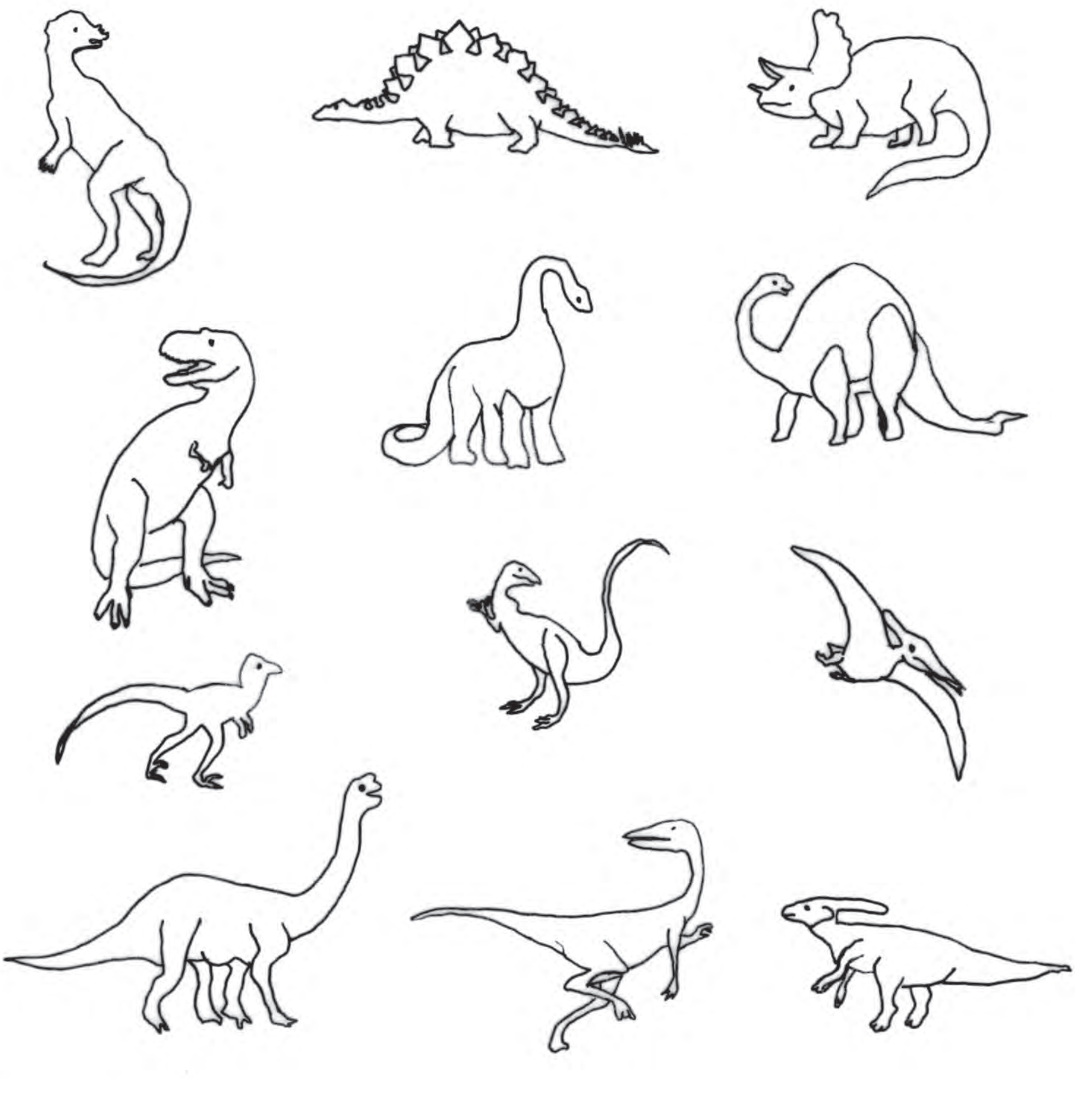


Dinosaur Ancestors

Activity Sheet 10, Dinosaur Dig

Geologic History — Geology, Level II

Color the dinosaurs and other animals on this page. Cut them out. Then, match the dinosaurs up with their match using the "Dinosaur Hips" activity sheet and staple them together near the top of each pair. Glue the back of each set to the "Dinosaur Family Tree" activity sheet.

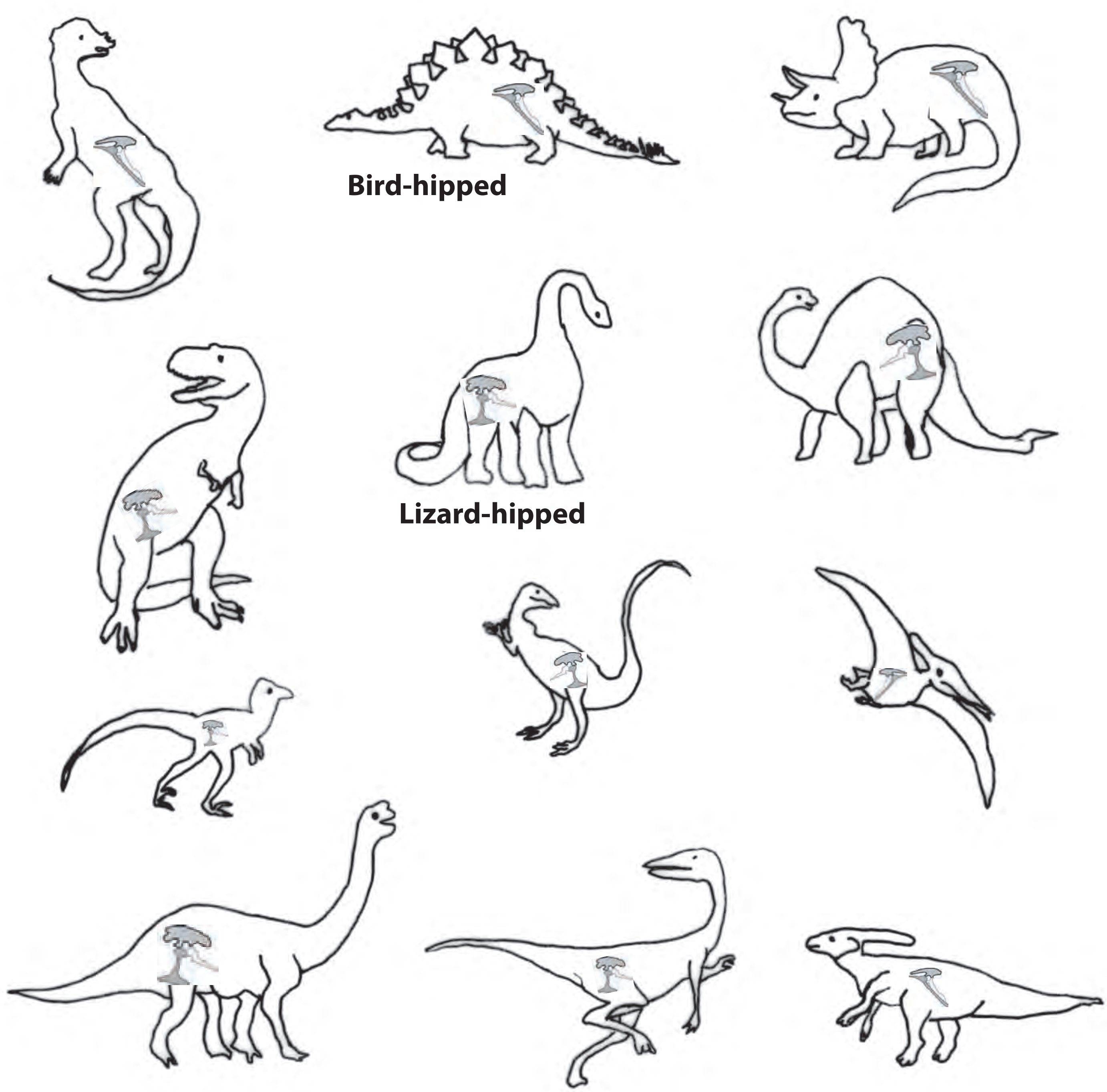


Dinosaur Ancestors

Geologic History — Geology, Level II

Activity Sheet 11, Dinosaur Hips

Dinosaurs have two kinds of hips. Color and cut the dinosaurs on this page and match them with the dinosaurs on the "Dinosaur Dig" page. Staple them together near the top of each pair. Sort the dinosaurs by hip bone type. Glue the back layer of each set to the "Dinosaur Family Tree" on the family tree page.

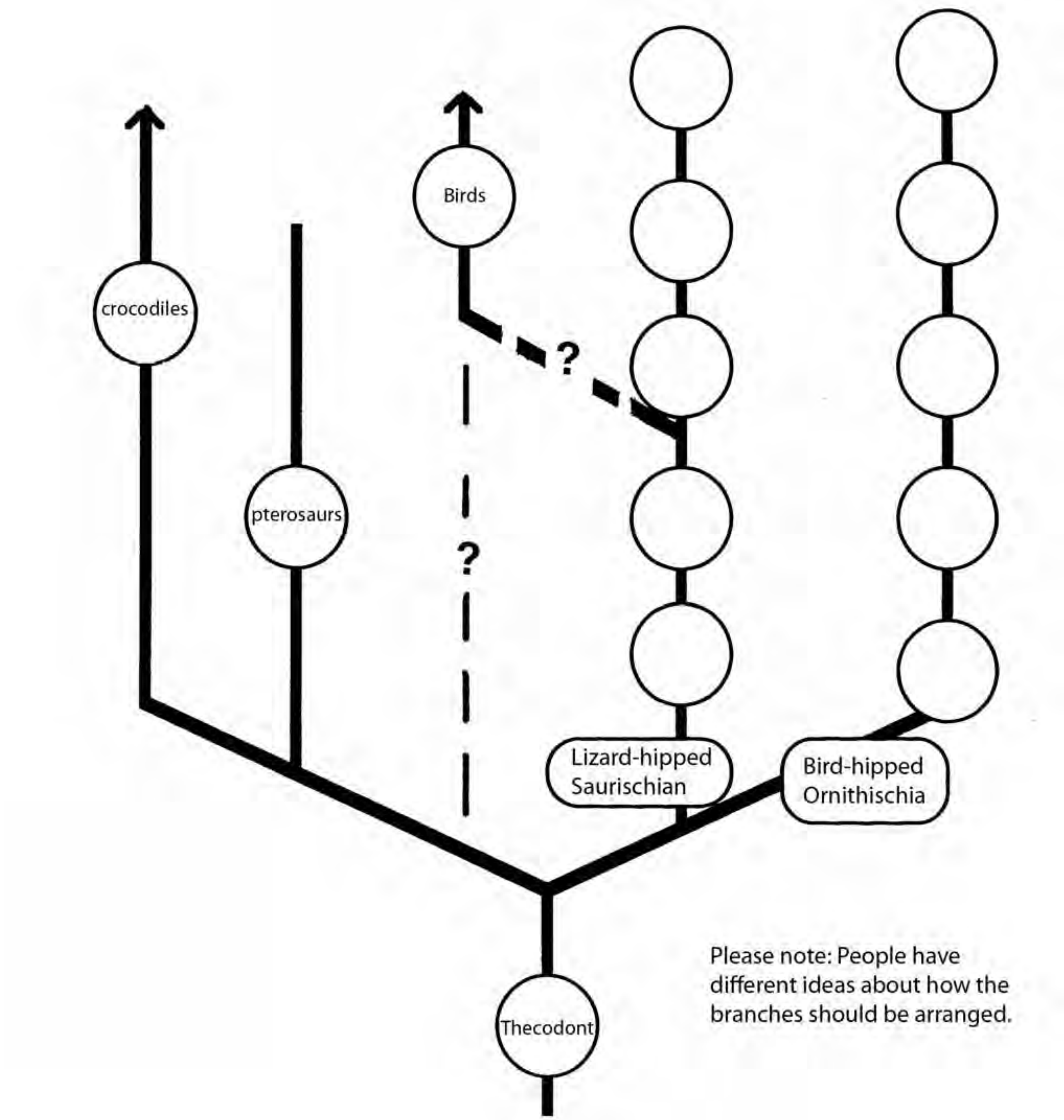


Dinosaur Ancestors

Activity Sheet 12, Dinosaur Family Tree

Geologic History — Geology, Level II

Glue the pictures of prehistoric animals on the family tree circles. The ones that are most alike should be on the same "branch."



Geologic Column

Geologic History — Geology, Level II

What members will learn:

About The Project:

- Major geologic time periods and eras.
- Typical plants and animals in each era.
- Progression of life from simple to complex.
- The order of time periods.
- Eras and periods are separated by geologic events.

About Themselves:

- How to use mnemonic devices and visual aides to help learning.
- Appreciation of living in a varied and interesting world.
- The relationship of people in geologic history compared to animals.

Materials:

- Activity Sheet 13, *Geologic Columns*
- Paste or glue, scissors
- Member Handout 10, *Geologic Column Figures*
- State geologic map, if possible (May be obtained from Kansas Geological Survey, or its Web site: www.kgs.ukans.edu/)
- Representative fossils of your area
- Four medium or large books

Activity Time Needed: 30-40 minutes

Activity

Geologists have divided time since the beginning of the earth into different periods. Geologists have found they can tell that different animals lived during different time periods of the earth's history. They seem to divide up naturally — by what fossils are found in them — into four big, long divisions. Some geologic event decides when they start and finish. For example, the Mesozoic ends with the dinosaurs dying out and then the next era, Cenozoic, begins with mammals becoming important. Here is an activity sheet on geologic eras. See how the big eras are shown here on the left side.

Leader's Notes

(It is recommended you complete the "Peanut Butter Geology" and "Era Dioramas" lessons before you begin this lesson)

If possible, complete an activity sheet yourself ahead of time to use as the answer sheet.

Hand out Activity Sheet 13, *Geologic Columns*. Hold up your own sheet and point to the eras.

This also serves as a review of earlier lessons. They may not remember all the names.

Let's pretend these four books are each an era. Remember peanut butter geology? Which layer was the oldest? *(The bottom one)*. We can pretend this lowest book is the oldest. Which era would that be? *(Precambrian)*. What is the next era? *(Paleozoic or Ancient Life)*. We'll pretend that the second book is the Paleozoic. What is the third one? *(Mesozoic, the age of the reptiles)*. Yes, let's pretend there are dinosaurs in this book. The last era — that we are still in — is what? *(Cenozoic)*

Each era is divided up into smaller pieces, like each of these books is divided into chapters. Look at your activity sheet, and show me where the time periods are located. What periods are in the Mesozoic era? *(Cretaceous, Jurassic, and Triassic)*. Which era and period are we in now? *(Quaternary)*.

If you don't have fossils in your area, ask them to remember what kinds of fossils they collect locally. Then proceed from memory.

Here are some fossils from this area. What era do you think these fossils are from? How can you determine their era? Is there a trilobite? They died out a long time ago, so they are not from the most recent eras.

You can take time to write some new mnemonics if you want to.

It will help you to know what fossils you might find if you memorize the geologic column. One way to make that easier is to use a mnemonic, a sentence that has the same first letter of each word as the list you are trying to memorize. Here is the mnemonic for the Periods of the Geologic Column starting at the bottom, "Can Old Senators Demand More Political Power Than Junior Congressmen? Tough Question." Do you see how each first letter of each word has the same first letter as that time period? What does the first word "Can" stand for? You can make up a different mnemonic saying if you like. Then, use it to memorize the time periods by the next meeting. Let's say it together a few times so we can remember it.

Distribute Member Handout 10, *Geologic Column Figures*.

Cut out the pictures of the animals and plants from your member handout and glue them in the correct Eras. You can use these geologic columns to look at and find the right era in which to glue the pictures. When we are done, you can put it in your geology notebook.

Pass out copies of the geologic columns from the Geological Survey.

Hold yours up.

Let's look at your completed sheets. Here is what it should look like. Now let's use it to think about some things.

Dialogue For Critical Thinking

Share:

1. What part of this exercise did you find easy or hard? Why?
2. Have you ever used a mnemonic to learn something before?

Process:

3. What era did dinosaurs live in? *(Mesozoic)*
4. What era did man live in? *(Cenozoic)*
5. At which age were animals the simplest? Most complex?
6. Figure out a nickname for each period. For example, the Mesozoic is known as the age of the reptiles. Which period within Mesozoic is most closely identified with dinosaurs? *(Jurassic)* Now figure out names for some of the other periods. Use the main life forms.

Generalize:

7. Is it easier or more difficult to memorize with a mnemonic?

Apply

8. What era and period is exposed in your county? *(Use a state geologic map if you don't know the answer).*
9. When else could you use a mnemonic?

Going Further:

1. Collect representative fossils on your field trips and compare them to the chart.
2. Periods are divided into even smaller segments of time called epochs. Find out what some of the periods are for this area and how to tell them apart.
3. Investigate one time period in detail. You could make a diorama or a poster about it and display it at the fair.
4. Use a mnemonic to memorize something else. You can make up your own if you don't know one.
5. Identify pictures used to the Phylum level or more.

References:

Geology, Geologic Time and Nebraska, by Marvin P. Carlson, Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, 1993.

Kansas Geological Survey Web site: *www.kgs.ukans.edu* (used during 1999 and 2000).

Author: Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

Steven D. Fisher, Professor and Extension Specialist, 4-H Youth Dev. (Retired)

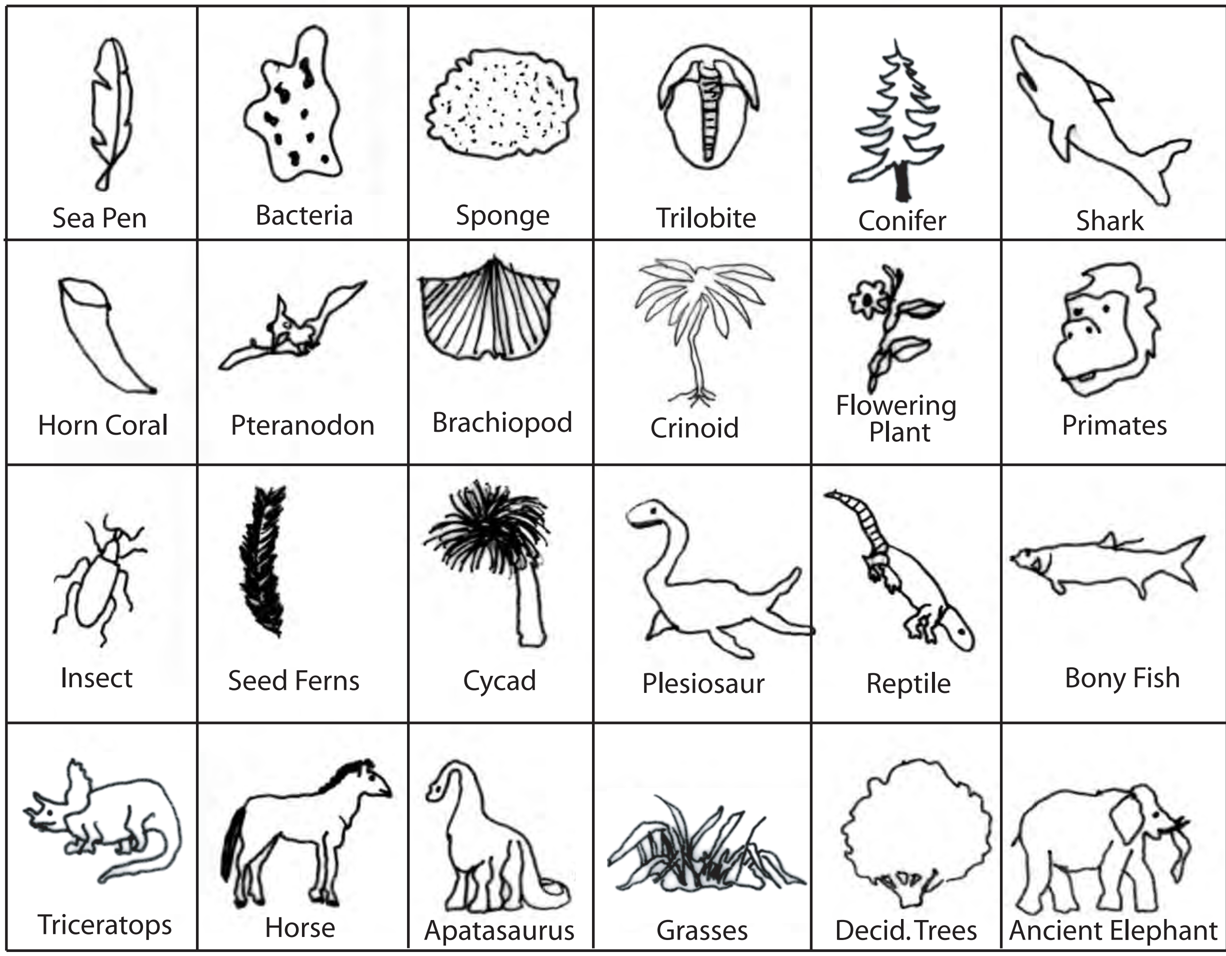
James P. Adams, Associate Professor, 4-H Youth Development

Geologic Column

Member Handout 10
Geologic Columns
Figures

Geologic History—Geology, Level II

Cut these pictures apart on the lines and glue them on the Geologic Columns Activity Sheet in the time period when they first became common. Please note that they are not to scale: for example, the bacteria are very small.



Answers:

Precambrian:

Bacteria
Sponges
Sea pens

Paleozoic:

Trilobite
Horn coral
Brachiopods
Crinoids
Insects
Seed ferns
Reptiles
Bony fish
Sharks

Mesozoic:

Triceratops
Apatasaurus
Plesiosaur
Pteranodon
Conifer
Cycads

Cenozoic:

Flowering plants
Ancient elephants
Grasses
Decidious trees
Primates
Horse

Geologic Column

Geologic History — Geology, Level II

Activity Sheet 13, Geologic Columns

Glue and draw pictures in the life forms section when they first became common. Approximate age in million years ago is given for each era.

Eons	Eras		Periods	Life Forms
PHANEROZOIC	**Cenozoic** 1-70 million		Quaternary	
			Tertiary	
	Mesozoic 70-225 million		Cretaceous	
			Jurasic	
			Triassic	
	Paleozoic 225-600 million		Permian	
			Pennsylvanian	
			Mississippian	
			Devonian	
			Silurian	
			Ordovician	
			Cambrian	
Proter-ozoic	**Pre-Cambrian**	600-4500 million		
Archean				

Geologic Timeline

Geologic History — Geology, Level III

What members will learn:

About The Project:

- The earth is very old.
- Eras are long lengths of time divided by the general types of life that lived during those times.
- Life forms progressed from simple to complex.
- Life forms had to build very slowly at first because of starting with basic elements and no oxygen.
- The major part of the earth's history was spent with very simple or no life forms.

About Themselves:

- Confidence when striving to be accurate.
- Appreciation for different learning styles.
- Metric measurements make it easy to multiply and divide.

Materials

- Meter sticks and rulers (most yardsticks have a meter stick side)
- Adding machine tape or shelf paper (five yards for the short form or 50 yards for the long form)
- Colored markers (washable)
- Activity Sheet 14, *Geologic Timeline*, and Activity Sheet 15, *Important Events*
- Member Reference Sheet "Kansas Geologic Timetable" for each member (also found on the KGS Internet site www.kgs.ukans.edu)
- Scissors and glue or glue sticks
- Pen or pencil
- Timescale showing geologic timeline for a reference

Activity Time Needed: Approximately 40 minutes

Activity

This exercise will show how long the earth has been around and how short a time humans and most animals have been around. It deals in large numbers and uses the adding machine paper to demonstrate this relationship. You may easily make it 10 times as long by simply moving the decimal over one place. The longer version does require a long hall,

Leader's Notes:

This lesson uses metric because it is easier to compute divisions of ten when using years.

The longer version is more difficult to manage but more impressive.

Accept any wrong answers graciously.

Show units as you talk. Make the units 10 times as long if doing long form (i.e. one meter is equal to 100 million years; a centimeter is a million years).

If time is short, the leader may want to measure the paper ahead of time. Hand out several copies of the *Geologic Timeline* and *Important Events* to participants. Have markers, scissors and glue readily available.

Show millimeters with the edges of your fingernails.

If you are using the long version, everything is multiplied by 10, and you should show a centimeter.

gym or other large room. You may enlarge the activity sheets on the copier or have the 4-Hers write larger letters if you are using wider paper.

Do you know how old the earth is? *(Approximately 4.5 to 4.6 billion years old)*

That is such a large number that it is difficult to even imagine. It is a lot longer than a million years. In fact, a billion years is 1,000 times longer than a million. The earth is very old. We are going to make a time line to show how old that is. We will make it on this paper and one meter on the paper will be equal to a billion years. One millimeter will be equal to a million years.

Then, we can glue information or events to it and note things on it to show when things happened. When we are done, we will have a nice way to show how old the earth is and when things happened.

First, we need to measure out the length of the paper and label the meter lengths. Let's use a pencil or pen to measure and mark off the total length of time the earth has been in existence. How long of a piece will we need? (4.5 meters for short version, or 45 meters for the long form). Measure out a piece a little longer than we will need.

Now, let's review the eras. What is the time we are in now? *(Cenozoic)*. How long has it lasted so far? *(About 66 million Years)*. Which era was next? *(Mesozoic)*. Third? *(Paleozoic, or Ancient Life)*. Fourth and oldest one? *(Precambrian or Archaic)*. It is also the longest. It lasted almost 4 billion years. We'll glue the square that says the beginning of the earth at the far end of the paper after we measure and mark it.

Now, let's measure in the eras, using different colored markers to draw the line for each. Draw a line about 1" from the edge of the adding machine paper (2" or 3" for the shelf paper) and 66 millimeters (or centimeters for long form) long for the Cenozoic. Draw a cross slash to mark the beginning and end of it. We'll cut out the era signs to glue below its line, on the narrow space of the paper. Here are all of the lengths:

	Short form	**Long form**
Precambrian	3.9 meters	39 meters
Paleozoic	.325 meters	3.25 meters
Mesozoic	.179 meters	1.79 meters
Cenozoic	.067 meters	.67 meters

That should bring us to a total of 4.5 meters. Glue the era squares beside their lines. (Eras could be written on with a marker.) Now, let's divide the eras into periods, each working on a section. Measure out the period you are working on, and mark it. The periods toward the middle of the eras will have to be done after the first ones have been established. Be sure to measure accurately. These time periods are smaller parts of the eras. It is as though the eras are different books and each period is a chapter of the book. You will also notice that different things lived at different times. When one kind of life dies out, that leaves room for something else to grow in its place. See if you can tell when that happened.

We can now start calling these numbers by millimeter instead of meters, as that will make the numbers easier to work with. A millimeter is one thousandth of a meter, so it is pretty small. It is this little mark on the ruler right here.

Now, let's glue on the pieces of paper from the next sheet showing the different events telling what kinds of life lived at different times. Cut them out of the sheet and glue them at the right place. The times given are in million of years ago, so you will need to start measuring from the present time marker, or from some period or era marker that gives a time close to the one you have. The times given on the event rectangle are approximate. It might vary just a little, but the order in which events happened will remain mostly the same.

Divide up the events, giving some to each. Supervise the measuring.

OK, doesn't that look great? Now, I would like each of you to stand next to the events you put on, and we'll go down through time as each of you tells us what happened.

We'll put it up somewhere so more people can see it when we are done studying it. Now, what can we learn from this time line?

Dialogue For Critical Thinking

Share:

1. What did you see when the timeline was completed?
2. Was it hard or easy for you to work with the metric measures? Why?

Process:

3. What was the most surprising thing you learned from this?
4. Have you ever seen a million of something? What?
5. What is the longest era? *(Precambrian)*
6. In which era would you find very few large animals? *(Precambrian)*
7. What animal forms were most common in each of the eras?
   Precambrian – Invertebrates, very simple forms
   Paleozoic – Invertebrates and other sea life
   Mesozoic – Reptiles and dinosaurs
   Cenozoic – Mammals
8. What plant forms wer common in each era?
   Precambrian – Simple, algae, etc.
   Paleozoic – Bushes, large fern-like trees
   Mesozoic – Lush tropical-like palms; conifers towards the end
   Cenozoic – Flowering plants and grasses
9. Compared to the rest of geologic time, how long has man been on earth? *(Very short period of time)*.

Generalize:

10. What seems to mark the end of each era and the beginning of the next? (Some animals die off and others begin).
11. Why is the Precambrian so long, and we don't have many events to put on it? (Conditions at first were not good for life — too much heat and metamorphism of rocks). So, fossil-wise not much was going on. Some fossils could have been destroyed by heat, erosion and time. Most organisms need oxygen for life as we think of it. Oxygen was driven off when the earth got too hot at first, so algae and bacteria had to build it up.
12. How did this activity help you identify ways which help you to learn?

Apply:

13. Coal forms from buried plant material. In which era would you expect to find the most coal? *(Paleozoic and Tertiary)* Why? *(The abundance of lush plants.)*
14. What era do we have exposed at the surface in this area where we live? How can you tell? *(Fossil evidence)*.
15. In what other situations is the metric system more useful?

Going Further

1. Add more things to the timeline. Look them up to see you are getting it right. You could easily add the pictures from the lessons "Geologic Column" or "Era Dioramas" to your timeline.
2. Display your timeline at the fair, to a class, at your 4-H club, etc.
3. Investigate one period in depth. Make a diorama, a timeline, a poster, a written report or several of these things, and display it somewhere.
4. Find out what periods are represented in your state. Collect representative fossils from each and make a display. You might want to correlate them with a geologic map of the state.

References:

Geologic Time, U.S. Geological Survey, U.S. Department of the Interior

"Kansas Geological Timetable." Originally from the *Decade of North American Geology*, 1983 Geology Time Scale, Geological Society of America. Adapted by the Kansas Geological Survey, Lawrence, Kansas, 1996.

Dates estimated from various sources.

Author: Pat Gilliland, Kansas 4-H Geology Curriculum Team.

Reviewed By: Rex Buchanan, Geologist, Kansas Geological Survey

Steven D. Fisher, Professor and Extension Specialist, 4-H Youth Dev. (Retired)

James P. Adams, Associate Professor, 4-H Youth Development

Geologic Timeline

Geologic History — Geology, Level III

Activity Sheet 14, Geologic Timeline

Measure out a piece of paper a little longer than 4.5 meters (or 45 meters for a longer model) and draw a line near the edge that long. Cut out the various rectangles and glue them to the geologic timeline at the places indicated. You may color them if you wish. Measure a millimeter for each of the million years given for the short timeline, and a centimeter for each million years if using the long form. Numbers are approximate, and show how long each was.

ERA SIGNS

Beginning of earth and beginning of Precambrian 4.5 billion years ago	**PRECAMBRIAN** 3.9 bllion years ago 	**PALEOZOIC** 325 million years long 	**MESOZOIC** 179 million years long 	**CENOZOIC** 66 million years long 

PERIOD SIGNS

CAMBRIAN 65 m. years 	**ORDOVICIAN** 67 m. years 	**SILURIAN** 30 m. years 	**DEVONIAN** 48 m. years 	**MISSISSIPIAN** 40 m. years 	**PENNSYLVANIAN** 34 m. years 
PERMIAN 41 m. years 	**TRIASSIC** 37 m. years 	**JURASSIC** 64 m. years 	**CRETACEOUS** 78 m. years 	**TERTIARY** 65 m. years 	**QUATERNARY** 2 m. years 

Geologic Timeline

Geologic History — Geology, Level III

Activity Sheet 15, Important Events

These signs show various thiings that have happened during Earth's history. The times listed represent the time from now in millions of years. The times listed are approximate.

Key: Mya = million years ago

Cut them apart, then place them where they happened on the timeline.

Oldest rocks found 3,800 mya	Oldest bacteria found 3,500 mya	Stromatolite-like mounds found — Algae? 3,500 mya	Mountain building 2,500 mya	Earliest cell with nucleus 2,500
Earliest plants: Blue-green algae 2,000 mya?	First invertebrates 590 mya	Abundant multi-cell plant life 570 mya	Earliest hard parts (shells); End of Precambrian 560 mya	Burgess Shale soft-body fossils 550 mya
First animal with vertebrae (jawless fish) 500 mya	First land life — plants 430 mya	Fungi, mosses 400 mya	First land animals — Amphibians 395 mya	First true ferns 355 mya
Seed plants Large trees 350 mya	First reptiles 320 mya	Early winged insects 300 mya	Coniferous trees 285 mya	Sharks 280 mya
First dinosaurs 230 mya	First birds 175 mya	Largest mass extinction 250 mya	Flowering plants 130 mya	Modern mammals 80 mya
Donosaurs and other species extinct 65 mya	First apes 35 mya	Human culture 2 mya	End of Ice Age .01 mya	Present time 0 mya

Stratigraphy

Geologic History — Geology, Level III

What members will learn:

About the Project:

- Breaks between rocks which represent missing time periods are called unconformities.
- Contacts are the areas where two types of rock meet with a visible division between the two.
- Formations are visually distinct bodies of rocks that have recognizable contacts with neighboring rock units.
- Formations are generally named for the location where they are first described and for the dominant type of rock they are composed of.
- Groups are rock units composed of two or more related formations.
- Members are smaller divisions within a formation.
- Formations, members and groups are rock type classifications and are only somewhat related to time periods.
- Formations can be diagramed in vertical columns called stratigraphic sections.
- The thickness of vertical sections of rocks can be measured or estimated to aid in identification of the formations and studying the formation.
- A small change carried on for a long time can accumulate to a large effect.

About Themselves:

- Using past reference points are helpful when estimating.
- Observation skills are important in making judgements and decisions.
- Confidence in classifying complex items.
- Adapting to change is a natural part of the life cycle.

Materials Needed

- Peanut butter sandwich (thick — several layers) and additional peanut butter or jelly and bread of a different kind.
- Two knifes — one sharp and one table knife
- Silly Putty; or another option using small chunk of ice and wire rack
- Small plate
- Handouts of stratigraphic sections of rock in your area, one for each member (You might be able to use one from a field trip guide or from KGS bulletins and maps.)

- Rulers and yardsticks
- Large field trip location with back slope (e.g. maybe a hillside road cut or dam spillway that is not overgrown with plants and clearly shows visible layers)
- Paper and pencils
- Clipboards or other writing surface for field trip

Activity Time Needed: 30 minutes plus field time

Activity

When we think of geologic time, we usually think about great changes like oceans coming and going and mountains being built and eroded away. But, these geologic changes take place so slowly that they may not look like much while they are changing. To see how that works, we are going to start an example now and look at it again later. Could I have a volunteer to roll this Silly Putty into a ball? Now, let's put it over here on this plate and check it periodically as we talk. (If using ice, place on plate and wire rack). Can you see anything moving or happening now? What do you think will happen?

While we are waiting for that, let's talk about **unconformities**. These are places where rock layers are missing. Remember when we made the peanut butter sandwich to show layers of the earth?

Leader's Notes:

If you have done that lesson, this part will be a review. If not, be sure to explain it carefully. It is a Level I lesson in this chapter, "Geologic History."

Here is a peanut butter sandwich. What geologic principles does it represent? Do you remember the Law of Original Horizontality? What does that mean? *(The layers were laid down flat)*. What does the Law of Supposition mean? *(The lower layers were laid down first)*.

What would happen if part of the layers were eroded away? First, I'll cut the sandwich in half so we can see what it looked like at first, and put it to the side. Now, could we have a volunteer to cut off a layer to show erosion? Cut off only one or two layers please. What kind of erosion could cause that to happen? *(Glacier scraped off, wind blew away, river washed away, etc)*. Now, let's pretend that another layer gets deposited on top of the eroded area. Please add a half piece of this bread and some jelly to half of the sandwich. What could be an example of this happening? *(Lake deposits, etc.)*. Now, let's compare it to the original half sandwich. Can you see where this layer is missing from one half? What was that called again? *(Unconformity)*. Thank you for helping demonstrate unconformity.

How many of you have heard about a formation? Common ones here are the ___________ and ____________.

Use local formations from a field trip guidebook or geological reports. Hand out copies to members now.

A **formation** is a layer of rock that looks different enough from the layers above and below it to easily tell them apart. It must also be a thick enough layer that it can show up on a map. Here is a handout showing some of the layers in this area. A drawing like this showing the formations is called a stratigraphic column. Even on the drawing you can tell the layers apart. The place where two formations meet is called the **contact**.

Formations have two part names. The first part is usually a place name where the layer was first identified, or that has a nice layer exposed. The second part of the name usually tells the main type of rock from which it is made. For example, Dakota Sandstone Formation is a common sandstone in the center of the United States. Look on your handout. Which names do you recognize?

Several formations are grouped together into Rock Groups. Look at the column to see what group or groups are on our stratigraphic section.

Pause to look it up.

If there are separate, smaller layers in the formation, they are called **members**. What members are listed on our section of the stratigraphic column?

The smallest division usually identified are beds. Are there **beds** listed on our section?

An example might be coal beds.

Now, let's see what happened to our Silly Putty (or ice cube). What did you observe? *(Flat or melted*). Did you see it happen? *(No, change was too slow).*

All of a formation is not always laid down at the same time. Sandstone can be laid down as a beach at the edge of bodies of water. Slowly, over time, the area where sand is laid down may move to a different area; for instance, as a sea dries up and the shores move. Therefore, one continuous band of similar rock was not necessarily deposited at the same time. Formations are not time divisions.

Pretty soon (or on the next field trip) we'll see this section — or one like it — in real life. We'll go to a back slope and compare it with a section. It's going to look a little different, so we'll have to look carefully to see which layer is which. What can we use to identify individual layers? *(The order of rock types; section may show some layers lumpier than others, etc.).* We'll also want to have some idea of a layer's thickness. That can be quite a problem to measure because most cuts slant and are uneven. This time, we'll just estimate its thickness and compare it to the section to see if the layer is about the right thickness to be the layer we think it is. To estimate more accurately, we can compare it to something for which we know the length. For example, would you each estimate the length of this table (or height of chair). Now, I'm going to put this ruler (or yardstick) near it. Now, estimate it again. Now, let's measure and see which time you were closer.

To help us estimate taller things, we could use our own height. Do you each know about how tall you are? It doesn't have to be exact. If you look straight across at something that is even with your eyes, it would be just a little shorter than you. This will only work with things close by. Let's practice by estimating the height of this wall. Now, when we are in the field, you can estimate the thickness of each layer and compare it to the section.

Refer to diagram at the end of this lesson.

Dialogue for Critical Thinking

Share:

1. What is a stratigraphic column used for?
2. How can you tell if you have any unconformities on your col-umn? *(It would be hard to tell unless you had another column to compare to, or knew something about the region. Unconformities are indicated by a wavy line)*.
3. What was the most difficult thing we did? What was the easiest? Why?

Process:

4. What was the area that is represented on the section of the stratigraphic column you have like? *(Ocean? Seashore or river? — sandstone, Shallow sea — limestone, Plant-rich land — coal, Thin layers — frequent change, etc)*.
5. What similar experiences have you had?

Generalize:

6. Is estimating as accurate as measuring? *(No)*. Then why use it? *(It is faster and close enough for many uses)*.
5. Have any of you made small changes that have added up to big changes over a long time? *(Growing, improving skills like reading and identifying rocks, etc)*.

Apply:

6. If you were not sure which part of the section was at a location, how could you figure it out? How could you use this concept in the future to better understand something you were unsure of? *(Compare rock types and order of layers, measure thicknesses to compare with thicknesses on section, ask an expert, consult field trip guides, etc)*.
7. Where else could you use estimating heights?

Going Further

1. Estimate the thicknesses of the different layers in the road cut. Draw a diagram of the layers as you see them. Compare to the stratigraphic column. Label each formation, member, etc.
2. Research local formations. How were they named? Where do they outcrop?
3. Research one formation in depth. Follow it from location to location. What are its characteristics? (*This is a physical correlation of a formation.*)
4. Look for examples of unconformities in your area.
5. Imagine a seashore goes down an average of 10 inches a year. How far will it have moved in a thousand years? *(833 ft. or approximately one eighth of a mile)*.
6. The plates in the earth are moving about as fast as your fingernails grow. Compare their original positions to their present ones. How many years did that take?

References:

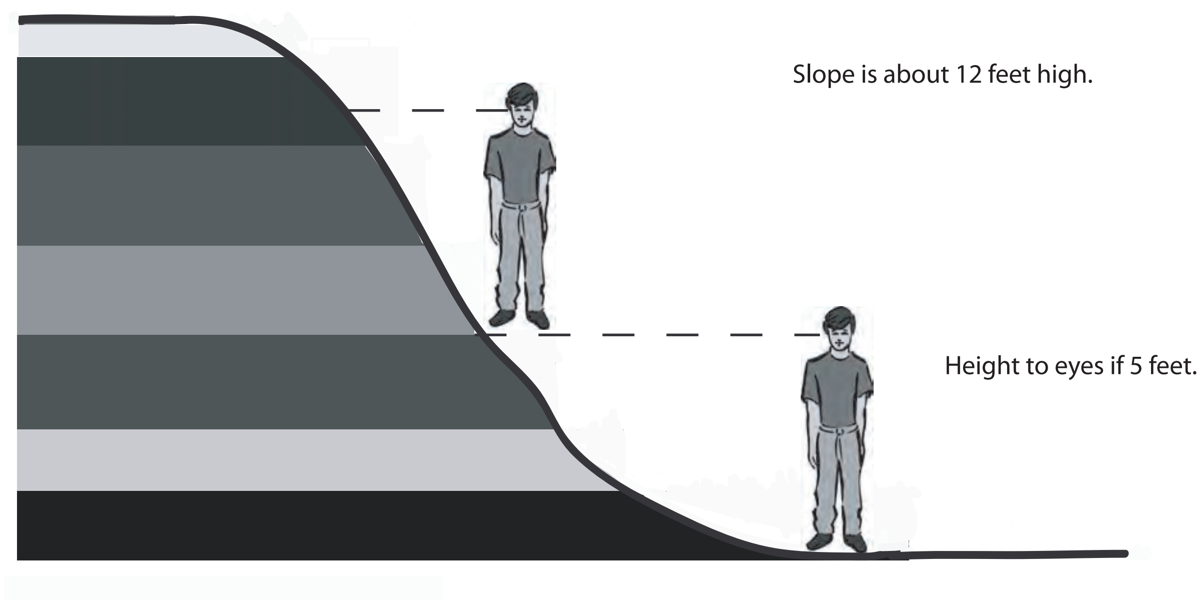
Written By: Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed By: Rex Buchanan, Geologist, Ks. Geological Survey

Steven D. Fisher, Professor and Extension Specialist, 4-H Youth Dev. (Retired)

James P. Adams, Associate Professor, 4-H Youth Development,

Estimating layers of formation by eyesight.



Measured Sections

Geologic History — Geology, Level IV

What members will learn:

About The Project:

- How to accurately measure the thickness of a formation.
- Which geologic terms describe time, which describe rock types, and which describe both.
- Fossils in a layer sometime help us identify the formation.
- How different naming systems relate to each other.

About Themselves:

- Accurate measurements are important.
- Appreciation and understanding of appropriate tools to get a job accomplished
- How to work together as a team.

Materials Needed

- Sturdy string
- Two poles at least five or six feet tall
- Yardstick or meter stick
- Line levels (obtainable at a lumberyard or home products store)
- Paper and pencils
- Stratigraphic sections of area formations
- Geologic map of the state
- Back slope free of vegetation clearly showing rock layers (spillway of a lake would be suitable)
- Member Handout 11, *Geologic Units and Measuring Sections*

Activity Time Needed: Two or more hours in the field, and about 30-40 minutes preparation with your group.

Activity

More than 200 years ago, people started drawing up stratigraphic columns of the layers in the earth. These columns are still considered fairly accurate today even though we have a much better understanding now about why the rock layers occur in the order we find them. The early geologists' observations of the earth support a modern view of geologic history. You have probably noticed stratigraphic columns are made of rock groups

Leader's Notes:

This lesson will be more effective if you have done several previous Level III activities. Refer back to the information in those exercises and include what you need for this activity. If you have a small group, you might want to make extra copies of this lesson so the members can follow along.

(formations, members, etc.). These rock groups have been described and named by geologists over many years. Usually, the names are related to some geographical location near where the rock unit was first described. You may have also noticed that the rock units are in a certain order in the column. What is that order? *(Oldest layer on the bottom).* The rock group name may also include the name of the main type of rock that comprises it. (e.g. Topeka Limestone Formation).

Different events could have been occurring at different places in the world in ancient times, just as still happens. Some places now have lakes and some don't. Some have blowing sand and some don't. Swampy areas sometimes dry up and some years they stay wet. Using the geologic principle "The present is the key to the past," we can look at the rock evidence and try to imagine what it was like millions of years ago. Imagine you are at the edge of a large shallow sea. What would it be like? Now imagine what would happen to sea levels when it was very wet. Would the same things grow there? What kind of rock would be deposited? Now, imagine that much of the water is frozen into glaciers, and sea levels go down. What is it like now? What kind of rock would be deposited? Would the shoreline be at a different place?

Write the Time-Stratigraphic chart out on big paper or a chalkboard, or give copies of the handout, *Geologic Units and Measuring Sections* to members.

Stratigraphic columns also often list the geographic time in which rock units were deposited. This blends together two different ways of working with the earth's past. The first is when things have occurred in the past (Era, Period, Epoch, Age) and the second is the kind of rock being deposited at that location (Group, Formation, Member, Bed). When we talk about the age of the rock layers, we usually refer to the period during which the rocks were deposited (See geologic time scale in this lesson). This blends together two different ways of working with the past in a time-stratigraphic system. This type of system helps us determine what rock we are working with and when in time they were deposited. The geologic units chart shows how time, stratigraphic-time and rock units compare to one another. The relationships are not always consistent.

Fossils often aid in the identification of these units. In fact, it is the main criteria determining some of the layers. You will want to remember what you learned in the units on fossils as you study correlation by fossils in rocks.

Now, we are going to learn how to measure the thickness of rock layers in the field. We'll use this method on our next field trip (or today).

Try to balance teams. Up to five or six people can be used on each team. If your group is small, use just one team. Possible duties: two pole persons, level reader, pole reader, recorder, manager (e.g. keep diagrams, instructions for moves, etc).

You will need to work carefully and accurately. We'll use string with a level on it to make sure we are sighting straight across from one measuring spot to another. You will need to work in teams, and you will need teams of at least three people, so let's form teams now. Each team will decide who will do what on their team. You need two people to hold and carry the poles, one person to observe the level, and a person to write down results and observations. Someone can double up on writing down descriptions if you only have three people on your team.

Practice this with them before going out in the field. Also practice later when you have it on the string. See diagram in the member handout, *Geologic Units and Measuring Sections* and demonstrate this section, if possible.

Then, we will mark your poles off in feet (meters if that is the unit of measurement used on your stratigraphic columns). Next, we'll tie 20 feet of string between your poles and slip the level onto the string before we wind the string up around the poles and carry them to the site. See how the bubble in the level moves around as you tilt it? Practice moving one pole to see how to make the bubble move to the middle section of the level.

At the site, you'll measure up the slope slowly, using the string and level to make sure your next measuring pole is placed at the height that your last measuring ended. To do that, two people have to be holding the poles and one has to observe the bubble in the level and tell the uphill pole holder to move his or her pole until the bubble is in the middle. When measuring the slope, start at the bottom. Hold one pole upright and set the second pole on the slope with the string at the bottom. Have one person move the string on the lower pole until the string is level and tight; or have the upper pole moved so that the string is level and tight. Record the difference in height from the foot markings on the lower pole. Then, someone has to write down how many feet up it is. Before or after a layer is measured, the person recording the height also needs to write down a good description of the rock layer being measured. Then, move the lower pole to the location where the upper pole had been, and move the upper pole to a higher location. Measure the next layer until you reach the top.

When you get done, draw a cross section of the slope. Use the same symbols that the stratigraphic section uses. Now, compare it to the section. Which part did you measure? Label each formation and smaller units as completely as you can.

You may want to help them out by giving them the starting formation.

Dialogue For Critical Thinking

Share:

1. What was the most difficult part of this exercise? Why?
2. Have any of you used a level before? Where?

Process:

3. Why is it important for the bubble to be in the middle of the level? *(So the string will be even and you will have an accurate measurement).*
4. Could one person have done a good job of measuring the slope by him or herself? *(No, not with two poles, a string and a level. A team is needed, with each member doing his or her part).*

Generalize:

5. What possibilities for errors existed? Where could similar errors occur in other projects? *(Accurate measuring is important in the building trade, sewing, crafts and many other pursuits Other answers also acceptable).*

Apply:

6. For what other purpose could you use this technique of measuring slopes? *(Telling others the best place on a slope to collect samples or to measure a slope for a building site).*

Going Further

1. Compare your measurements of the slope to others. Why could there be differences?
2. Measure another slope and practice your skills.

3. Use your new skills to map a good collecting slope you don't think has been mapped in detail before. Make your information available to others by doing a display at the fair and/or writing a paper. Samples from each layer would add to the display.
4. Correlate stratigraphic sections with geologic columns for your area. Then, compare them to some other area of the world. How do they differ? Make a chart or drawing.

REFERENCES:

Session presented at a Kaw Valley in-service for teachers by the Kansas Earth Science Teachers Association.

Authors: Pat and Will Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed By: Rex Buchanan, Geologist, Kansas Geological Survey

Steven D. Fisher, Professor and Extension Specialist, 4-H Youth Dev. (Retired)

James P. Adams, Associate Professor, 4-H Youth Development

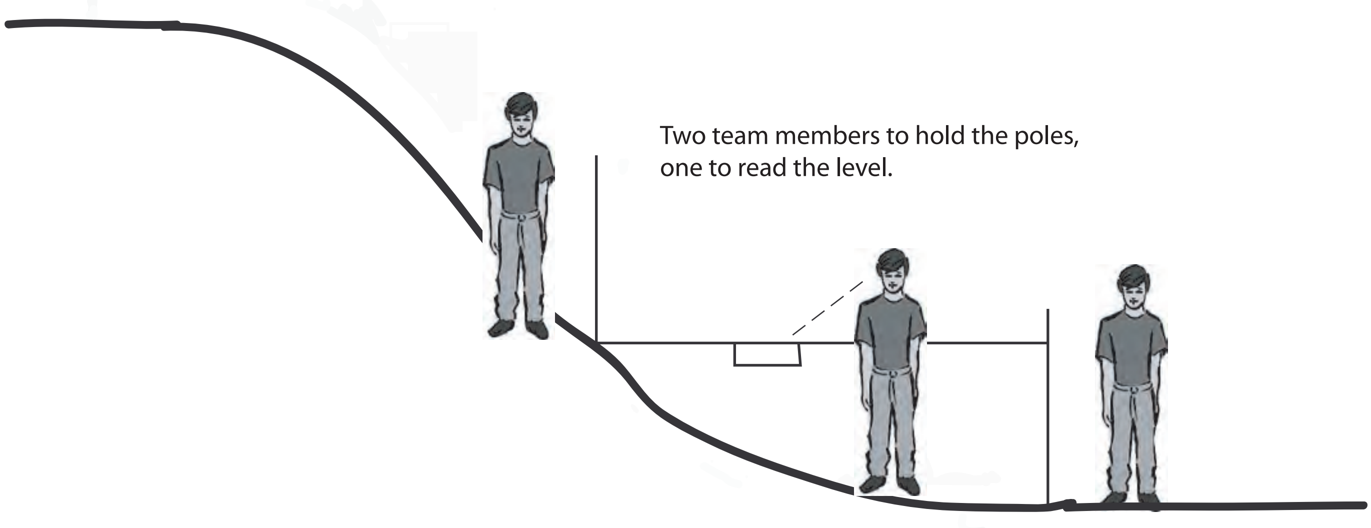
Measured Sections

Member Handout 11, Geologic Units and Measuring Sections

Geologic History — Geology, Level IV

Time Unit	Example	Time Stratigraphic Unit	Example	Rock Unit	Example
Era	Paleozoic	Erathem	Paleozoic		
Period	Pennsylvanian	System	Pennsylvanian		
Epoch	Late Pennsylvanian	Series	Upper Pennsylvanian		
Age		Stage	Virginian	One or more groups	
				Group	Shawnee
				Formation	Topeka L.S.
				Member	Hoyt Shale

Measuring Sections



Kansas 4-H Geology Leader Notebook

Chapter 3 — Minerals, Table of Contents

Crystal Shapes

Minerals — Geology Level II

What members will learn. . .

About the Project:

- What is a mineral?
- What shapes of minerals come in.
- How to identify a crystal.
- How the molecular structure determines a crystal's shape.

About Themselves:

- What's inside is what is important.

Materials Needed:

- Activity Sheet 16, *Crystal Models*
- Scissors
- Tape or glue (glue sticks are easy)
- Pencils
- Common minerals showing different shapes
- Square children's building blocks
- Magnifying glasses
- Member Handout 12, *Introduction to Minerals*
- Member Handout 13, *Crystal Recipes*; see specific recipe for additional materials
- Member Handout 14, *Crystal Shapes*

Time Needed: 30 Minutes

Activity

How many of you like crystals? They are pretty, aren't they? Today, we are going to start growing some crystals. We will also find out what some common shapes are and how to tell what kind of mineral a sample is by looking at the shape.

Now we are going to start a crystal-growing experiment. It will take a while to evaporate, so I will bring it back next time for you to see. Shapes form as the water evaporates and brings the molecules closer together.

A mineral always has the same basic shape. The shape may be messed up a little bit, with a portion missing, but the basic shape is always the same. How can that be? Well, it's because the way the mineral is made inside, its very smallest pieces always stay the same for one kind of mineral. Table salt, for example, is always made up of two chemicals, sodium and chloride,

Leader's Notes:

Use Member Handout 12, *Introduction to Minerals*, to introduce the mineral concept before beginning this lesson.

Use Member Handout 13, *Crystal Recipes*. The epsom salts in a plate is an easy and striking experiment. You might want to do it the night before, and bring it in, so they can see a finished product if it will be a while until you meet again.

Use building blocks to show how a larger cube is made of smaller ones. Take out one of the blocks to show a piece missing.

Hold up examples and pass around for members to handle. Also pass a magnifying glass, or have it available later.

Hand out Activity Sheet 16, *Crystal Models*

Younger members may want to skip the hexagonal model as it is the hardest.

Pass out Member Handout 13, *Crystal Shapes*.

Hold up examples that you have, and follow the same procedure of identifying the shape.

and it is always in the same amount to each other. If something else is in the formula, then it becomes a different mineral and might also have a different shape. Sometimes the crystal shapes are very small, and you need to use a magnifying glass to see them. Sometimes the shapes bump into each other as they are growing and combine in odd shapes. Sometimes the crystal gets broken after it is made, and it is hard to tell its original shape.

When there are easy-to-see shapes, it can help you tell which mineral a specimen is because the crystal shape is always the same for a mineral. If a piece of the mineral is square and clear, for example, you know it is not quartz because quartz forms pointed shapes with six sides. Several minerals might share one shape, however, so you can't use only crystal shape to identify a specimen. Color and hardness and other things are important also.

Now, here is an activity sheet to build models of some common kinds of crystals. Here are some of the models I have made up. First you will need to cut out all the shapes on the dark lines. Then, fold them on each light line. Check to see that the shape looks right. Then glue the tabs to the side of the shape near it. Hold them a little while for the glue to set. When we are all finished, we can talk about them.

Now that we are finished building the shapes, let's look at them and at this chart. What minerals come in this cubic shape? Here is a real salt crystal. Is it about the same shape? When you are done using the chart, put it in your notebook to save as a reference.

Dialogue for Critical Thinking

Share:

1. What did you see when observing the plate crystal?
2. Was it easier to see the shape on the model or the real crystal? Why?

Process:

3. What are some of the basic crystal shapes?
4. What are some minerals with cubic shapes? Hexagonal?
5. When a crystal "grows or forms," how is that different from a living thing that grows? (A living thing makes new material from sun energy and nutrients. It grows from the inside. A crystal makes no new material, it just results when the materials in the mixture clump together as the water evaporates, and it forms from the outside.)

Generalize

6. What did you learn about yourself through this activity?
7. Are your values, feelings, thoughts (things from within) more important than appearance, what you wear (things on the outside)? Why? Or why not?

Apply:

8. How do crystal shapes affect your life now and in the future? (*Consider value of special stone jewelry shapes*.)
9. How will you act differently in the future as a result of this activity

and discussion?

Going Further

1. Grow another recipe of crystals from the Member Handout ___, *Crystal Recipes*. How is it the same? How different?
2. Design some model of other crystal shapes and make them. Tell what minerals come in that shape.
3. Using the same directions, make several different samples using different chemicals. Salt, alum borax and Epsom salts all work well. Give everybody a bottle of one of the solutions and see if they can tell what it is by growing the crystals and comparing it to yours.
4. Buy a crystal kit and grow crystals from it. Compare them to the crystals from the household chemicals. Often they use less common chemicals that make larger or brightly colored crystals.
5. Look for examples of minerals in different or unusual shapes. Rock shops often sell them.
6. Look at crystals under a microscope. Observe crystals as they form by putting a little saturated solution on a slide. Warm slide carefully with a match (leader does this) as you watch. What happens?

References

Donitrovic, Anna; "Eggshell Geodes," *Rock Talk* Jan 94. (Reprinted in *The Glacial Drifter*.)

Hoehn, Robert G.; *Earth Science Curriculum Activities Kit*; 1991; The Center for Applied Research in Education, West Nyack, NY 10995

Stangl, Jean, *Crystals and Crystal Gardens You Can Grow*

VanCleave, Janice; *Earth Science for Every Kid*; John Wiley & Sons, Inc. NY

Written by: Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by: Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Crystal Shapes

Member Handout 12, Introduction to Minerals

Minerals — Geology Level II

What is a mineral?

"A mineral is a natural, inorganic substance with a characteristic chemical composition and definite physical properties."

1. A mineral is formed in nature. A ruby that formed in the earth is a mineral, but a ruby that was made by a person (synthetic) is not a mineral.
2. A mineral is made up of substances that were never alive (inorganic). Coal, natural gas and petroleum are not minerals, because they were formed from the remains of animals and plants.
3. A mineral has the same chemical make-up wherever it is found .The kind of matter present and the amount of each kind of matter are always the same for a given mineral no matter where it is found. Sand is not a mineral because samples from different places usually have different chemical make-ups.
4. The atoms of a mineral are arranged in a regular pattern and form solid units called crystals. For example: salt is a mineral having crystals shaped like tiny cubes. Sugar is another substance that has a crystal form, however, sugar is not a mineral since it is made from a plant.

Identifying Minerals:

1. Minerals are identified by their physical properties.
2. Each mineral has physical properties which make it different from all other minerals. (Which can be used for identification.)
3. The physical properties of minerals are:

Crystal Form: Many minerals form crystals which are helpful in their identification.

Color: Color may be the most obvious property of a mineral; however, some minerals have slight impurities which give a variety of colors. Example: quartz

Streak: Streak is the color of a mineral in its powdered form and is obtained by rubbing a mineral across a plate of unglazed porcelain. The streak of the same minerals usually shows the same color, even though the minerals themselves sometimes have a different color. Hematite may very in color, but it will always show a red-brown streak.

Luster: Luster refers to the way light is reflected from a mineral surface. There are two types of luster: metallic and non-metallic.

Hardness: Hardness is a mineral's resistance to being scratched. The harder mineral always scratches the softer mineral.

Cleavage: Minerals cleave if they break along smooth, flat planes.

Fracture: Fracture is breakage along an irregular surface.

Specific Gravity: Specific gravity refers to the ratio of the mineral's mass to the mass of an equal volume of water.

Taste, Smell, Magnetism: Some minerals have specific properties of their own which help to identify them. You can taste halite (salt), smell sulfur, tap jade for a bell-like ring, and pick up magnetite with a magnet.

Author: Rita O'Neal, Kansas 4-H Geology Curriculum Team

Reference: *Exploring the World Through Geology*, p.10, K-State Research and Extension, Manhattan, Kansas.

Crystal Shapes

Member Handout 13, Crystal Recipes

Minerals — Geology Level II

General Instructions:

Most of these recipes use a saturated or super saturated solution of a chemical. This can be made by stirring the chemical into water until no more dissolves. One to 4 tablespoons of material usually dissolve in one cup of water. You can usually feel the undissolved material in the bottom with your spoon. To make a supersaturated solution, heat the water before you try to dissolve the chemical. It will hold more dissolved material than unheated.

Different common household chemicals can be used and usually substituted and compared with each other. They are: Table salt, Epson salts(available in drugstores) and Alum (a canning ingredient). Sugar also makes crystals, but is not a mineral. Laundry bluing or food coloring may be added for color. Avoid disturbing the crystals as they grow.

Materials Needed:

- Spoons, measuring cups, bowls, water, household chemicals
- Additional materials as stated in each recipe

Plate crystals

Cut a circle of dark construction paper to fit the bottom of a disposable pie or pot pie pan or an old lid. Pour a thin layer of the saturated solution in the pan, about 1/8 inch or less. Allow it to stand undisturbed for about one day. This easy experiment produces clearly visable crystals. Epsoms salts are especially effective.

Suspended Crystals

Pour a little of the solution in a shallow container and allow it to evaporate. Take the best crystal and suspend it with string so it hangs into a glass or other container (a "seed" crystal). Fill the container with supersaturated solution and suspend the crystal in it. Allow it to set for a day or two, or longer, until it grows bigger. This produces bigger, more impressive single crystals, but can go wrong if the solution is not saturated. A variation is to skip growing a seed crystal and just suspend the string.

Crystal Gardens

There are many variations of this. Basically, you place some porous materials like brick, cinder, charcoal briquette, flower pot shards, lava, sponge, etc. in a pan. A shallow disposable plastic container works well. Then you pour on a solution of a chemical, usually salt and ammonia (1 or 2 tablespoons hasten evaporation). You may also add some bluing (a laundry aide) or food color for color. Three tablespoons each water, salt, and bluing, and 1 tablespoon ammonia works well. You may sprinkle a little salt on for seed. Let it stand for a few days. Add more solution to the bottom of the container after a few days if you want it to continue to grow.

Eggshell Geodes

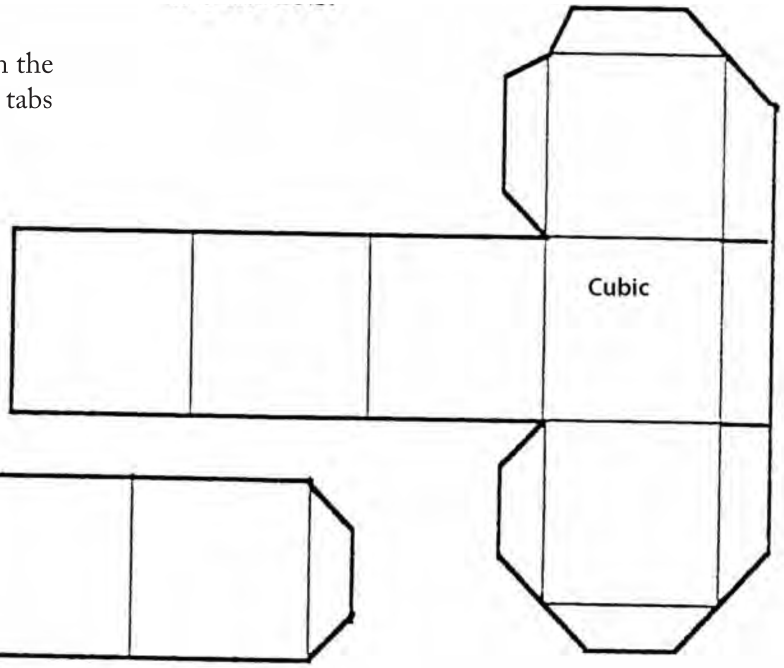
Remove the membrane from half an eggshell. Place the eggshell in the egg carton and pour saturated salt solution in it. Add a drop of food color, if desired. Let set until evaporated. Add more solution as it evaporates if you want more crystals.

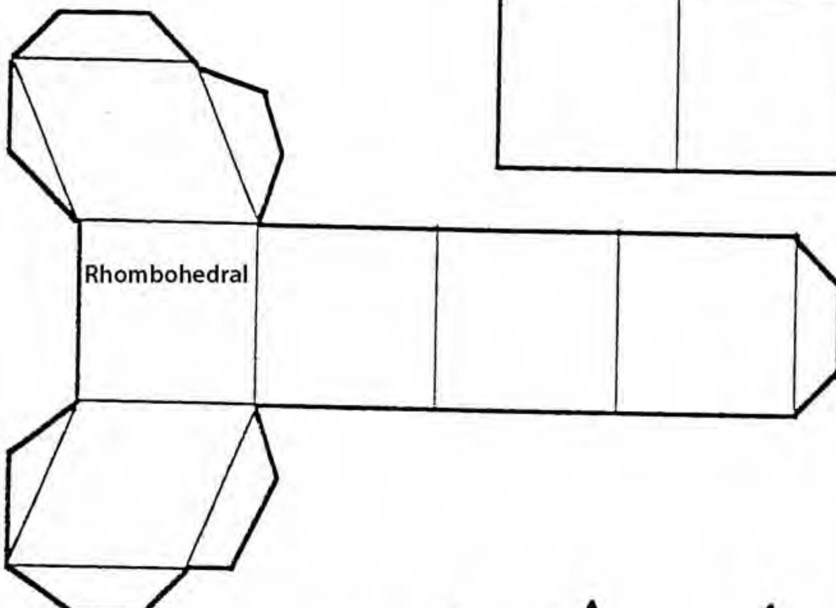
Crystal Shapes

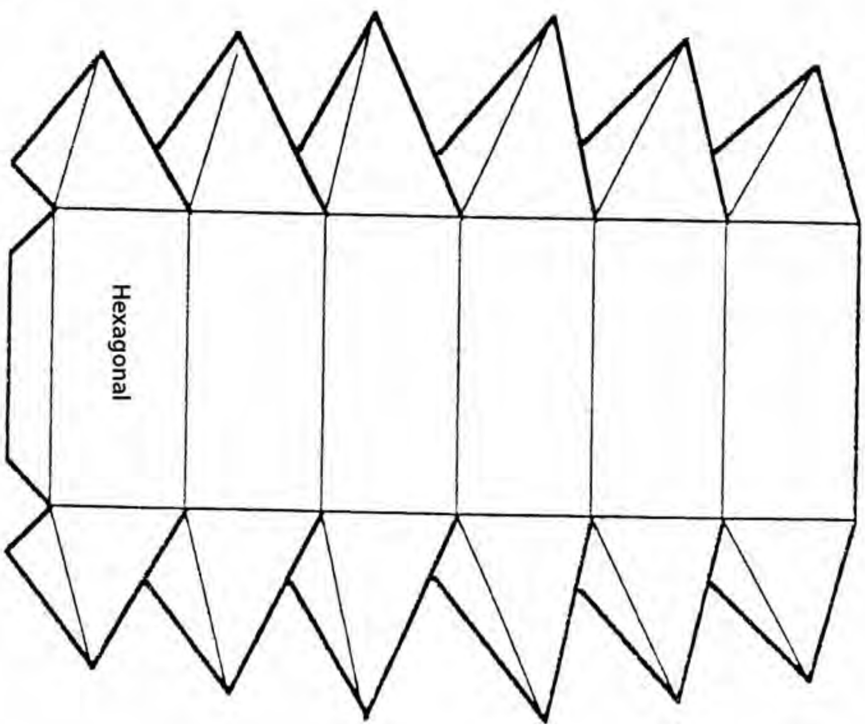
Activity Sheet 16, Crystal Models

Minerals — Geology Level II

Cut out the models on the dark lines and fold on the lighter lines. Fold all lighter lines back. Glue the tabs to form the models.



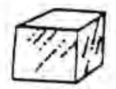
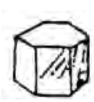
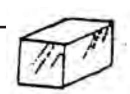




Crystal Shapes

Member Handout 14
Crystal Shapes

Minerals — Geology Level II

Type	Surfaces	Shapes of Surfaces		Examples
Cubic	6		all are square	alum, pyrite, garnet, gold, sodium chloride (salt), silver, diamond
Hexagonal	8		two are hexagons; six are rectangles (angles of rectangles are right angles)	ice, ruby, sapphire, quartz, emerald, apatite
Monoclinic	6		four are rectangles; two are parallelograms; 16 angles are right angles; eight angles are not right angles	sugar, gypsum, borax
Orthorhombic	6		all are rectangles; three pairs of rectangles, each pair a different size; corner angles are right angles	topaz, Epsom salt, rhombic sulfur
Rhombohedral	6		all are rhombuses; no right angles	calcite
Tetragonal	6		four are rectangles; two are squares (corner angles are right angles)	white tin, zircon
Triclinic	6		all are parallelograms (no right angles at corners)	boric acid, copper sulfate

Cleavage and Fracture

Minerals — Geology Level II

What members will learn …

About the Project:

- How to identify a mineral by how it breaks.
- Some minerals have both cleavage and fracture.
- Minerals that show cleavage break along flat surfaces or planes.
- Minerals that show fracture break along irregular planes.

About Themselves:

- They can observe and learn from the various tests they make on mineral specimens.
- They need to protect their eyes with safety glasses when breaking minerals and rocks.
- Experimenting can be fun.

Materials:

- Safety glasses for each child
- Mineral samples with cleavage like halite or calcite
- Covering to protect the table surface (newspapers)
- Some type of rock hammer, such as one made by welding a piece of pipe to a railroad spike.
- Member Handout 15, *Types of Mineral Cleavage*

Activity Time Needed: 20 minutes

Activity

Does the mineral have a broken surface? The way in which a mineral breaks is described as either cleavage or fracture. Minerals cleave if they break along smooth flat planes. Different minerals have their own characteristic cleavage that can be used to identify them.

Types of cleavage:

Cubic: Halite or salt, cleaves in three directions, each at right angles to the others. Therefore, halite breaks up into cubes or rectangular blocks.

Rhombohedral: Calcite also cleaves in three directions, but the surfaces are not at right angles. Therefore, calcite breaks up into blocks that lean on one side.

Leader's Notes:

Show examples of each.

Provide Member Handout 15, *Types of Mineral Cleavage*.

Basal: Basal cleavage is parallel to the base of the crystal. Mica cleaves in only one direction and fractures in all others. Therefore, a block of mica splits into thick sheets. Each sheet, however, fractures when bent or twisted.

Cleavage should not be confused with crystal forms. When a mineral exhibits cleavage, it will break into pieces that have the same configuration as the original sample. By contrast, quartz crystals do not have cleavage, and if broken, would shatter into shapes that do not resemble each other or the original crystal.

Minerals that do not exhibit cleavage are said to fracture when broken. Those that break into smooth curved surfaces resembling broken glass have a conchodial fracture. This conchodial fracture made it possible for Indians to chip arrowheads. Other minerals with fracture break into splinter or fibers, but most break irregularly.

Give each child newspapers to cover the table, safety glasses for eye protection, hammer, and mineral sample.

Instruct the members to tap the specimen firmly with enough force to break the specimen, but not to smash it. Discuss the type of cleavage of the specimen. Demonstrate or experiment with the other two types of cleavage not illustrated by the experiment.

Dialogue for Critical Thinking:

Share:

1. What mineral did you find hardest to break along lines?

Process:

2. What is the difference between cleavage and fracture? (Cleavage breaks in straight lines, and fracture breaks are round, irregular or splintered.)
3. What are three types of cleavage? Give examples of each.

Generalize:

4. Why is it important to wear safety glasses when breaking the minerals?
5. How does experimenting help you learn?

Apply:

6. Which of the cleavage types do you have in your collection?
7. What minerals can you identify using cleavage? Fracture? Crystal Form? (Cleavage: mica cleaving in layers. Fracture: glass, obsidian and chert breaking with conchoidal fracture. Crystal form: Quartz, characteristic of pointed crystals.)

Going Further:

1. Investigate other forms of cleavage such as a diamond, etc
2. Explain why the conchoidal fracture was important to the Indians and tell what minerals they used to make artifacts.
3. List types of fracture and give examples of each.
4. Make a collection of different types (examples) of cleavage or fracture.

Author: Rita O'Neal, Kansas 4-H Geology Curriculum Team

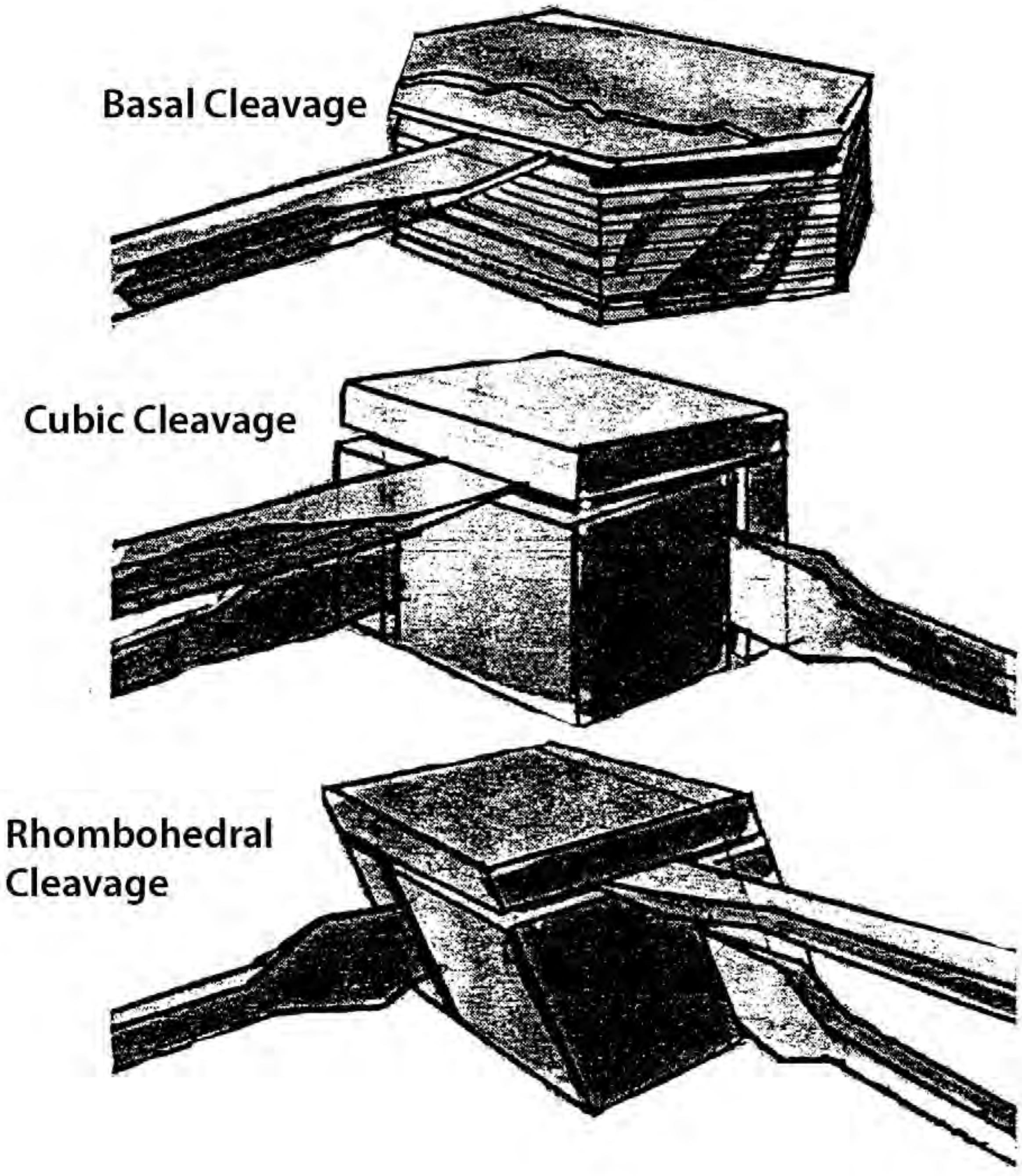
Reviewed by: Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Cleavage and Fracture

Member Handout 15
Types of Mineral Cleavage

Minerals — Geology Level II



How Hard is Hard?

Minerals — Geology Level II

What members will learn …

About the Project:

- How hardness can be used to identify minerals.
- How to use the hardness scale.

About Themselves:

- Preferred way of learning.
- Mnemonic devices help them remember lists.

Materials:

- Small samples of Calcite, Quartz and Gypsum (Selenite) for each member (Do not tell them what they are.)
- Plastic zip-lock bag to hold the three specimens
- Copies of *Kansas Rocks and Minerals* or other mineral I.D. guide
- Hardness Test Kit (optional)

Activity Time Needed: 30 minutes

Activity:

Not all minerals are the same hardness. A mineral that can scratch another is the harder of the two. There is a hardness scale called the Mohs Scale.

This hardness scale was named after Frederich Mohs, a German mineralogist, who lived from 1733-1839. He recognized the fact that some minerals are harder than others and devised the hardness scale we now use. All minerals have a hardness number and can be placed on this scale according to their hardness. This scale lists 10 common minerals and gives each mineral a number from one to 10, with number one being the softest and 10 being the hardest.

Leader's Notes:

The MOHS Scale should be explained to members. This presentation could be given by the leader or be presented as a project talk by one of the members.

Ask the members to create a mnemonic saying to help remember the hardness scale such as: "The Girls Can Flirt And Other Questionable Things Can Do."

The MOHS Scale includes the following:

1. Talc (softest)
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase (Feldspar)
7. Quartz
8. Topaz
9. Corundum
10. Diamond (hardest)

The following levels of hardness can be determined by scratching the mineral with the suggested item:

2 to 3 – Fingernail
3 to 4 – Penny
4 to 6 – Window Glass
5 to 6 – Knife Blade or Nail
6 to 7 – Steel File

Give each member a plastic bag with the three mineral specimens: calcite, quartz, and gypsum (selenite). Do not tell members what they are.

Caution the members to make sure the there is a definite scratch by trying to rub the powder away with their fingers. What appears to be a scratch may be the powder left by the softer of the two minerals.

We are going to test the hardness of these three minerals.

To determine the hardness of each mineral, each of you should experiment by trying to scratch a fresh surface of one of the minerals with a second mineral.

Arrange the specimens in order of hardness, the softest to the hardest.

Provides copies of *Kansas Rocks and Minerals.*

Name a mineral and tell the page where it is found in the book. Have each member look up the mineral. After determining the hardness of the mineral, have a member show where that mineral should be placed on the hardness scale. Discuss which mineral would scratch this mineral and which minerals it would scratch.

The next activity involves using a copy of *Kansas Rocks and Minerals*.

Look up the minerals I.D. hardness section.

Dialogue for Critical Thinking:

Share:

1. How difficult was it to determine the hardness of the three minerals?
2. Why did you have to use the hardness test to identify the three minerals?

Process:

3. When you try to scratch one sample with another, which one receives the scratch?
4. How can you tell a true scratch from a streak?

Generalize:

5. Does the mnemonic sentence make it easier for you to remember the order of the mineral hardness?
6. What other methods of learning or memory aids do you prefer?

Apply:

7. What is the hardest mineral you have collected?
8. What are some common minerals used in everyday situations?

Going Further:

1. Make a hardness kit using a penny, small piece of glass, a pocketknife or nail, and a steel file.
2. Visit a rock shop, or gem and mineral show, to purchase specimens they may not already have to make a special display of the MOHS Scale. This display could be used for a project talk and could also be a special display at the fair.
3. Make a hardness scale using Kansas specimens.

Author: Rita O'Neal, Kansas 4-H Geology Curriculum Team

Reviewed by: Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Possible answers for question No. 8:
Diamonds – saw and drill bits

Marble or granite – tombstones

Talc – Talcum powder

Gypsum – Wallboard

Specific Gravity

Minerals — Geology Level III

What members will learn …

About the Project:

- How to measure the specific gravity of a mineral.

About Themselves:

- The importance of neatness and accuracy in their lives.

Materials:

- Plastic cup with a small hole cut near top
- Small dish with volume equal to plastic cup that will fit on the scales
- Large towel or tray
- Scales
- Mineral specimens for identification (must fit in cup)
- Pencil and paper
- Reference book which lists mineral and their specific gravity

Activity Time Needed: 30–40 minutes

Activity

Equal sized pieces of two different minerals may not weigh the same. The heavier mineral is said to have a higher specific gravity. The specific gravity of a substance is a comparison of its weight with the weight of an equal volume of water. A mineral having a specific gravity of 3.0 is three times as heavy as the same volume of water. Jewelers often use specific gravity as a way to identify gem minerals.

Specific gravity is one of the physical properties of a mineral and can be used for identification. To measure the specific gravity of a mineral, you must first weigh the specimen. Next, you must obtain and weigh an equal volume of water. Compare the weight of the mineral specimen with the weight of the water. Divide the weight of the mineral by the weight of the water to determine the specific gravity of the mineral.

Leader's Notes:

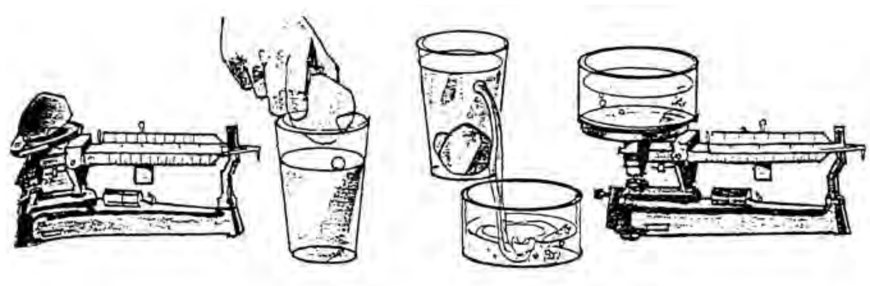
Place a towel, tray or plastic cover on the table to catch spilled water.

Now let's try the procedure one step at a time.

1. Weigh mineral specimen on the scale, while it is dry and record weight.
2. Fill plastic cup with water up to the hole in the side.
3. Place cup of water in a dish to collect displaced water.
4. Place mineral specimen into plastic cup
5. Collect the water which is forced out through the hole, it is equal to the volume of the specimen
6. Weight the displaced water and record its weight.
7. Divide the weight of the mineral specimen by the weight of the displaced water. This is the specific gravity of the mineral specimen.

If you don't know what the specimen is, look up the specific gravity in a geology book. This list will identify the unknown material.

The illustration below shows a way that can be used to get a volume of water equal to that of the specimen being tested.



Dialogue for Critical Thinking:

Share:

1. What problems did you have while weighing certain specimens or their displaced water?
2. How easy or difficult was it to determine the specific gravity of your specimen?
3. Was your specimen an unknown or were you verifying a known mineral? How accurate were you?

Process:

4. Why is specific gravity important?

Generalize:

5. What did you learn about yourself while doing this activity?
6. How important are neatness and accuracy? Why?

Apply:

7. Where else might specific gravity be important? Why?
8. What other areas of your life are neatness and accuracy important? Why?

Going Further:

1. Determine the specific gravity of other minerals such as: orthoclase, feldspar, galena, calcite, quartz, chalcopyrite, magnetite, talc, hematite, limonite, etc.
2. Keep a record of your specific gravities for a personal identification reference.
3. Research and give a demonstration of other methods of determining specific gravity.
4. Write a paper about the Greek mathematician, Archimedes, who discovered the facts of specific gravity. Read the story about how Archimedes determined that the goldsmith who made a crown for the king replaced some of the gold with silver.

Author: Rita O'Neal, Kansas 4-H Geology Curriculum Team

Reviewed by: Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Flame It, Fizz It

Minerals — Geology Level IV

What members will learn …

About the Project:

- Minerals have unique chemical properties that can be used to identify them.
- Two tests that can be used to determine chemical properties of minerals.

About Themselves:

- The importance of safety when working with chemicals or fire.
- The value of experimentation.

Materials:

- Propane torch
- Platinum loop
- Dilute (30%) Hydrochloric Acid (Muriatic Acid is already diluted and is available at most hardware stores)
- Baking soda
- Hammer
- Water solution
- Evaporating dish or something similar
- Safety glasses
- Safety matches
- Samples of galena, calcite, celestite, sphalerite, halite
- Activity Sheet 17, *Mineral Identification Reactions*
- Activity Sheet 18, *Mineral Identification Reactions, Leader's Key*
- *Kansas Rocks and Minerals*, Tolsted and Swineford, Kansas Geological Survey, 2nd ed.

Activity Time Needed: 1 hour

Activity

In previous lessons we have learned about physical properties of minerals. Today we will experiment with some chemical properties of minerals. We will be using the following minerals for out tests: galena, calcite, sphalerite, halite and celestite.

Before beginning our experiments we will review the safety procedures. Goggles will be worn during all phases of testing. Hydrochloric acid is very

Leader's Notes:

Have members review the physical properties, such as hardness, cleavage, luster, and streak.

Make sure the members follow the safety procedures throughout the process.

strong and corrosive and can burn skin and clothing. Be very careful when handling the acid. Since we will be using a propane torch, long hair and loose clothing must be kept away from the flame.

Minerals are divided into groups based on their chemical composition. Halides are minerals that are composed of halogens, such as the elements chlorine, iodine, bromine, and fluorine. Halite, or salt, is composed of sodium chloride (NaCl) and is classified as a halide.

Have the members complete the chemical composition and mineral type section of the Activity Sheet 17, *Mineral Identification Reactions*, as this section is discussed.

Minerals that contain the element sulfur in combination with metal ores are called sulfides. Galena, the principle ore of lead, is composed of lead sulfide (PbS). Sphalerite is composed of zinc sulfide (ZnS) and is a primary ore of zinc. Chalcopyrite ($CuFeS_2$) and pyrite (FeS_2) also fall into the sulfide group.

Oxides are those minerals that combine oxygen with one or more metals. Hematite ($FexO_3$), ilmenite ($FeTiO_3$) and magnetite (iron oxide, Fe_3O_4) are minerals in this group.

Carbonates are those minerals that combine an element with both oxygen and carbon. Calcite or calcium carbonate ($CaCo_3$) is a very common mineral and belongs in this group. Other carbonates include siderite ($FeCO_3$), dolomite [$CaMg(CO_3)_2$], cerussite ($PbCO_3$) and malachite ($Cu_2CO_3[OH]_2$).

Sulfates are minerals that combine an element with both sulfur and oxygen. Celestite is strontium sulfate (SrSO4), which exhibits a distinctive crimson color when exposed to a flame. Gypsum is a common mineral composed of calcium sulfate and water molecules ($CaSO_4$+$2H_2O$). Barite (barium sulfate, $BaSO_4$) exhibits a distinctive green color in the flame test. Anhydrite ($CaSO_4$) and goslarite ($ZnSO_4$+$7H_2O$) are also included in the sulfate group of minerals.

If the mineral barite is available, it can be used in the flame test also.

Silicates are mineral compounds containing silicon and oxygen and include quartz (SiO_2), opal (SiO_2+H_2O), feldspar, mica and garnet.

The chemical properties of minerals can aid in their identification. Dilute hydrochloric acid applied to a carbonate mineral will result in fizzing or effervescence. The HCL breaks the chemical bonds of the material releasing carbon dioxide gas (CO_2). When HCL is applied to some sulfide bonds of the minerals it reacts to form hydrogen sulfide gas (H_2S).

These properties will be evident in the acid test.

Certain elements will exhibit characteristic colors when exposed to a flame. If a mineral contains the element, it may exhibit that color. Elements known to exhibit specific colors with HCL in the flame test are: barium – green, calcium – brick red, copper – sky blue, lithium – red, potassium – violet, sodium – yellow, and strontium – red.

These properties will be evident in the flame test.

Acid Test

1. Use the hammer to powder each of the five minerals.
2. Place a small amount of each mineral in separate wells of the evaporating dish.
3. Place a few drops of dilute hydrochloric acid in each well on the crushed minerals.
4. Observe the reactions.
5. Record results on the activity sheet.

IMPORTANT!!! Dispose of the used acid as follows: Dilute the acid carefully with a baking soda and water solution, being careful it doesn't fizz over. It may safely be poured down a drain followed with water.

Flame Test

1. Light the torch by turning on the propane very low and ignite the gas by using a safety match.
2. Dip the platinum loop in the pure acid and touch the loop to the flame to clean it.
3. Allow the clean loop to cool.
4. Dip the loop in the first mineral solution that was used in the acid test.
5. Place the loop in the flame.
6. Observe the color change of the flame (if any)
7. Clean the loop prior to testing each mineral solution.
8. Record the reactions on the activity sheet.

Caution members to not leave the loop in the flame too long or it will melt.

The color changes in the flame will be very brief, so advise the members to observe closely.

Dialogue for Critical Thinking:

Share:

1. Which mineral test was easiest to do? Why?
2. Which mineral test had the most vivid or distinct results?

Process:

3. What other geologic items can you identify with the acid test? (rocks, limestone and chalk)
4. What mineral produces the rotten egg odor?
5. What causes the carbonates to fizz when tested with HCL (hydrogen chloride)?

Generalize:

6. Why is it necessary to wear goggles when working with acid?
7. What safety precautions should you take when working with a torch?

Apply:

8. Who might use these tests in their business or career? Why? When?
9. What minerals or rocks might be identified by a "Taste Test?" (halite, salt, sandstone, shale)

Going Further:

1. Try the Acid and Flame tests on other minerals you have collected and chart the results.
2. Identify any other special properties of minerals that may aid in their identification and research methods to test for those special properties (for example: magnetism).

References:

Buchanan, R.C. *Kansas Geology*, Lawrence, University Press of Kansas, 1984.

Tolsted, L.L., Swineford, A. *Kansas Rocks and Minerals*, Lawrence, University Press of Kansas, 1986.

Pellant, Chris. *Rocks and Minerals*, New York, Dorling Kindersley Limited, London Text, 1992.

Wooley, Alan. *Illustrated Encyclopedia of Minerals*, New York, Gallery Books, 1990.

Author:

Megan McCoy, Kansas 4-H Geology Curriculum Team

Reviewed by: Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Flame It, Fizz It

Activity Sheet 17, Mineral Identification Reactions

Minerals — Geology Level III

Sample	Galena	Sphalerite	Halite	Calcite	Celestite
Chemical Formula					
Mineral Type					
Acid Test Reaction					
Flame Test Reaction					

1) In the acid test, what causes the rotten egg odor of the Galena and the Sphalerite?

2) What reaction takes place when the acid is placed on the Calcite?

3) What element in Halite categorizes it as a Halide?

4) Oxygen and carbon are found in minerals of the _________ group.

5) A mineral in the sulfide group contains which element?

6) Sulfur and oxygen are found in minerals of the _________ group.

7) What element in the Celestite causes the color change in the flame test? Why?

8) Draw lines to match the color reaction to the element in the flame test.

Barium	Yellow
Calcium	Crimson
Sodium	Brick Red
Strontium	Green

Flame It, Fizz It

Activity Sheet 18, Mineral Identification Reactions Leader's Key

Minerals — Geology Level III

Sample	Galena	Sphalerite	Halite	Calcite	Celestite
Chemical Formula	PbS	ZnS	NaCl	$CaCO_3$	$SrSO_4$
Mineral Type	Sulfide	Sulfide	Halide	Carbonate	Silicate
Acid Test Reaction	Rotten egg odor	Rotten egg odor	Dissolves	Fizzes	None
Flame Test Reaction	None	None	Yellow	Brick red	Crimson red

1) In the acid test, what causes the rotten egg odor of the Galena and the Sphalerite?

Hydrogen Sulfide gas is produced by the HCl reacting with the sulfur.

2) What reaction takes place when the acid is placed on the Calcite?

The HCl breaks the chemical bonds of the Calcium carbonate to form carbon dioxide gas.

3) What element in Halite categorizes it as a Halide?

Chlorine or Chloride

4) Oxygen and carbon are found in minerals of the **Carbonate** group.

5) A mineral in the sulfide group contains which element?

Sulfur

6) Sulfur and oxygen are found in minerals of the **Sulfate** group.

7) What element in the Celestite causes the color change in the flame test? Why?

Strontium – the atoms are supercharged and excited by the heat to produce the crimson color

8) Match the color reaction to the element in the flame test.

Barium	Yellow
Calcium	Crimson
Sodium	Brick Red
Strontium	Green

Kansas 4-H Geology Leader Notebook

Chapter 4 — Rocks, Table of Contents

Size It Up

Rocks — Geology, Level I

What members will learn …

About the Project

- Sedimentary rocks are made of small pieces (particles).
- Small particles are different sizes for different rocks.
- The importance of size in geology.

About Themselves

- How to learn using comparisons and relationships.

Materials

For each member:

- Activity Sheet 19, *Size Comparisons*
- Pencil

For group:

- 2 pieces of chalk
- Metamorphic rocks
- 1 or 2 tablespoons of each in separate containers and labeled with name and number:
  - flour #1
  - salt #2
  - dried beans #3
  - clay #4 (or a little chalk, rubbed fine)
  - sand #5
  - gravel #6
  - shale #7
  - sandstone #8
  - conglomerate #9
- Jar with a mixture of "dirt," clay, sand, small gravel, etc.
- Water to fill jar
- Magnifying glass
- Paper or newspaper
- Examples of sedimentary rock (shale, limestone, sandstone, conglomerate, chalk, etc. as available)
- Activity Sheet 20, *Size Comparisons, Leader's Key*

Activity Time Needed: 30 minutes

Leader's Notes

Provide two pieces of chalk an dsome paper to a volunteer. You could let each member take a turn.

Allow time for several responses.

Show jar with mixed particle sizes. Let a member add water until most particles can be in liquid. Make sure the lid is on tight and let members take turns shaking the jar. Solicit several responses or have them write on a piece of paper.

Show piles of flour, salt and beans.

Have members number the rocks by particles size and then compare them with soil and cooking items.

Hand out Activity Sheet 19, *Size Comparisons*.

Activity

Let's start an experiment, then we will do an activity and check on the experiment later. Who would like to help? First we will rub these two pieces of chalk together over over this paper. What happened? Chalk is like a rock that has formed from pressing these tiny dust-like particles together to become hard. Rubbing the pieces together causes small pieces to fall off.

Now, let's look at this jar of "dirt." Are there different sizes of pieces in the jar? What types of sizes do you see? Who would like to help me add some water to the jar of dirt? Now, shake the the watery mixture until it is well mixed. We will set this jar to the side while we do anothe ractivity. What do you think will happen to the muddy water?

To help us understand particle size, let's look at some cooking items you see around your house. What are these piles? (*flour, salt and beans*) Which has the smallest pieces? Which has the largest pieces? Which is in the middle size?

Next we will look at soil particles that come from rocks. Look at these three piles — what do they look like? Which pile has the smallest pieces? Next smallest? Largest pieces? Which soil particles are most like the cooking items found around the house?

Now, let's look at three different rocks. These rocks are called a conglomerate. The pieces that make up these rocks have been pressed together very hard. You will have to look closely to see the particles that each are made from. Does anyone want to use a magnifying glass to view the particles? Which rock has the smallest particles? Next smallest? Which rock has the largest particles?

To finish this particle size activity, let's review each set of particles and fill in the blanks on this Activity Sheet of size comparisons. First find the words for cooking items. Next, find the words for soil particles and then the rock names.

Let's go back and look at the jar with dirt and water. What has happened? What size particles are in the bottom of the jar? Why? Can you find small, medium and large size particles like in the other activity? Where are the smallest particles? Why will it take the smaller particles longer to settle to the bottom? These small particles that make the water look muddy will make a fine mud that will become shale if it is pressed hard for a long time. What would the sandy layers become? (*sandstone*) What type of rock would the bottom later of large particles become? (*conglomerate*)

Dialogue For Critical Thinking:

Share:

1. Which items were smallest? Largest?
2. When mixed with water, which size of items settles out first? Last? Why?

Process:

3. How are the three items in each size similar or different?

Generalize:

4. How important is it to use comparisons of things you know well to learn about new things?

Apply:

5. How can you use comparisons to learn about other new things in the future?

Going Further:

1. Let one child take the jar home, or set it in a safe place until next time to see all the layers that settle out.
2. Visit sites that show the different types of rocks discussed today. Use a magnifying glass where appropriate to examine the particle size.

References:

Author: Pat Gilliland, Kansas 4-H Geology Curriculum Team.

Reviewed by: Rex Buchanan, Geologist with the Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Size It Up

Activity Sheet 19, Size Comparisons

Rocks — Geology, Level I

Use these words to fill in the chart:

Flour **Shale** **Beans** **Sandstone** **Sand**

Gravel **Salt** **Clay** **Conglomerate**

SIZE			
	Small	**Medium**	**Large**
Cooking item			
Soil particle			
Rock			

Size It Up

Activity Sheet 20, Size Comparisons Leader's Key

Rocks — Geology, Level I

Use these words to fill in the chart:

Flour Shale Beans Sandstone Sand

Gravel Salt Clay Conglomerate

	SIZE		
	Small	**Medium**	**Large**
Cooking item	*Flour*	*Salt*	*Beans*
Soil particle	*Clay*	*Sand*	*Gravel*
Rock	*Shale*	*Sandstone*	*Conglomerate*

How Rocks Change

Rocks — Geology, Level I and II

What members will learn …

About the Project:

- Three types of rocks are sedimentary, igneous and metamorphic.
- Igneous rocks are formed from magma.
- Sedimentary rocks are formed from sediments.
- Metamorphic rocks have been changed by heat and pressure.
- The cycle of rocks is a continuous process.

About Themselves:

- Importance of cycles.
- How important various rocks are in everyday life.

Materials:

For each member:

- Activity Sheet 21, *Rock Cycle*
- Activity Sheet 23, *Rocks*
- Activity Sheet 24, *Rock Pile,* Level II
- Activity Sheet 25, *Rocks Are Different,* Level II

For groups:

- pencil
- colored pencils or crayons
- 6 slices of bread
- 4 or 5 books
- 6 slices of bread that have been weighted by books for one day
- Paper towels
- Scissors, optional
- Red candle
- Index card
- Matches
- Easel
- About ½ cup each of soil, sand, and gravel
- From the rocks members bring, choose examples of:
    - Obsidian or granite
    - Limestone
    - Sandstone
    - Shale
    - Quartzite
    - Marble

- Activity Sheet 22, *Rock Cycle, Leader's Key*

Activity Time Needed: 45 minutes

Leader's Notes

[Note: Before the meeting, ask members to bring a variety of rocks.]

Ask each member to describe the appearance and "feel" of the rock and where it was obtained.

Display Activity Sheet 22, *Rock Cycle Leader's Key*. Enlarge if needed.

Hand out Activity Sheet 21, *Rock Cycle*. Color the Rock Cycle to illustrate red for igneous, blue for sedimentary, and green for metamorphic.

Allow time for some answers.

Light a candle.

Drip some wax on an index card and extinguish candle.

If any of the members brought an igneous rock, pass it around and ask members to discuss its features further.

Make sure members understand weathering.

Allow the members to examine the soil, sand, and gravel samples.

If members brought sandstone, shale, or limestone rocks, pass them around.

Ask a member to neatly stack six slices of bread on a paper towel.

Ask the same member to carefully stack some books on the bread.

Make sure a paper towel is placed on top of the bread so that it is between the bread and books.

Display some samples of marble and quartzite.

Activity

What makes a rock a rock? Geologists define rocks as substances that are made up of one or more minerals. Most people think rocks are rigid. But a type of rock called itacolumite, found in India and North Carolina, is easy to bend with your hands. Are all rocks heavy? No. Pumice will float in water. How does your rock feel and where did you get it?

Rocks are the important building materials from which the earth is constructed. They are a mixture of various kinds and amounts of minerals. There are three types of rocks: igneous, sedimentary and metamorphic.

The many rocks that make up the earth's crust are the result of geological processes acting through the ages, building up some rocks and breaking down others. The Rock Cycle illustrated here can help understand the formation of the types of rocks.

Over 4.5 billion years ago there was nothing on earth but a molten liquid mass known as magma. What do you think magma looked like?

What will happen to the wax of this candle as it is heated by the flame?

If some wax is dropped on an index card what begins to happen to the dripped wax?

As the magma, or molten liquid, cooled or crystallized it became igneous rock and formed the earth's crust. Igneous rocks are known as the ancestors of all other rocks.

After the earth's crust was formed the igneous rocks were then weathered or subjected to heat and pressure or some were even melted again, resulting in the formation of a different kind of rock.

What is meant by weathering? Weathering has occurred when igneous rocks are worn down by wind, water and ice-forming sediments. Will all the pieces of sediment be the same size?

The sediments may undergo further weathering or layer after layer of sediment will build up. When many layers have been piled up for thousands of years, the bottom layer becomes hard and forms layers of rock — sedimentary rock. You have seen sedimentary rocks exposed in road cuts, creek or river beds, river banks and excavations for building. Those areas were once under water, and layers of rock formed by the pressure on the sediment and debris.

Sedimentary rocks may undergo weathering and again form sediments or they may be subjected to heat and pressure. What do you think happens to a rock when it is subjected to pressure?

How do you think pressure might change these slices of bread?

What do you think this bread will look like after one day under the books?

Rocks are changed by heat and pressure and form what we call metamorphic rocks. Metamorphic means something that has been changed.

Some examples of metamorphic rocks include marble, formed from limestone, and quartzite, formed from sandstone.

The formation of metamorphic rocks brings us to the final stage of the rock cycle, but the metamorphic rocks may be subjected to weathering resulting in forming of sediments, or to extreme heat resulting in the formation of magma. In either case the rock cycle continues — matter from the earth's crust is changed from one form to another but never is lost.

Together let's complete the activity sheet on rocks.

Is the bread thinner and harder than before? Why? The pressure from the books above the bread changed the bread and pressure on the surface of the Earth changes the rocks below.

Now, I want you to complete your own rock cycle.

With a red pencil, shade in the igneous rocks box. Draw red arrows from igneous rocks to weathering, melting, and heat and pressure. Shade the metamorphic rocks with a green pencil. Draw green arrows to weathering, heat and pressure, and melting. With a blue pencil shade the sedimentary rocks box. Draw blue arrows from that box to heat and pressure, weathering, and melting. Refer to the "Rock Cycle" on the easel if you need to do so. After completing the rock cycle, fill in the boxes to show what sediment and rocks change in to.

Distribute pencils and Activity Sheet 23, *Rocks*. Read instructions and questions, and allow time to write answers and draw pictures.

Answers:

1. pile
2. squeezed
3. rocks
4. hot
5. magma
6. rocks

When ready to draw what the bread looks like after one day under books, display the slices of bread you prepared 24 hours before the meeting.

Distribute colored pencils or crayons with Activity Sheet 21, *Rock Cycle*. When *Rock Cycle* sheet is complete, discuss changes. Refer to *Leader Key Illustration*.

Rock Changes Table Answers:

Material	Sedimentary	Metamorphic
Clay	Shale	Slate
Sand	Sandstone	Quartzite
Calcium	Limestone	Marble

Level II:

Hand out Activity Sheet 25, *Rocks are Different*. Have members color pictures and sort or label by rock types (sedimentary, igneous, metamorphic). Discuss decisions.

Level II:

Hand out Activity Sheet 24, *Rock Pile*.

Have members draw and color what they would build from a pile of rocks. When completed, discuss drawings and types of rocks used.

Dialogue For Critical Thinking:

Share:

1 What kind of rocks were brought to the meeting? Which group was the largest? Why?

2. What did you do to demonstrate the affect of weathering, pressure, and heat on various kinds of rocks?

Process:

3. What kind of rock is formed from tiny pieces in layers?
4. What kind of rocks are formed by heat and pressure?
5. What kind of rock does magma become when it cools?
6. Where does the rock cycle end? (A. Cycles never end.)

Generalize:

7. Of what other cycles are you aware?
8. How do cycles affect living things?

Apply:

9. What types of rocks are used to build buildings?
10. What common rock may be burned to heat homes or produce electrical power? (coal)

Going Further:

1. Go for a walk and look for signs of erosion caused by water on hillsides and slopes, where trees and grass have been removed, and on stream banks. Also look for loose rock and soil at the base of slopes.
2. Divide members into groups of five or six. Ask each group to group the rocks they brought to the meeting by rock types. Discuss their results.
3. Pick a rock and write a story or create a display about the cycles it went through. Did it cycle more than once? Were some parts stressful? Where did you find the rock?

References:

Cole, Joanna. *The Magic School Bus Inside the Earth.* Scholastic, Inc: New York. 1987.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team.

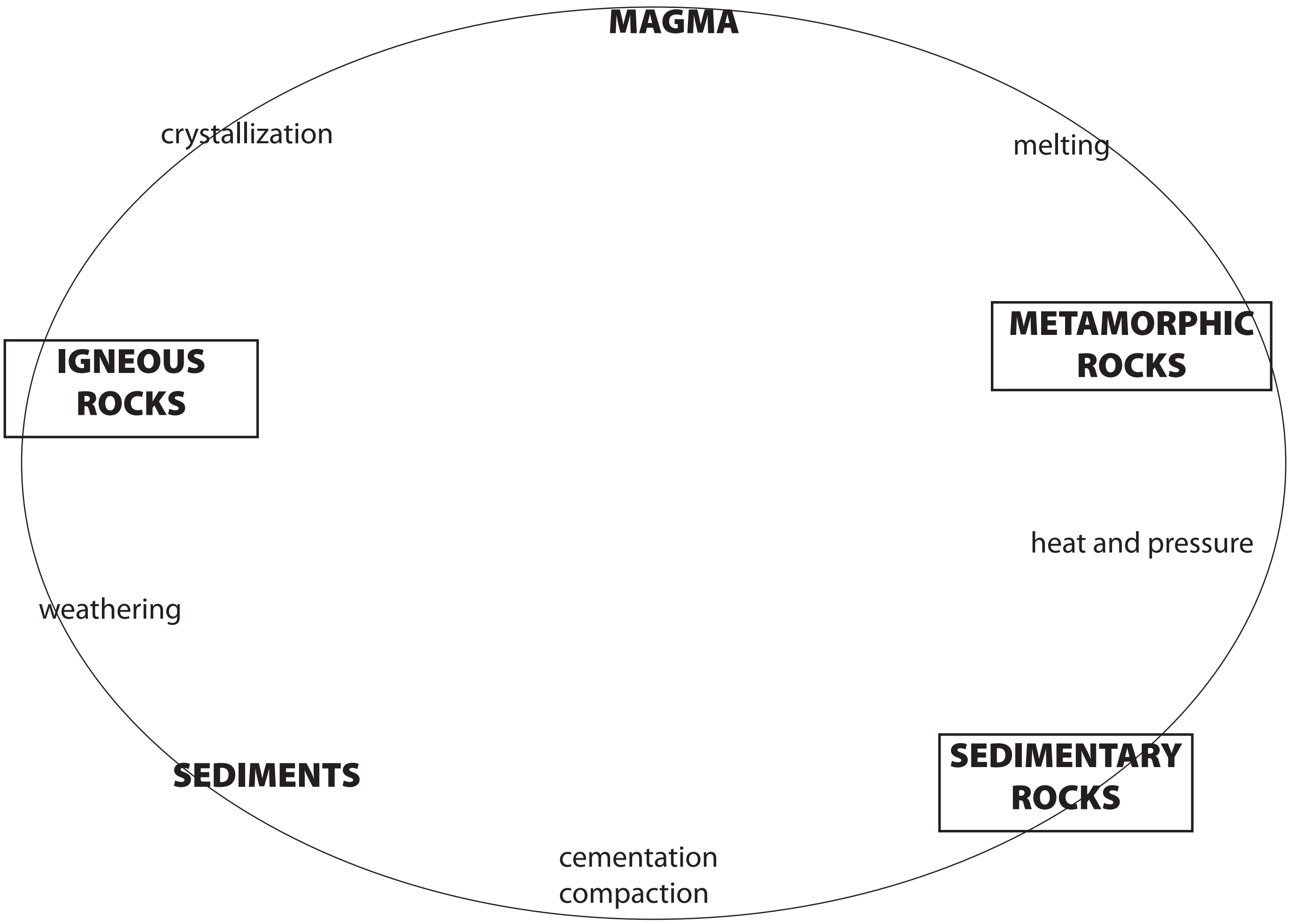
Reviewed by: Rex Buchanan, Geologist with the Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

How Rocks Change

Activity Sheet 21
Rock Cycle

Rocks — Geology, Level I



Rocks are moving and changing, but very slowly. With colored pencils, shade each type of rock and draw in arrows to show what makes one type of rock change into another.
Key: Igneous — red; Sedimentary — blue; Metamorphic — green.

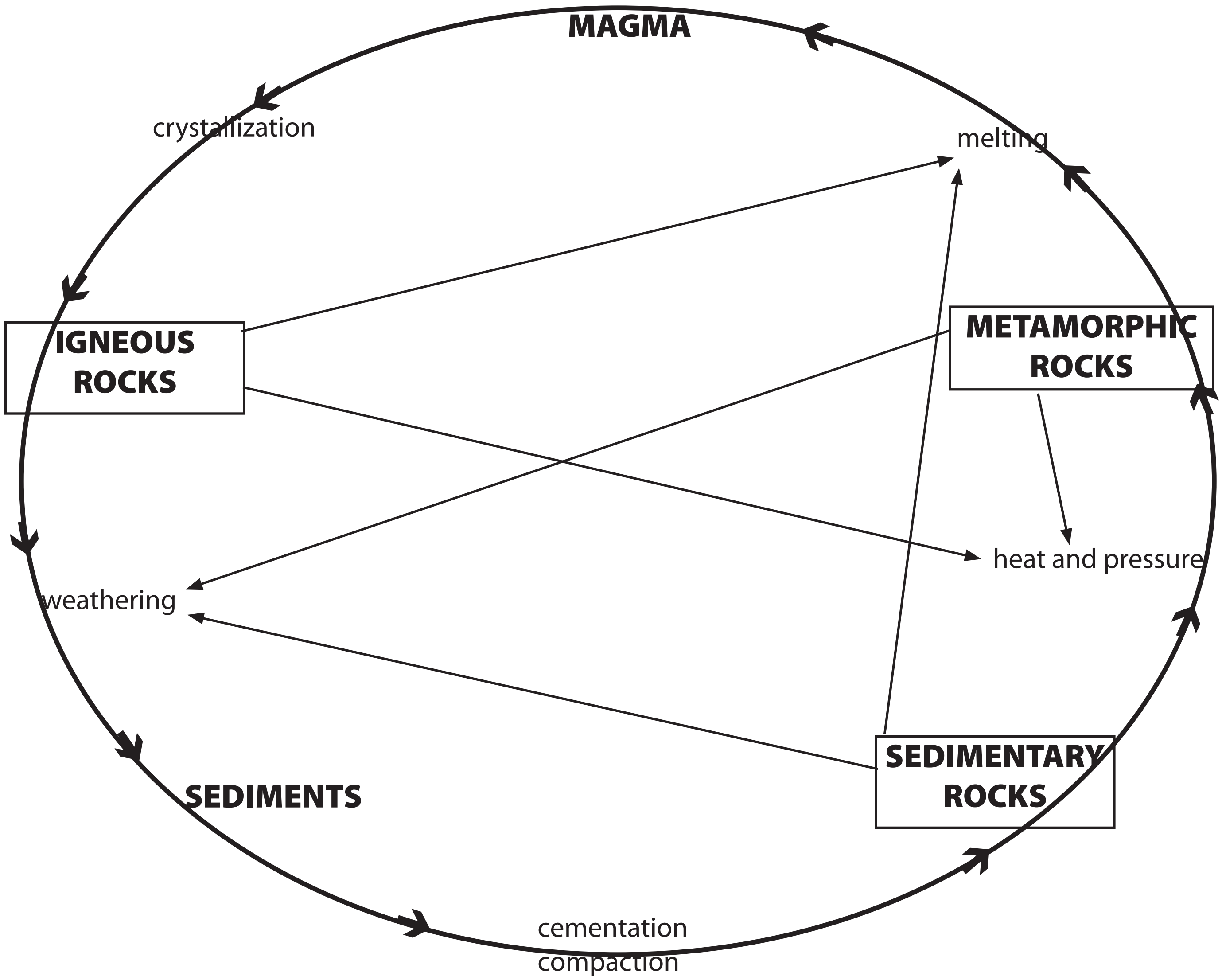
Rock Changes Fill in the boxes to show changes that can occur.

Material	Sedimentary	Metamorphic
Clay		
	Sandstone	
Calcium		

How Rocks Change

Activity Sheet 22, Rock Cycle Leader's Key

Rocks — Geology, Level I



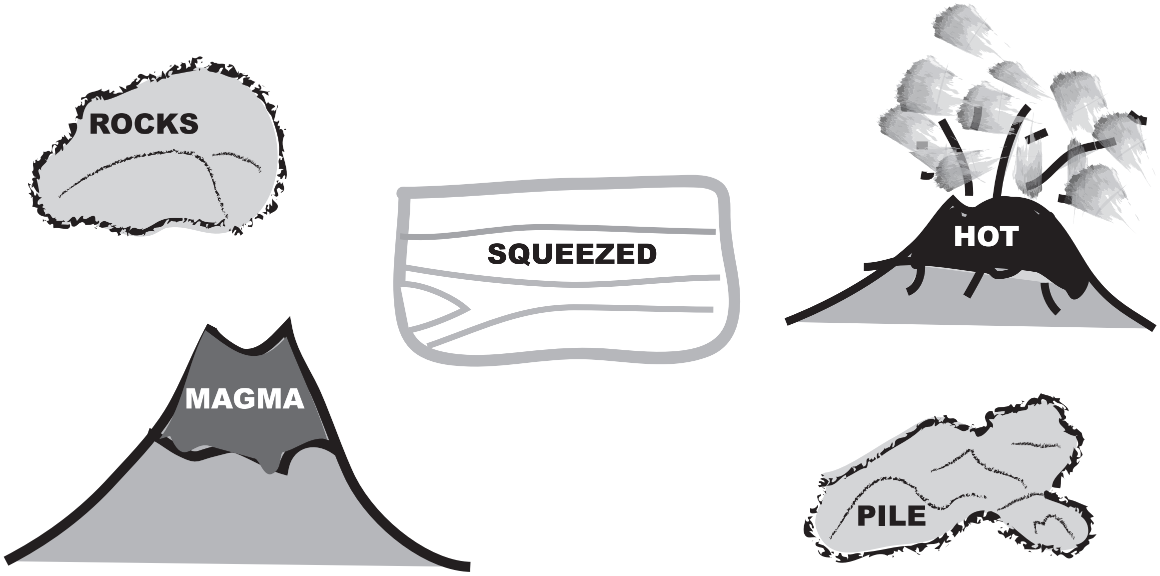
Rocks are moving and changing, but very slowly. With colored pencils, shade each type of rock and draw in arrows to show what makes one type of rock change into another.

Key: Igneous — red; Sedimentary — blue; Metamorphic — green.

How Rocks Change

Activity Sheet 23, Rocks

Rocks — Geology, Level I



Use the above words to fill in the blanks.

Sedimentary rocks are formed when mud, sand and bits of rock pile up in layers under water.

1. As the mud, sand and rock bits ______________________ up, layers are formed.

2. The layers at the bottom get ______________________ together.

3. The bottom layers get squeezed into new ______________________.

Igneous rocks are formed from melted rock deep in the earth.

4. Melted rock inside the Earth is very ______________________.

5. It is called ______________________.

6. When magma cools, it hardens into new ______________________.

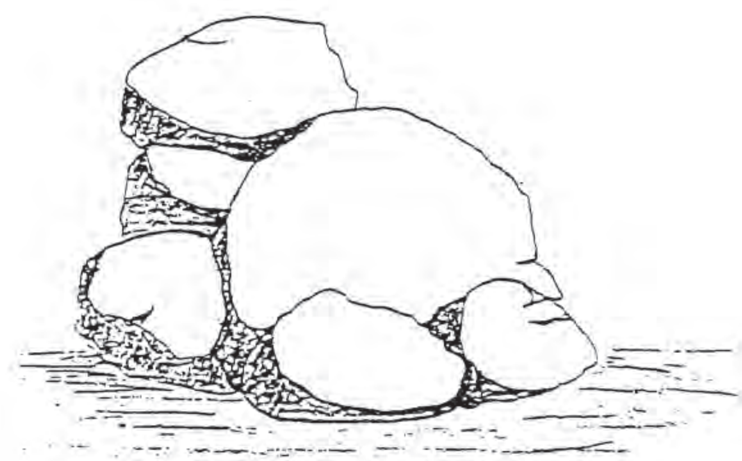
Sometimes igneous and sedimentary rocks are deep inside the Earth. The heat and pressure there can change the rocks into new rocks. The new rocks are metamorphic rocks. Pile books on six slices of bread in a stack and watch how pressure can change things.

Draw what you think the bread will look like after one day under the books.	Draw the bread as it really looks after one day under the books.

How Rocks Change

Activity Sheet 24, Rock Pile

Rocks — Geology, Level II



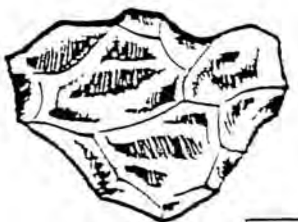
Rocks can be used in construction. Draw what you would build from a pile of rocks. What type of rocks (igneous, sedimentary, metamorphic) are in your rock pile?

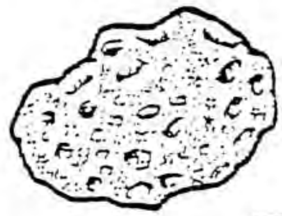
How Rocks Change

Activity Sheet 25, Rocks Are Different

Rocks — Geology, Level II

Color the pictures, then cut out the pictures and sort them into rock types.


Obsidian

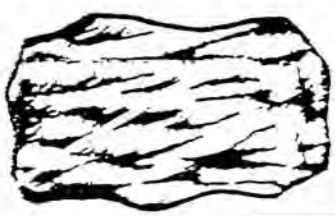

Pumice

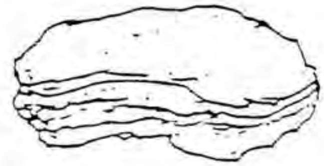

Granite

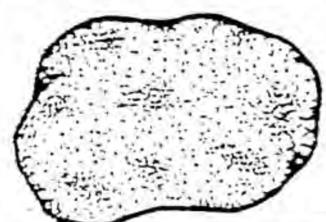

Limestone

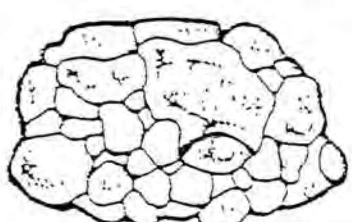

Shale

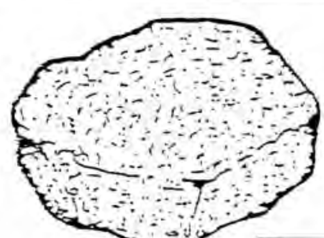

Gneiss


Basalt


Slate


Sandstone


Conglomerate


Quartzite


Marble

Limestone Adventure

Rocks, Sedimentary — Geology, Level II

What members will learn...

About the project:

- Limestone is a sedimentary rock that is made up chiefly of the mineral calcite.
- Limestone may be formed by either organic or inorganic processes.

About themselves:

- Observation skills.
- How to describe things to others.
- Relating to others.

Materials:

For each member:

- A sample of limestone with a freshly broken surface
- Activity Sheet 26, *Formation of Sedimentary Rocks*
- Member Handout 16, *Word Search Definitions*
- Activity Sheet 27, *Word Search*
- Activity Sheet 28, *Word Search, Leader's Key*
- Activity Sheet 29, *Sidewalk*, optional
- Pencil

For group:

- Magnifying glasses
- Newsprint pad
- Wide felt-tip marker
- Specimens to serve as examples of terms used in Word Search

Activity Time Needed: 45 minutes

Activity

How do you think the formation of limestone differs form that of other sedimentary rocks?

Limestone has been deposited in either inorganic or organic chemical processes. Organic means derived from living organisms. Did you see any shells in your limestone rock?

Did you see a mineral without the aid of a magnifying glass in any of the limestone samples?

What do you think that mineral might be?

Leader's Notes

From a collection of limestone rocks ask each member to select one specimen. Ask each to tell about the rock selected, describing it in terms of color or colors; the size, shape and pattern of the mineral grains (texture); and structure — is it layered or banded. Provide magnifying glasses so members can closely examine rocks.

After members have shared their descriptions, use questions to develop a discussion and an understanding of limestone. Allow time for complete expression of ideas.

Write "calcite" on newsprint. Explain that this is also calcium carbonate ($CaCO_3$).

Limestone is a sedimentary rock that is made mostly of the mineral calcite (calcium carbonate, $CaCO_3$). Organic formed limestones are created by the action of plants and animals that extract calcium carbonate from the water in which they live. Most limestone is formed from the shells and other calcareous parts of animals and plants. These organisms extract calcium carbonate for the building of their hard parts from the waters in which they live. When the animal or plant dies, the hard parts sink to the bottom and slowly accumulate, sometimes to great thicknesses. Over a great period of time, the spaces between the shells are filled by fine fragments of the shells. By compaction caused by the continuous depositing of sediments, the sediment containing abundant shells and pieces of shells is converted to massive limestone. Compaction and re-crystalization often result in the complete destruction of the form of the shell leaving only crystalline calcite. For that reason some deposits of limestone do not contain fossils. Which of the limestones looked at today do you think might have been formed by an organic process?

Allow members to examine again the limestone samples and express their opinions.

Inorganically formed limestone is formed from a solution rich in calcium carbonate. If enough of the water evaporates, or if the temperature rises, or if the pressure falls calcite or impure calcite can be precipitated from the solution, thus forming limestone. Do you think the sediments forming limestone would accumulate in fast-moving water or very still water?

Answer: Very still water.

Now we are going to do some activity sheets about sedimentary rocks.

Distribute Activity Sheet 26, *Formation of Sedimentary Rocks*. As a group complete the sheet. Discuss why the various sediments are deposited at the locations indicated.

You may wish to show members samples of sandstone, shale, and conglomerate.

Answers to *Formation of Sedimentary Rocks* activity sheet:

A. Dissolved chemicals and organic sediments	A. Limestone
B. Gravel	B. Conglomerate
C. Sand	C. Sandstone
D. Mud or clay	D. Shale
	1. Shale
	2. Sandstone
	3. Conglomerate
	4. Limestone

Distribute Activity Sheet 27, *Word Search*.

Discuss the terms in the Word Search activity. Distribute Member Handout 16, *Word Search Definitions*, as a reference. This discussion might be conducted effectively by displaying specimens and asking members to find an example specimen for each term.

What are some uses of limestone?

Write uses given on newsprint pad to learn how many can be cited.

Limestone is the basic rock used in the process of making cement. In the "wet cement" of the *Sidewalk* activity sheet draw or write a message of one thing you learned today about limestone.

Dialogue for Critical Thinking:

Share:

1. Where have you seen limestone rocks?
2. Why do you think fossils are visible in some limestones and not in others?

Process:

3. How does limestone formation differ from sandstone formation?
4. Limestone is made up largely of what mineral?

Generalize:

5. What can you learn by closely examining a rock?
6. What did you learn about yourself through this activity?

Apply:

7. What does the presence of limestone in a local road cut tell us about the environment in that location at the time the limestone was formed?
8. In the future when you see a road cut what will you most likely look for?
9. What do you need to do to improve your ability to describe things to others?

Going Further:

1. Study the various kinds of limestone such as crystalline limestone, micro-crystalline limestone, oolitic limestone, coquina, fossiliferous limestone, chalk, and travertine.
2. As a group study the process of making cement.
3. Visit an outcrop that exposes some limestone formations.
4. Visit and examine a building or buildings constructed with limestone. How do the limestone properties work as a building stone? Where was the limestone mined?

Time may not permit the use of Activity Sheet 29, *Sidewalk*.

References:

Member Level:

Simon, Seymour, *The Rock Hound's Book*, Xeroy Education Publications: Middletown, Connecticut, 1973.

Tolsted, Laura Lu and Ada Swineford (Revised by Rex Buchanan), *Kansas Rocks and Minerals*, Educational Series 2, Kansas Geological Survey: Lawrence, Kansas.

Leader Level:

Fenton, Carroll Lane and Mildred Adams Fenton, *The Rock Book*, Doubleday and Company, Inc.: Garden City, New York, 1949.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum team

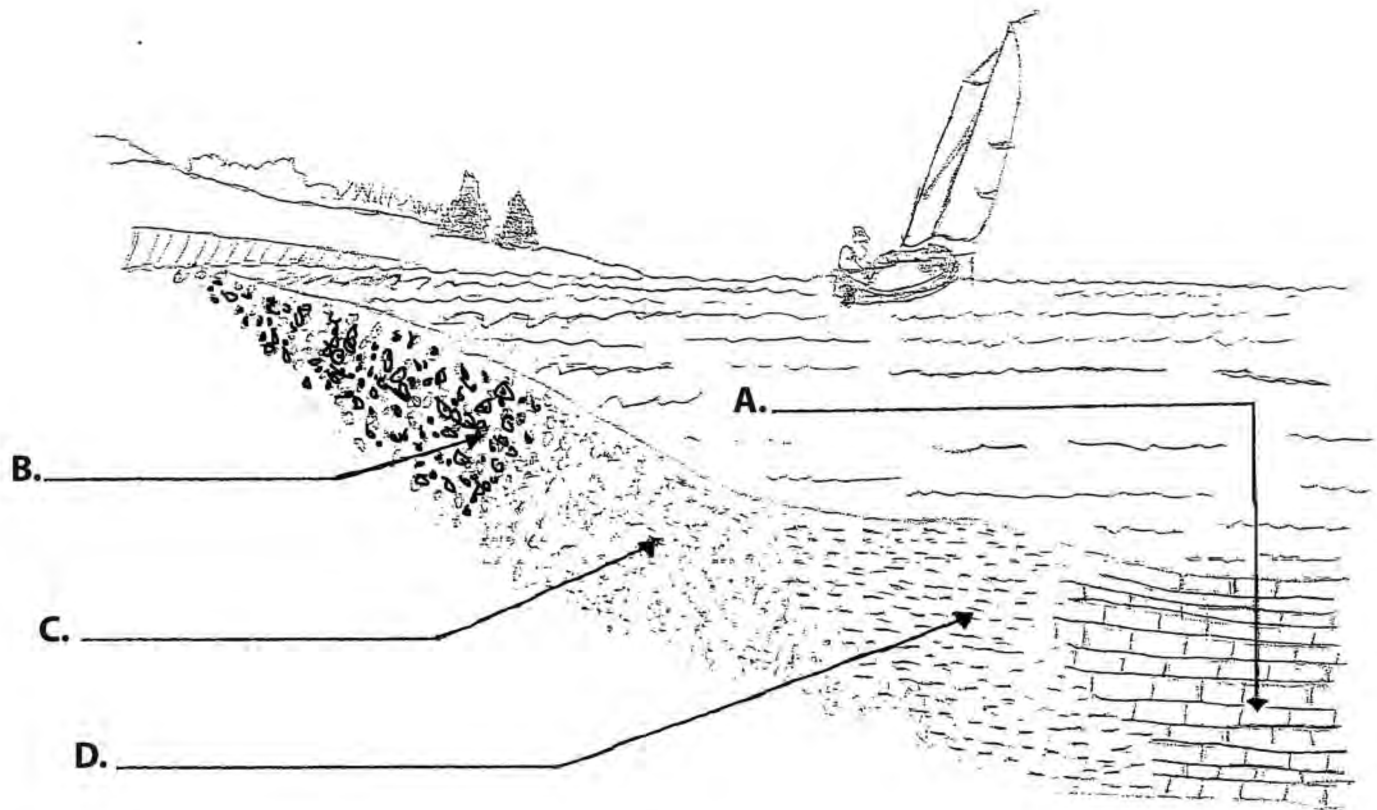
Reviewed by: Dr. James Underwood, retired Geology Professor, Kansas State University

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Limestone Adventure

Activity Sheet 26, Formation of Sedimentary Rocks

Rocks — Geology, Level II



Locate and label on lines A through D in the illustration the following sediments deposited by rivers: **mud or clay, sand, gravel, dissolved chemicals and organic sediments**.

At the A through D locations, which of the following rocks are most likely to be found: **sandstone, limestone, conglomerate, shale**.

A. ______________________ B. ______________________

C. ______________________ D. ______________________

Write the name of the rock in Column E on the line before its description in Column D.

	Column D	Column E
1. ______________	formed by mud or clay under pressure	sandstone
2. ______________	has a gritty feeling	limestone
3. ______________	a mixture of different-sized sediments	shale
4. ______________	composed of the mineral calcite	conglomerate

Limestone Adventure

Member Handout 16, Word Search Definitions

Rocks — Geology, Level II

SEDIMENTARY ROCK: One of three major types of rock. It is formed by the deposition of sediments in water or by wind. Deposited in layers or beds.

ROCK: Any naturally occurring solid mass of one or more minerals.

SHALE: A sedimentary rock made up mostly of clay minerals. Commonly breaks in sheets or along parallel planes. Most abundant sedimentary rock.

LIMESTONE: A sedimentary rock composed largely of calcium carbonate.

CALCITE: Calcium carbonate mineral, which is the principal component of limestone.

SANDSTONE: Rock that is formed by grains of sand that have been cemented together. Sandstone was generally formed near the shores of ancient seas.

QUARTZ: A hard mineral composed of silica and oxygen (SiO_2). It is the most common rock-forming mineral.

CONGLOMERATE: Rock composed of smooth, rounded pebbles, gravel, or boulders that have been cemented together.

CHALK: A variety of limestone made of microscopic calcareous fossils. It is a soft, porous rock that crumbles easily.

CALCAREOUS: Containing calcium carbonate.

COQUINA: Limestone composed of broken shells, corals, and other organic debris.

INORGANIC: In general, refers to material not derived from living organisms.

COAL: A combustible sedimentary rock of altered vegetable tissue, a large percentage of which has been changed to carbon.

CLAY: Is an earthy aggregate. When used to describe the size of a particle it refers to material less than 1/256 mm in diameter.

ORGANIC: In general, refers to any material derived from living organisms.

SEDIMENT: Material that settles out of or to the bottom of water.

Limestone Adventure

Activity Sheet 27, Word Search

Rocks — Geology, Level II

Find the words from Activity Sheet _____, Word Search Definitions in the puzzle below.

S	C	O	Q	U	I	N	A	S	U	T	R	R	S	I
E	L	F	V	I	N	O	R	G	A	N	I	C	M	Q
D	S	E	D	I	M	E	N	T	A	R	Y	E	P	U
I	N	H	T	Q	Y	V	O	U	K	W	B	H	L	K
M	L	X	A	A	V	E	N	O	T	S	D	N	A	S
E	Y	V	U	L	R	M	F	D	P	R	N	D	Z	Q
N	P	V	E	O	E	E	S	K	L	A	H	C	N	U
T	Z	Z	C	L	A	Y	M	J	T	E	P	I	E	A
A	K	K	B	G	M	L	A	O	C	S	O	N	T	R
R	E	N	O	T	S	E	M	I	L	G	I	A	I	T
Y	M	F	V	F	D	M	L	X	Y	G	J	G	C	Z
R	K	E	S	D	P	Z	J	A	I	P	N	R	L	N
O	C	B	B	R	N	U	V	N	O	W	I	O	A	O
C	P	I	Z	S	U	O	E	R	A	C	L	A	C	B
K	A	L	I	E	Z	U	N	Z	W	U	T	H	R	R

Limestone Adventure

Activity Sheet 28, Word Search, Leader's Key

Rocks — Geology, Level II

Find the words from Activity Sheet _____, Word Search Definitions in the puzzle below.

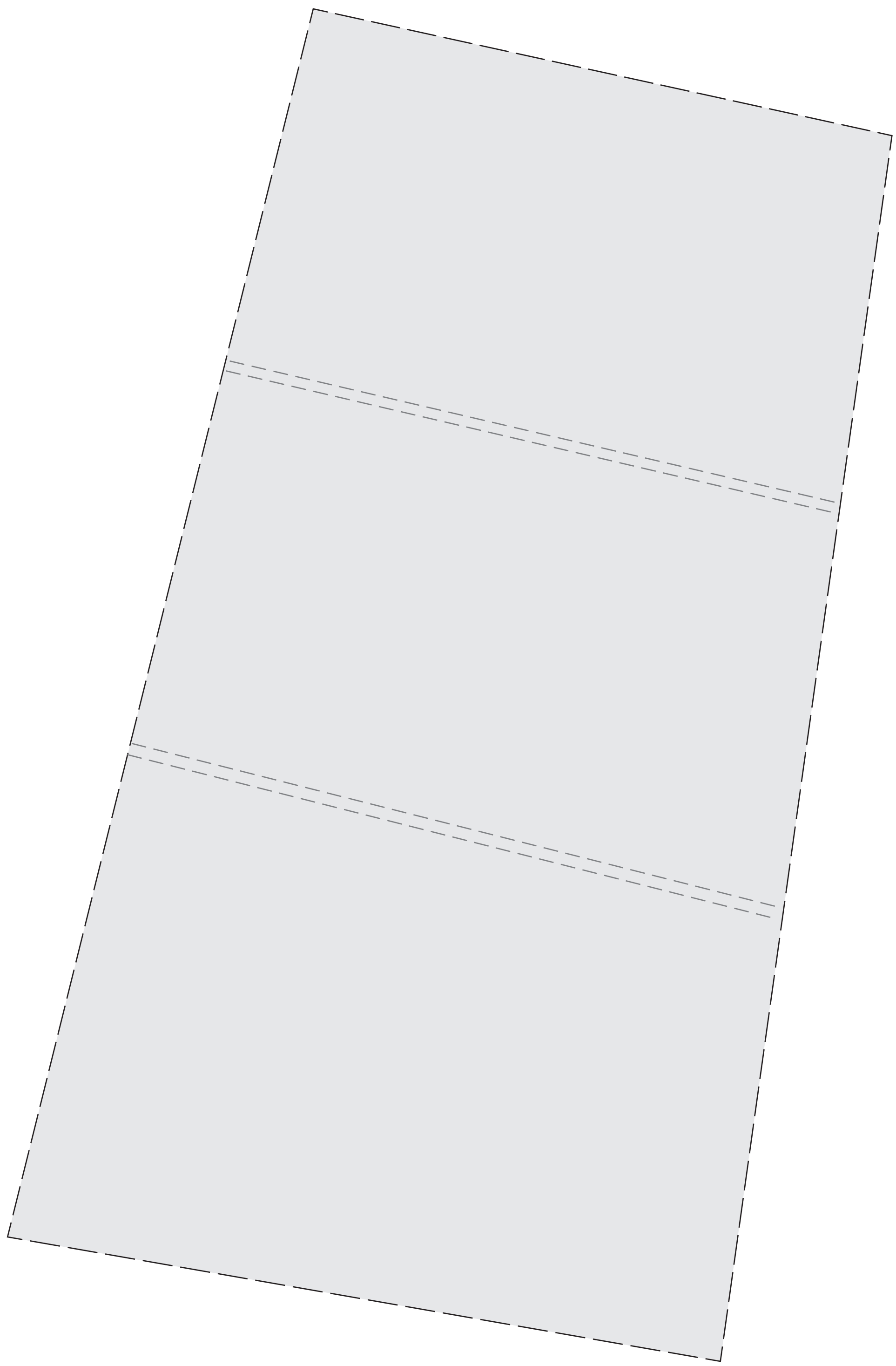
S	C	O	Q	U	I	N	A	S	U	T	R	R	S	I
E	L	F	V	I	N	O	R	G	A	N	I	C	M	Q
D	S	E	D	I	M	E	N	T	A	R	Y	E	P	U
I	N	H	T	Q	Y	V	O	U	K	W	B	H	L	K
M	L	X	A	A	V	E	N	O	T	S	D	N	A	S
E	Y	V	U	L	R	M	F	D	P	R	N	D	Z	Q
N	P	V	E	O	E	E	S	K	L	A	H	C	N	U
T	Z	Z	C	L	A	Y	M	J	T	E	P	I	E	A
A	K	K	B	G	M	L	A	O	C	S	O	N	T	R
R	E	N	O	T	S	E	M	I	L	G	I	A	I	T
Y	M	F	V	F	D	M	L	X	Y	G	J	G	C	Z
R	K	E	S	D	P	Z	J	A	I	P	N	R	L	N
O	C	B	B	R	N	U	V	N	O	W	I	O	A	O
C	P	I	Z	S	U	O	E	R	A	C	L	A	C	B
K	A	L	I	E	Z	U	N	Z	W	U	T	H	R	R

Limestone Adventure

Activity Sheet 29, Sidewalk

Rocks — Geology, Level II

Draw or write a message of something you learned about limestone in the wet cement of this sidewalk.



Clastic or Nonclastic Rocks

Rocks, Sedimentary — Geology, Level III

What members will learn …

About the Project:

- Sedimentary rocks can be classified as clastic (inorganic) and nonclastic (organic).

About Themselves:

- How to observe and analyze.
- The benefits of experimentation.

Materials:

For each member:

- Member Handout 17, *The Layered Jar*
- Member Handout 18, *A Sour Trick*

For group:

Sedimentary rock samples:

- shale
- siltstone
- sandstone
- conglomerate
- breccia
- coal
- chert
- rock salt
- gypsum
- chalk
- coquina
- limestone

Supplies for the layered jar demonstration sack:

- quart jar with a lid
- water
- pebbles or small gravel
- sand
- soil
- paper towels

Supplies for a sour trick experiment sack:

- lemon juice
- vinegar, 5% or stronger acidity
- 2 medicine droppers
- paper towels
- limestone, 2 specimens
- calcite, 2 specimens
- chalk, 2 specimens
- quartz, 2 specimens

- Newsprint pad
- Wide felt-tip marker
- Easel

Activity Time Needed: 45 minutes

Advance Preparation:

Ask each member to bring a sedimentary rock to the meeting.

Assemble supplies and place in a paper sack for each demonstration.

Review the information on sedimentary rocks found in *Rock Identification Member Reference* located at the end of this section.

Leader's Notes

Before the meeting begins, ask a couple of members to do one of the demonstrations described in the handouts. In a paper sack, have the supplies and instructions needed for each demonstration. Allow each member time to review the instructions and ask you questions he/she may have.

Be sure members understand weathering and erosion. Weathering is the breaking of solid rock into small pieces. Erosion includes all the processes that cause rock to be carried away.

Write "clastic" on newsprint pad.

Display a poster or write on newsprint the following information and discuss. List and discuss each particle size before listing another

Grain size	Rock formed	Diameter
Clay	Shale or Mudstone	Less than 1/265mm
Silt	Siltstone	1/265 to 1/16mm
Sand	Sandstone	1/16 to 2 mm
Pebbles	Conglomerate/ Breccia	2 to 64mm*

*A millimeter is about 1/25 of an inch (one inch equals 25.4mm) or about the diameter of the lead in a pencil.

When discussing grain size, allow members to examine rock formed from that particular size of particle.

Allow time for *Layered Jar* demonstration and group discussion.

Select one and discuss its features and how it probably was formed.

Allow time for demonstration, *A Sour Trick* and discussion.

Write "nonclastic" on newsprint pad.

Write "precipitates" on newsprint pad.

Display a sample of limestone.

Write "evaporates" on newsprint pad.

Activity

Sedimentary rocks may be classified as clastic or nonclastic. Clastic rocks contain fragments of minerals and rocks. Nonclastic rocks are deposited from solution or by organic processes. After magma cooled and igneous rocks were formed, they began to be worn down by abrasive action of wind, water, and ice. This action is called weathering. The weathered material is carried by water, wind, glaciers or gravity to a place where it is deposited as sediments. Nearly all sedimentary rocks are made of materials that have been moved from a place of origin to a new place of deposition. Layer after layer of sediments build up and compaction and cementation occur, forming CLASTIC sedimentary rocks. Clastic sedimentary rocks are made up of sediments that can be described as grains or particles. The grains range from very fine to coarse depending on the time and amount of weathering.

What is the smallest particle listed here?

What is the rock formed by the clay sediments?

What is the largest particle listed?

A sedimentary deposit of pebbles can form a conglomerate or breccia. How do these two rocks differ from each other? Conglomerate is made up of rounded pebbles. Breccia consists of sharp, angular fragments.

(Member Name) is going to show us what happens when sediment settles by presenting "The Layered Jar" demonstration.

When a fast-flowing river carrying gravel, sand and a soil of clay particles begins to slow down, what will settle out first?

When a river slows down, the heavy particles settle out first, the fine silt and clay settle out last. This is why a fertile delta commonly forms at the mouth of a river.

Doubling the speed of the water in a stream increases the amount of small rock pieces and dissolved minerals it can carry by four times. When a stream flows into a larger body of water such as a river, lake or ocean it slows down. When it slows down the stream can carry less material; therefore, part of it settles out of the water.

Clastic sedimentary rocks are named according to the size and shape of their particles. Who brought a clastic sedimentary rock to the meeting today?

Do acids dissolve rocks?

(Member name) is going to show us whether acids do or do not dissolve some rocks.

As you have learned, an acid, even a weak acid, can dissolve some rocks, so let us now discuss the second classification of sedimentary rocks, nonclastic. Nonclastic sedimentary rocks are chemically formed and may have an inorganic or organic origin. These rocks may be precipitates or evaporates.

Precipitates occur when chemical reactions form a solid that settles out of the solution. Many beds of limestone are precipitates. The shallow warm sea, hot springs and saline lakes have limestones forming this way on earth today.

Nonclastic rocks also can be formed by evaporation. Evaporites form when water evaporates, leaving its dissolved solids behind. The Black Sea and the Great Salt Lake are examples of this today. Common evaporites include rock salt, gypsum and chert.

These chemically formed nonclastic sedimentary rocks have crystals that are interlocking and need no further hardening to be called rocks.

Organic sedimentary deposits result from living processes. The shells of many animals are composed of calcite or carbonate. When the animals die their shells are left on the ocean floor, lake bottom or riverbed where they may accumulate into thick deposits and in time harden to form limestone.

Plant debris such as trees, twigs and ferns may be buried in a swamp (a warm, humid environment). Compaction causes certain chemical changes to take place as well as squeezing out some of the water. Eventually this organic material becomes peat and peat is changed to coal, a nonclastic organic sedimentary rock.

Display rock salt, rock gypsum, and chert.

Display a sample of limestone in which shells may be seen.

Display a sample of coal.

Ask members to describe the sedimentary rock they brought. If a member does not know, have the group help to determine if the rock is clastic or nonclastic, the name of the rock, and the environment in which the rock was formed.

Dialogue for Critical Thinking:

Share:

1. Did our group have more clastic or nonclastic sedimentary rocks? Why?
2. What kind of sedimentary rock do you like best?

Process:

3. When a fast moving river enters the ocean will the water slow up or gain speed? What will happen to the particles the river is carrying?
4. Would chalk and coquina be considered clastic or nonclastic sedimentary rocks?

Generalize:

5. After completing this discussion what new understandings about sedimentary rocks do you have?
6. What did the demonstrations/experiments help you better understand about rocks?
7. What other situations have experiments helped you better understand?

Apply:

8. Why are fossils often found in sedimentary rocks but seldom in other types of rock?
9. When the river overflows its banks what happens to the surrounding land?
10. Besides rocks, what else can experience weathering?

Going Further:

1. Visit a cut that reveals several layers of sedimentary rocks. Have the members identify each layer, and the conditions present when each layer was formed.
2. Visit river shoreline and have members dig down to note grain sizes found in layers through which they dig.

References:

Buchanan, Rex, *Kansas Geology, An Introduction to Landscapes, Rocks, Minerals, and Fossils*, University Press of Kansas: Lawrence, 1984.

Brown, Lawrence, *A Description of Some Oregon Rocks and Minerals*, Dept. of Geology and Minerals Industries: Portland, Oregon, 1976.

Leet, Don L. and Sheldon Judson, *Physical Geology*, Prentice-Hall, Inc.: Englewood Cliffs, New Jersey, 1971.

Thompson, Graham and Jonathan Turk, *Modern Physical Geology*, Saunders College Publishing: Chicago, 1991.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team

Reviewed by: Dr. James Underwood, retired Geology Professor, Kansas State University

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Clastic or Nonclastic Rocks

Member Handout 17, The Layered Jar

Rocks, Sedimentary — Geology, Level III

Materials:

- Quart jar with lid
- Water
- Soil
- Sand
- Pebbles or small gravel
- Paper towels for clean-up

Procedure: (describe what you are doing as you work)

Put a layer of each of the soil, sand and pebbles in the jar. These are sediments of differing sizes. Fill the jar with water and cover it with the lid. Shake the jar until everything in the water is jostled about. Ask if anyone else would like to shake the jar. If so, allow them to do so. Place the jar on the table and ask members to watch what happens. Ask the following questions:

- How does the water look after we (I) shook the jar?
- Which material seems to settle to the bottom first? Why?
- Which material will settle to the bottom last? Why?

Answers:

When the jar is first shaken, the water appear cloudy. As the particles settle, the water becomes clearer. First, the heaviest material — the gravel — settles to the bottom. Then the sand settles out. Finally, the lightest material — the soil (composed of silt and clay) — settles on top. It is believed that soil consists of 80 percent or more of silt and less than 12 percent clay.

Clastic or Nonclastic Rocks

Member Handout 18, A Sour Trick

Rocks, Sedimentary — Geology, Level III

Materials:

- Lemon juice
- Vinegar — 5 percent or stronger acidity
- Two medicine droppers (one to use with vinegar, one to use with lemon juice)
- Two pieces each of limestone, calcite, chalk and quartz (label each)
- Paper towels

Procedure:

On each of the two paper towels line up one piece each of limestone, calcite, chalk and quartz. Place each grouping of rocks so they can be easily seen by all the members. One grouping will be treated with lemon juice; the other will be treated with vinegar. Use the following dialogue while testing specimens:

I will put a few drops of lemon juice on each of the four samples lying on this paper towel. Look and listen carefully each time I add the lemon juice. Did you see or hear anything?

I will put a few drops of vinegar on each of the four specimens lying on the other paper towel. Again, look and listen carefully each time I add the vinegar. Did you see or hear anything?

Did the lemon juice and vinegar act the same way on each specimen?

Why did some of the specimens react differently?

Answers:

The lemon juice and vinegar both contain weak acids. The lemon juice contains citric acid and the vinegar contains acetic acid. These mild acids can dissolve rocks that contain calcium carbonate. The lemon juice and vinegar should have bubbled or fizzed on the limestone, the calcite mineral and the chalk. They all contain calcium carbonate. Water often contains weak acids that dissolve rocks containing calcium carbonite and other minerals.

Identifying Sedimentary Rocks

Rocks, Sedimentary — Geology, Level III

What members will learn …

About the Project:

- Sedimentary rocks can be identified by studying texture and composition.
- The two main types of sedimentary rocks..

About Themselves:

- Their feelings about learning via the use of a key.
- How to classify items.

Materials:

For each member:

- Member Handout 19, *Key to Identifying Common Sedimentary Rocks*
- Member Handout 20, *Sedimentary Rock Definitions*
- Activity Sheet 30, *Sedimentary Rock Identification Form*

For group:

- pencils
- Dilute hydrochloric acid (HCl)
- Tissue
- Magnifying glass
- Steel knife
- Small piece of glass for hardness test
- 8 to 16 numbered samples of sedimentary rock with clean fracture to aid in identification. The specimens might include:
  - mudstone
  - calcareous shale
  - siltstone
  - fossiliferous limestone
  - arkose
  - graywacke
  - sandstone
  - coquina
  - coal
  - peat
  - chalk
  - oolitic limestone
  - crystalline limestone
  - breccia
  - conglomerate
  - diatomite
  - dolomite
  - travertine
  - oil shale

Activity Time Needed: 45 minutes

Advance Preparation:

Ask each member to bring a sedimentary rock to the meeting

Leader's Notes

Allow time for each to share. If rock is incorrectly named do not correct at this time.

Distribute Member Handout 19, *Key to Identifying Common Sedimentary Rocks*. Review and discuss the key making sure members understand all terms used.

Use samples of rock specimens and/or use definitions on Member Handout 20, *Sedimentary Rock Definitions* to help develop better understanding of terms used in identification key. Use these terms in a brief quiz bowl.

Distribute Activity Sheet 30, *Sedimentary Rock Identification Form*. Go over the form and make sure members understand how to use it.

Divide members into groups of two and circulate specimens, asking each group to identify each specimen by referring to identification key and filling in spaces on identification form.

Emphasize that the number found on the rock specimen agrees with the corresponding number they place on their sheet.

If you have a very capable group you may wish they work individually instead of in groups.

When all have completed identifying specimens go over the correct identifications. Ask members if they still believe the rock brought by each was correctly identified. If members believe a name change needs to be made discuss reasons.

Activity

Would you each please share the rock you brought with the group by describing your rock and, if you think you know, the name of the rock such as shale, limestone, etc.

There are two general types of sedimentary rocks: clastic and non-clastic. Clastic are sedimentary rocks consisting of fragments of rocks and minerals. Nonclastic are rocks formed by chemical precipitation and can be organic or inorganic. Organic or biogenic are composed of fragments of plants or animals. Inorganic rocks are composed of crystals.

Dialogue for Critical Thinking:

Share:

1. What was the most unique rock brought to the meeting?
2. How many rocks were correctly identified before using the key?

Process:

3. What are the two main types of sedimentary rocks? (Define each.)
4. Which type of sedimentary rock was the most difficult to identify? Why?

Generalize:

5. Which method of learning do you prefer: 1) keying out or discovering an unknown; or 2) learning a definition and looking at the sample first? Why?
6. What other areas have you learned to identify by using a key?

Apply:

7. How will issues raised by this activity be useful in the future?
8. How can you use the "key" process differently next time?

Going Further:

1. Prepare a collection of sedimentary rocks.
2. Study sandstone including variety of colors and reason for this variance, mineral content of sand grains, size of sand grains, etc.
3. Collect a variety of limestone rocks and prepare an explanation for each variety.

References:

Member Level:

Buchanan, Rex, *Kansas Geology, an Introduction to Landscapes, Rocks, Minerals, and Fossils*, University of Kansas: Lawrence, Kansas, 1984.

Leader Level:

Brice, James C., Harold L. Levin, and Michael S. Smith, *Laboratory Studies in Earth History*, William C. Brown: Dubuque, Iowa, 1989.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist with the Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University.

Identifying Sedimentary Rocks

Member Handout 19, Key to Identifying Common Sedimentary Rocks

Rocks — Geology, Level III

Texture				Diagnostic Features	Rock Name	
Clastic			Boulders, cobbles, pebbles or granules (>2 mm size) embedded in a matrix of sand grains	Angular rock/mineral fragments	Breccia	
				Rounded rock/mineral fragments	Conglomerate	
			Coarse sand	Angular fragments mixed with coarse sand. Color: pink, reddish-brown, buff	Sandstone	Arkose
			Sand-size particles	With few to no rock/mineral fragments — mainly quartz. Color: buff, white, pink, brown		Sandstone
			Course — fine sand-size particles with clay-size matrix	Fine to coarse, angular to sub-angular rock fragments, poorly sorted. Color: dark gray to gray-green		Graywacke
			Silt and fine-grained clay-sized particles	Chiefly silt particles, some clay. Surface is slightly gritty to touch	Siltstone	
				Shows fissile nature, soft enough to be scratched with fingernail. Color varies	Shale	
				Not fissile, looks like hardened mud or clay. Color varies	Claystone, mudstone	
			Very fine-grained silt-sized particles	Silty feel, yellowish appearance, softer than a finger-nail, but some particles will scratch glass.	Loess	
Nonclastic	Chemical	Inorganic	Crystalline or oolitic	Effervesces strongly with dilute HCl, may contain fossils (fossiliferous) or oolites (oolitic), harder than a fingernail, softer than glass	Limestone	
			Crystalline	Powder of this rock effervesces weakly with dilute HCl, similar in appearance to limestone	Dolomite	
				Scratches glass, conchoidal fracture. Color: black, white, gray, red	Chert	
				Same hardness as a fingernail, salty taste. Color: white to gray	Rock salt	
				Scratched with a fingernail. Color: varies, but usually pink, buff or white	Rock gypsum	
		Organic	Fragments of organic matter	Whole or nearly whole shells cemented together	Coquina	
				Softer than a fingernail, effervesces with dilute HCl. Color: usually white	Chalk	
				Soft, crumbles, but particles scratch glass, does not react with dilute HCl. Color: gray-white (microscopic siliceous plant remains)	Diatomite	
			Fibrous vegetation fragments	Brown plant fibers, soft, porous	Peat	
			Dense/shiny, no fibrous fragments visible	Sooty feel, may be fossiliferous. Color: brown to lustrous black	Coal	

Identifying Sedimentary Rocks

Member Handout 20, Sedimentary Rock Definitions

Rocks — Geology, Level III

Aphanitic: a textural term used for rocks in which the crystalline components are too small to be recognized with the unaided eye.

Arkose: This is a variety of sandstone with 25 percent or more of feldspar grains.

Biogenic: Sedimentary rocks composed of plants and/or animals.

Breccia: This is a coarse-grained sedimentary rock formed by the cementation of course, angular fragments of rubble.

Clastic: A sedimentary rock consisting of fragments of rocks or minerals.

Claystone: A clastic sedimentary rock made of very fine-grained compacted clay and silt that is also called shale.

Conglomerate: A coarse-grained sedimentary rock formed by the cementation of rounded gravel.

Coquina: A clean sediment or sedimentary rock composed largely of shells or marine invertebrates.

Crystalline: A textural term that describes a sedimentary rock composed of crystals.

Diatomite: The silica of microscopic, single-celled plant growing in marine or fresh water that has dried to a fine powder.

Fissile: A property of some sedimentary rocks that separate into thin, flat layers, usually along bedding planes.

Graywacke: A poorly sorted sandstone with considerable quantities of silt and clay in its pores.

Inorganic: In general, refers to materials not derived from living organisms.

Loess: A soft, crumbly sedimentary rock formed from accumulations of wind-blown silt.

Matrix: Fine-grained material found in the porous space between larger sediment grains.

Mudstone: Sedimentary rock made of very fine compacted clay with thick blocky layers.

Nonclastic: Sedimentary rock formed mainly by chemical precipitation.

Peat: Decayed or partially decayed plant remains. It is considered an early stage in the development of coal.

Phaneritic: Pertaining to a rock texture in which constituent mineral grains or crystals are large enough to be seen with the unaided eye.

Oolitic: Type of limestone containing oolites, which are spheroidal grains of sand size, usually composed of calcium carbonate, $CaCo_3$, and thought to have originated by inorganic precipitation.

Organic: Substance derived from or produced by a living organism.

Identifying Sedimentary Rocks

Activity Sheet 30, Sedimentary Rock Identification Form

Rocks — Geology, Level III

Specimen Number	Texture	Grain/Particle Size	Composition	Other Distinguishing Features	Rock Name

Stratigraphic Cross Section

Rocks, Sedimentary — Geology, Level IV

What members will learn …

About the Project:

- Layers of sedimentary rocks occur widely and vary in thickness and composition.
- The three basic laws of geology are illustrated by sedimentary rock layers.
- Earth history from sedimentary rocks.

About Themselves:

- How to organize, do and evaluate projects.

Materials:

For each member:

- Activity Sheet 30, *Cross Section Data*
- Pencil
- Clip board (optional)
- A sheet of white paper

For group:

- Magnifying glasses
- Ruler, yard stick or tape measure
- Rock hammer
- Container for specimens
- Masking tape and marker for numbering specimens

Activity Time Needed: 1 to 2 hours

Activity

The earth's surface is no longer composed of igneous rock as it was originally. Processes at work on the surface reduce igneous to sediments by weathering and erosion. Sediments are moved from one place and deposited in another. Layers of sediments can change into sedimentary rocks, which contain a record of much of the earth's history.

As we work on stratigraphic cross section profiles, remember the three general principles or basic laws of geology:

1) Principle of Uniform Process — the geological processes which occur today, such as earthquakes, faults, and erosion, also occurred in the past. In other words, the present is the key to the past

Leader's Notes

You may wish to review the types of minerals or sediments found in sedimentary rocks.

2) Law of Original Horizontality — water-laid sediments are deposited horizontally or nearly so; that is, parallel to the surface on which they are accumulating. Frequently this is also true for sediments deposited by ice or wind. Sedimentary rocks formed from such sediments preserve the horizontal layering in the form of beds

3) Law of Superposition — in undisturbed sedimentary rocks, the youngest rocks are at the top, the oldest are at the bottom.

We will study and discuss a sample stratigraphic cross section before we visit a site at which you will draw a cross section.

What rocks are represented in this column cross section?

When studying a section of sedimentary rock layers, grain size also is checked. What information does the grain-size graph tell you?

Under "Layers in Order of Grain Size," complete recording the rock-layer numbers in order of finest to coarsest. The first two have been done for you.

The beds or the layers of sedimentary rocks are separated by bedding planes along which the rocks tend to separate or break. In general, each bedding plane marks the termination of one deposit and the beginning of another. Bedding planes are usually horizontal as they are in this cross section. Some beds are laid down at an angle to the horizontal bedding plane. Such bedding is called cross bedding. Cross bedding is found most often in sandstone.

Distribute Activity Sheet 31, *Cross Section Data* and pencils.

Leader Key for Stratigraphic Column

1. Rock Salt
2. Shale
3. Sandstone
4. Conglomerate
5. Sandstone
6. Conglomerate (finer)
7. Shale
8. Sandstone (coarse)
9. Sandstone (fine)
10. Sandstone (medium)

Layers in Order of Grain Size

finest	-1
	-7
	-2
	-3
	-5
	-9
	-10
	-8
	-6
coarsest	-4

As a group answer questions 1 through 14 on the activity sheet or allow each to complete the activity and then discuss answers.

When discussing the questions and answers, work for greater understanding of the information sedimentary rocks can reveal

Answers to questions

1. shale
2. conglomerate
3. water was probably calmer.
4. no
5. rock salt
6. shale at layer 7

Dialogue For Critical Thinking:

Share:

1. What did you see when we visited the exposed sedimentary rocks?
2. Where else have you seen exposed sedimentary rocks that would be interesting to our group?

Process:

3. In the sample cross section, what geological principles were illustrated?
4. What are at least two things you can learn about the Earth's history from sedimentary rock levels?

Generalize:

5. What did you learn about yourself through this activity?
6. How would you evaluate the data you collected and drawing that you did?
7. What decisions did you make in preparing for this field trip?

Apply:

8. Based on the data you have collected for this activity, what do you think was the environment of this area 250 million* years ago?

Going Further:

1. Visit another location and draw a profile to scale. Compare this cross-section to the previous one.
2. Study types of bedding and explore areas that show some of these types (laminated bedding, cross bedding, graded bedding, etc.).

References:

See "Geological History of the Earth" section of this curriculum.

Leet, L. Don and Sheldon Judson, *Physical Geology*, Prentice Hall, Inc.: Englewood Cliffs, New Jersey, 1971, 687 p.

Plummer, Charles C. and David McGeary, *Physical Geology*, William C. Brown Publishers: Dubuque, Iowa, 1991, 543 p.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team

Reviewed by: Dr. James Underwood, retired Geology Professor, Kansas State University

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

7. conglomerate at layer 4. Remember that larger grains of sediment require faster running water to carry them.

8. once

9. slower current

10.clay (very fine shale) and rock salt. Probably climate became very dry for a long period of time and sediment laid down in very calm water which may have formed an inland shallow sea.

11. twice, at layers 1 and 7

12. the body of water may have been cut off from source and grew more calm.

13. sandstone found in layer 10, Law of Superposition

14. Law of Original Horizontality

After completing the *Cross Section Data* sheet, visit a road cut or a stream bank where an exposure of several rock layers may be found. Ask members to record the approximate thickness of each layer, to collect a specimen of each layer — numbering each layer from top to bottom of exposure — and to record the kind of rock in each layer.

When members complete collecting the data, return to meeting location where members will draw a cross section profile of the area using symbols to indicate rock layers. Allow members to examine specimens and chart grain size. After completing profiles, discuss what they did and what they learned.

Make sure rock samples are laid out in order of layers.

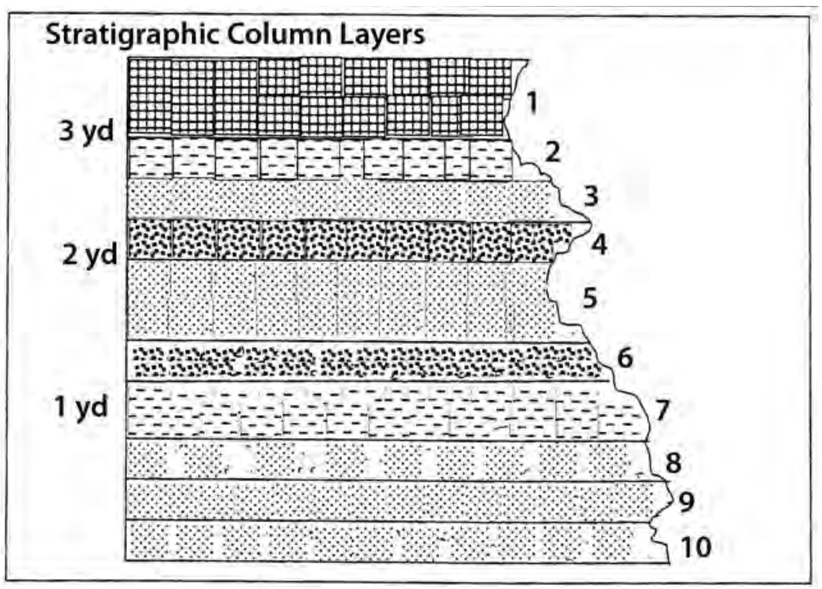
Apply Question #8:

*Use the geological age of surface rocks in your area.

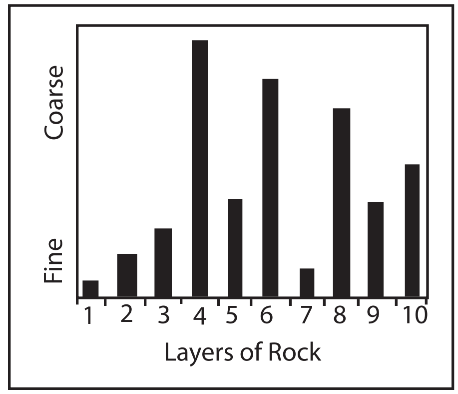
Stratigraphic Cross Section

Activity Sheet 31, Cross Section Data

Rocks — Geology, Level IV



Stratigraphic Layers by Grain Size

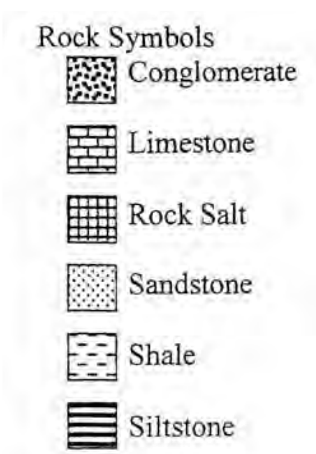


Number the layers of rock in order of grain size:

Finest ....___1__
___7__
______
______
______
______
______
______
______
Coarsest ....______

Activity Questions:

1. What kind of rock is found at the 1-yard level?
2. What kind of rock is found just above the 2-yard level?
3. Why is the shale found at the 1-yard level slightly finer grained than the shale located near the top of the 2.75-yard level?
4. Do all the sandstone layers have the same grain size?
5. What kind of rock layer was a chemical sediment?
6. Which rock layer was deposited as very fine clay?
7. What kind of rock was formed by sediments transported by the fastest moving water?
8. How many times during the history of this section did the water show such a swift current?
9. As the grain size of the sedimentary rock became finer, what must have happened to the speed of the current of water that delivered the sediment?
10. Which kind of sediment was laid down when the water was very calm? Where might such a condition be present?
11. How many times did the water become very calm?
12. How can you account for the layer of rock salt being just above the last shale layer deposited?
13. Which is the oldest rock and in which layer is it found? This is an example of what principle of geology?
14. The horizontal bedding in this cross section illustrated what basic law of geology?



Rocks from Fire

Rocks, Igneous — Geology, Level I

What members will learn …

About the Project:

- Igneous rocks form when magma cools and hardens.
- Two main types of igneous rocks.
- What crystals are.

About Themselves:

- How to observe, describe and sort into categories (types).

Materials:

For each member:

- Activity Sheet 32, *Granite Mosaic*
- Member Handout 21, *Igneous Rock Cross Section*, or create a poster to use with the group
- Scissors
- Glue
- Strips of pink, blue, and black construction paper

For group:

- Hand lens
- Igneous rock samples including obsidian and granite
- Easel
- Newsprint pad
- Bowl and spoon
- Hot water
- Alum and/or Copper sulfate
- Small glass dishes
- Thread
- Pencils
- Bowl of ice and ice water

Activity Time Needed: 90 minutes (or three 30 minute sessions)

Leader's Notes

Write "Igneous" on newsprint pad.

Write "Intrusive" on newsprint pad.

Write "Extrusive" on newsprint pad.

Ask members to carefully examine each of the igneous rocks assembled, thinking about how each looks and feels. Have each member select a favorite rock and think of words to describe it. Have each member describe their favorite rock. List the descriptive words on the newsprint. Possible words might be: rough, fine, coarse, jagged, smooth, dark, heavy, etc. Indicate "intrusive" or "extrusive."

Divide members into small groups and provide each group with 5 or 6 igneous rocks (including the favorite rock each selected). Ask each group to separate the rocks in to two piles and explain the reason for each group, using descriptive words.

While members are grouping rocks, prepare a graph on newsprint pad listing descriptive words on the horizontal axis and number of members on the vertical axis. Ask each member to pick up their favorite rock and study it carefully. Ask how many have a rock that fits each descriptive word on the chart. Ask a member to illustrate on the newsprint pad the number of specimens fitting each descriptive term by drawing a column to that number on a graph. When the graph is completed, explain to the group that the information about all of their rocks is now in a "picture" called a graph.

Activity 1

Igneous rocks form when a hot solution called magma cools and hardens. The word "igneous" means coming from fire.

Some igneous rocks form underground when magma that is pushed up toward the crust cools and crystallizes before it reaches the surface. These igneous rocks are called intrusive rocks. These rocks cool slowly.

The different minerals that grow, formerly grew very slowly over a long period of time, and finally the coarse mineral crystals are big enough to be easily seen.

If magma spilled out onto the surface before cooling, the rocks that form as the magma cools are called extrusive rocks. Extrusive rocks cool rapidly forming fine grain rocks or even glass.

Igneous rocks are much less common than sedimentary rocks on the Earth's surface but are more abundant deeper in the earth.

Activity 2

Earlier we said igneous rocks were known as intrusive or extrusive. Remember the extrusive rock is formed as a result of the extrusion of hot, molten rock onto the surface. Magma moves through the rock layers and lava emerges from the ground through a hole called a vent. A cone forms around the vent, which can have a steep or gentle slope. Some volcanoes eject solid pieces. Extrusive means "pushed out." Magma that reaches the surface is called lava. The extrusive igneous rock is fine grained because the hot solution cools rapidly and crystals do not have time to form. Obsidian, basalt and rhyolite are some examples of extrusive rocks.

Magma does not always break through to the surface. It may push its way upward through the rocks cutting whatever rock is present or squeezing between them and becoming solid before reaching the surface, cooling slowly. These rocks are known as intrusive rocks. Intrusive means "forced in." They will be coarse and have mineral crystals big enough to see with the naked eye. One example is granite.

Why do you think magma remaining under the surface of the Earth would cool slowly?

Let's try to grow some crystals and see if the rate of cooling a hot solution will result in differing crystal sizes. Using alum or copper sulfate and hot water, prepare a saturated solution. You will know the solution is saturated when you see a few particles starting to settle out on the bottom of the bowl.

Pour one half of the solution into each of two glass dishes. Using a pencil placed across the top of each bowl to hold a piece of thread, dangle a thread into each solution. Allow one solution to cool slowly. Place the second dish of solution in a bowl of ice water to promote quick cooling. Watch for the formation of crystals but be careful not to disturb solutions.

In addition to classifying igneous rocks by where they cooled and solidified, they may also be classified by their chemical composition or by identifying the minerals that are in them. For example, the minerals feldspar, quartz, and mica or hornblende make up the rock known as granite.

If you look closely at the granite samples you can see the different minerals. What you see is feldspar, which looks grey, white, or pink. The glassy, clear mineral is quartz. The dark speckles are mica if they appear very shiny, or hornblende if they are dull. Do all the pieces of granite look exactly alike?

Granite is always made up of the same minerals, but the amount of each mineral may vary from sample to sample. Each of you is going to "make" your own piece of granite using bits of colored paper. Each of you will use the same "minerals" but your rocks will not look exactly alike.

Cut the pink strip into small rectangles to represent feldspar, cut the light blue strip into triangle pieces for quartz, and the black strip into small squares to represent mica or hornblende. After you complete cutting the strips, glue one of each shape in the appropriate box on the page — a black square in the horneblende or mica box, a light blue triangle in the quartz box and a pink rectangle in the feldspar box. Then glue the pieces in a random pattern on the area enlarged by the hand lens.

Distribute Member Handout 21, *Igneous Rock Cross Section*.

Circulate samples of obsidian and other fine-grained igneous rock.

Show granite sample.

Refer to *Crystal Shapes*, Level I, Minerals, for recipe on growing crystals.

Have members hypothesize what will happen in each dish. After working with the solutions, wash hands and containers carefully.

In the slow-cooling solution, large crystals should form. In the quickly-cooled solution the crystals should be so small as to be indistinguishable to the naked eye. Leader may desire to grow crystals in advance so a finished product may be displayed. While solutions cool, continue with next activity.

Look at granite samples with a hand lens so members can see the minerals.

Distribute Activity Sheet 32, *Granite Mosaic*.

Hand out scissors, glue and one strip each of pink, black, and light blue construction paper.

You may need to draw a rectangle, a triangle and a square on newsprint pad so members have a clear understanding of these shapes.

After all the "rocks" are finished, display the results and compare the different patterns. Have members check to see if any crystals have begun to appear in previously prepared solutions.

Dialogue For Critical Thinking:

Share:

1. Do any of the mosaic displays look exactly alike? Why or why not?
2. What was the most common descriptive word used to describe an igneous rock?
3. What happened when the saturated solutions cooled?

Process:

4. How do extrusive and intrusive igneous rocks differ?
5. What is the texture of an extrusive igneous rock?
6. What minerals are commonly found in granite?

Generalize:

7. Besides granite, what else may be composed of the same minerals but look different?
8. What do you use to sort personal items like clothes, cards, or toys?

Apply:

9. Where can you find igneous rocks in your area?
10. What are some common uses of igneous rocks?

Going Further:

1. Observe the saturated solutions for several days and record crystal growth daily.
2. Increase crystal size. Crystals will grow on the thread. Select the largest and keep it on the thread, scraping the others off. Reheat the saturated solution and put the chosen crystal back in the solution.
3. Take a group on a field trip to collect their own samples of igneous rocks.
4. Have members make rock candy by using saturated sugar solution to grow sugar crystals.

References:

Barnes, John H. *Rocks and Minerals of Pennsylvania.* Educational Series 1. Pennsylvania Geological Survey: Harrisburg. 1991. 30 pages.

Dixon, Dougal. *The Practical Geologist.* Simon & Schmaster, Inc: New York. 1992. 160 pages.

Ramsey, William, Gabries, Lucretia A., McGuirk, James F., Phillips, Clifford R., & Watenpaugh, Frank M. *Earth Science.* Rinehart and Winston: New York. 1978. 503 pages.

Ranger Rick's Nature Scope. *Geology: The Active Earth.* Vol 3 (2). National Wildlife Federation: Washington D.C.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team

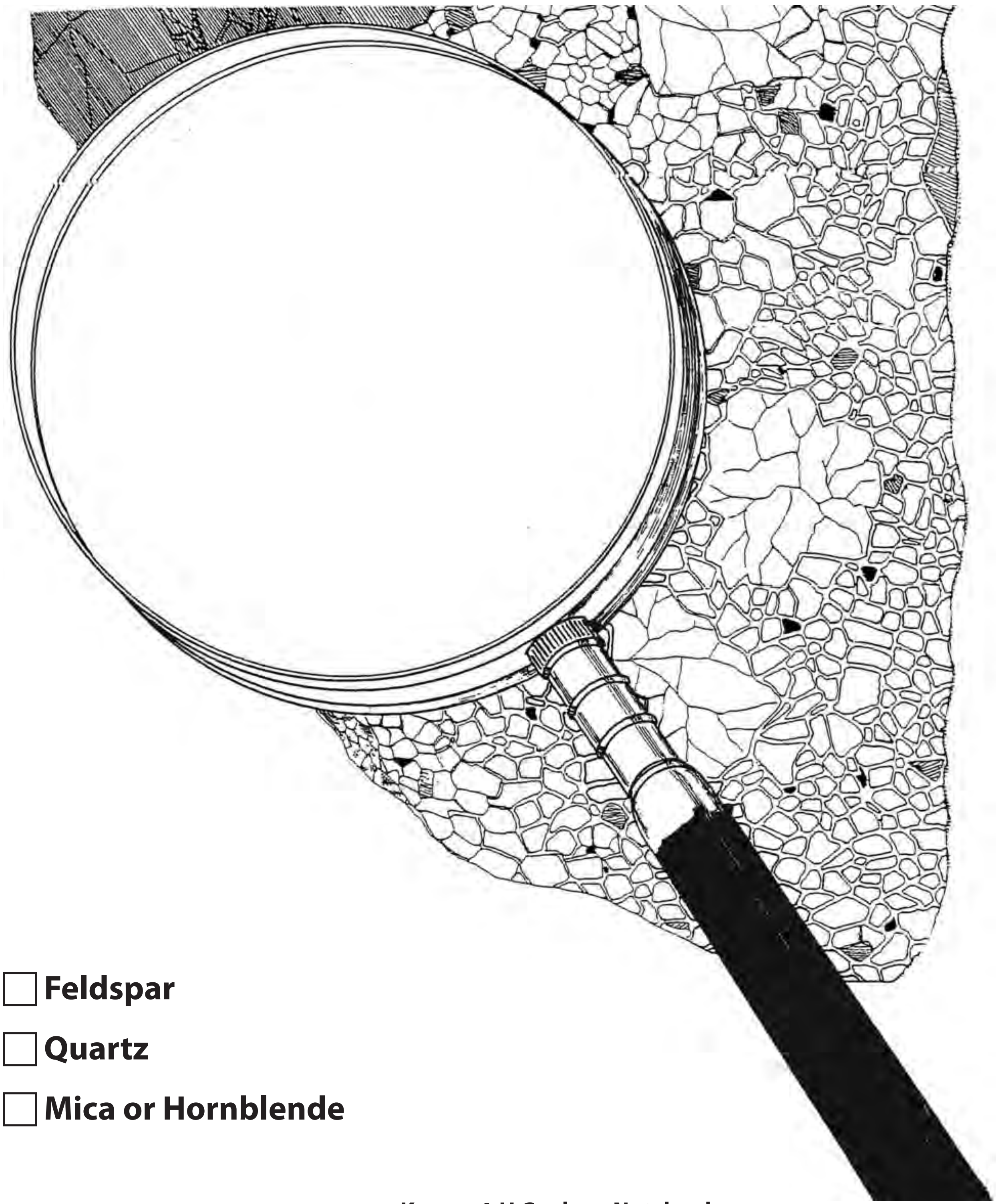
Reviewed by: Dr. James Underwood, retired Geology professor, Kansas State University

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Rocks from Fire

Activity Sheet 32
Granite Mosaic

Rocks — Geology, Level I

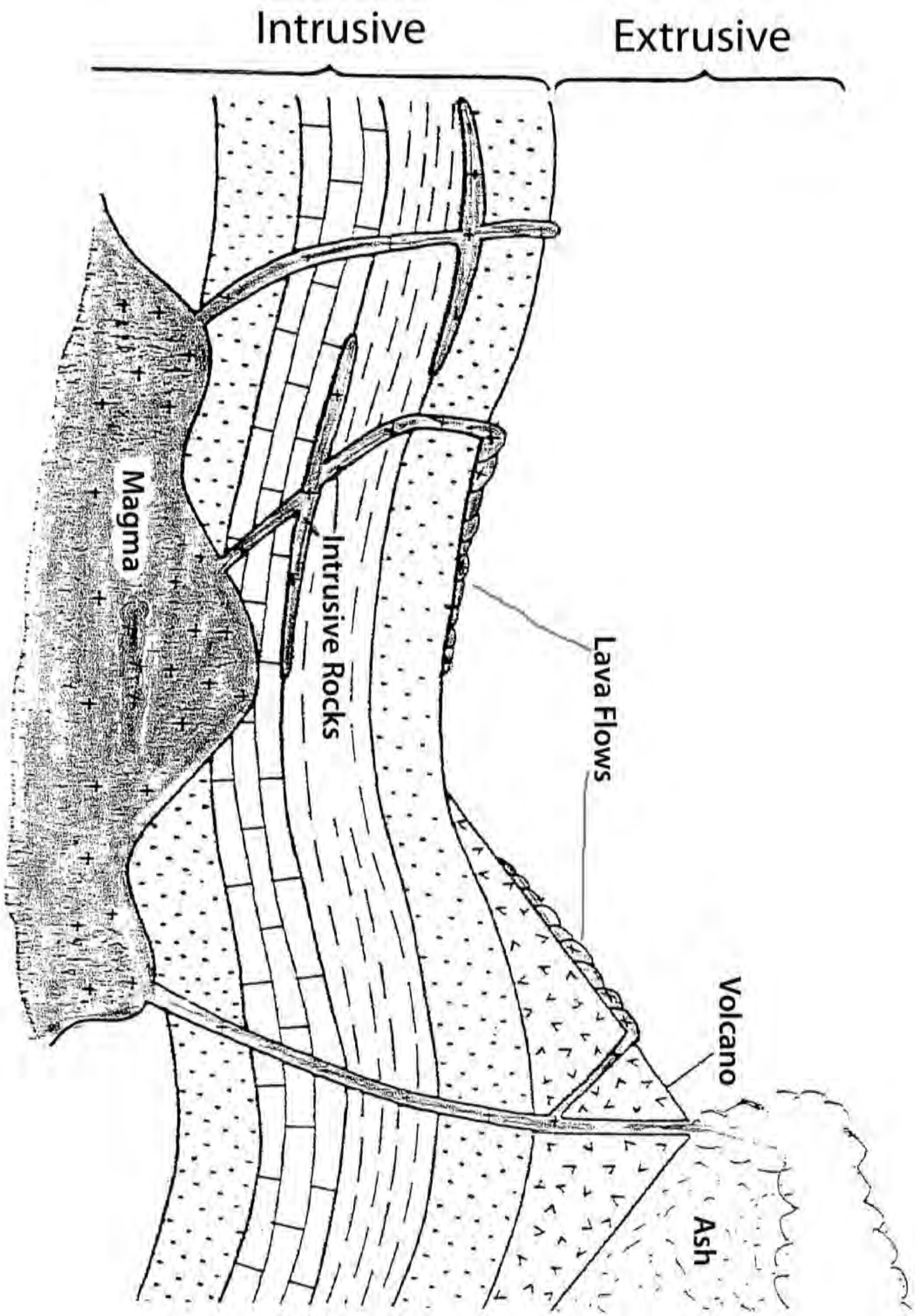


- [ ] **Feldspar**
- [ ] **Quartz**
- [ ] **Mica or Hornblende**

Rocks from Fire

Member Handout 21, Igneous Rock Cross-Section

Rocks — Geology, Level I



Igneous Bodies

Rocks, Igneous — Geology, Level II

What members will learn …

About the Project:

- The rate of cooling affects crystal size of igneous rocks.
- Intrusive igneous rocks are formed beneath the surface of the earth.
- Four types of intrusive igneous bodies include batholith, laccolith, dike and sill.
- Three kinds of extrusive igneous bodies include volcano, lava flow and cinder cone.

About Themselves:

- Preferred method for learning new terms.
- How to use observation skills.

Materials:

For each member:

- Pencil
- Activity Sheet 33, *Igneous Bodies Crossword Puzzle*
- *Rock Identification Member Reference* (p. 87, Extra Reference at end of Rock section)

For group:

- candle
- candle holder
- test tube
- test tube holder
- plastic spoon
- index card
- Paradichloreobenzene (PDB)*
- matches
- A collection of igneous rocks — obsidian, basalt, granite, diorite, basalt porphyry, volcanic, breccia, etc.

- Activity Sheet 34, *Igneous Bodies Crossword Puzzle Answer Key*

Activity Time Needed: 60 minutes

Activity

Today, we are going to look at how the rate of cooling affects crystal size, discuss intrusive and extrusive igneous rocks, and intrusive and extrusive

Leader's Notes

*Moth crystals found at the local department or drug store are 99.6% to 100% paradiclorobenzene. Check the label for active ingredient.

PDB is being used as a substitute for magma because it melts at about 50 degrees C and forms crystals upon cooling.

Fill a test tube about 1/3 full with small pieces of PDB. Hold the test tube with the test tube holder over the lit candle until the PDB is melted. Hold the test tube about 1 cm. above the flame, POINTING THE OPEN END OF THE TEST TUBE AWAY FROM YOURSELF AND OTHERS.

(As PDB melts, continue discussion of igneous rocks.)

When PDB is completely molten, pour about half of it onto the index card. Pour the remaining PDB into the plastic spoon. Lay the spoon on the table with the handle propped up so the molten material does not spill.

Allow members to observe the PDB as it cools and discuss observations.

Refer to the cooling PDB

After the PDB in the spoon is completely hardened, have the members look closely at its crystals.

Distribute igneous rock portion of *Rock Identification Member Reference*, page 87.

After members have read information on igneous rocks, discuss igneous bodies using Member Handout.

**Batholith, Laccolith, Dike, Sill

igneous bodies.

I'm going to melt some paradiclorobenzene, then we will observe crystals form as it cools.

You will remember that igneous rocks are formed by the cooling and hardening of molten rock material. This hot liquid is known as magma.

1. What is the name for magma that has flowed out on the surface? (*Lava*)

Melting PDB to represent magma or lava will let us see what happens when portions are allowed to cool at different rates.

2. Where are intrusive igneous rocks formed? (*Beneath the surface of the earth.*)
3. How would you describe the texture of an intrusive igneous rock? (*coarse-grained or easily seen crystals*)
4. What are igneous rocks that form when lava cools on the earth's surface called? (*extrusive igneous rocks*)
5. How would you describe the texture of an extrusive rock? (*fine, small grains, or no apparent crystals*)

If magma begins to cool and crystals begin to grow, then it is forced to rise rapidly and erupts at the surface; the remaining magma cools quickly to form a very fine-grained rock with the large early-formed crystals. A rock that has such a texture representing the two-stages of cooling is called a porphyry.

- Which sample is cooling the fastest, that on the index card or in the spoon?
- Which one of these samples best represents lava, as it is poured out onto the earth's surface?
- Are crystals present on the index card? If so, how would they be described?
- How would you describe the shape of the crystals in the spoon?
- How do they compare to the PDB on the index card?
- How does the rate at which PDB cools affect its crystal size?
- Based on your observations in this activity, how do you think the rate at which lava cools affects crystal size in igneous rock?
- Name four types of intrusive igneous bodies.**

Name three kinds of extrusive igneous bodies:

1. Volcano – is a hill or mountain formed from lava and rock fragments ejected through a vent. Any rock formed when lava or solid rocks erupt explosively is called a pyroclastic rock. The particles forming pyroclastic rocks may be as small as fine ash less than .06 millimeters in diameter to mid-sized particles called cinders to larger fragments called volcanic bombs.

2. Lava flow – is the molten rock that reaches the Earth's surface.

3. Cinder cone – is composed of loose pyroclastic material that forms steep slopes as it falls back around the central vent.

Dialogue for Critical Thinking:

Share:

1. Of the igneous rocks we looked at, which one did you like the most or find most interesting? Why?
2. What extrusive rock bodies have you seen? Where?

Process:

3. How do the intrusive bodies, batholith and laccolith, differ?
4. What is the difference between a dike and a sill?
5. What might be the origin of an extrusive igneous rock?
6. What is the texture of an intrusive igneous rock? Why?

Generalize:

7. What else can you think of that is affected by rate of cooling?
8. What other processes do you use to learn?

Apply:

9. What is the learning value of a crossword puzzle?
10. Where in Kansas can we find some igneous intrusions?

Going further:

Group some igneous rocks by their texture, determine if they are intrusive or extrusive, think about the environment from which they may have come, and examine each rock with a magnifying glass so that crystal size and shape can be seen and drawn.

References:

For Youth:

Bishop, Margaret S., Berry Sutherland, and Phyliss G. Lewis, *Focus on Earth Science*, Charles E. Merrill Publishing Co.,: Columbus, Ohio, 1981, pp. 103-111.

Zim, Herbert S. and Paul R. Shaffer, *Rocks and Minerals*, Golden Press: New York, 1957, pp. 103-111.

For Adults:

Berendsen, P., Cullers, R. L., Mansker, W. L., and Cole, G.P., "Late Cretaceous Kimberlite and Lamroite Occurrence in Eastern Kansas," *Geological Society of America*, v. 17, no. 3, p. 151 (Abstract).

Distribute Activity Sheet 33, *Igneous Bodies Crossword Puzzle*.

Give members a few minutes to complete the crossword puzzle before discussing the answers.

Circulate specimens to illustrate some of the words–

Extrusive – obsidian or basalt

Intrusive – granite or diorite

Porphyry – basalt porphyry

Pyroclastic – volcanic breccia

10. Riley and Woodson Counties

Brookins, Douglas, G., "Kimberlite at Winkler Crater, Kansas," Manuscript, Department of Geology, KSU: Manhattan, KS, p. 25.

Buchanan, Rex, Kansas Geology, *An Introduction to Landscapes, Rocks, Minerals, and Fossils*, University Press of Kansas: Lawrence, 1984, 208 p.

Dixon, Dougal, *The Practical Geologist*, Simon and Schuster, Inc.: New York, 1992, pp. 32-33.

Fenton, Carrol Lane and Mildred Adams Fenton, *The Rock Book*, Doubleday 7 Co., Inc.: Garden City, New York, 1940, pp. 92-129.

Flint, Richard Foster and Brian J. Skinner, *Physical Geology*, John Wiley & Sons, Inc.: New York, 1977, pp. 46-58 and Appendix C. A2.7-A3.1.

Hamblin, W. Kenneth and James D. Howard, *Exercises in Physical Geology*, Prentice Hall, Inc.: Englewood Cliffs, New Jersey, 1995, pp. 22-26.

Kansas Science Teacher, vol. 12, Fall 1996-Spring 1997, Science and Mathematics Education Center of ESU: Emporia, Kansas, p. 25.

Merryman, R. J., "Geology of the Winkler Area, Riley County Kansas," M. S. thesis, Kansas State University: Manhattan, Kansas, 1957, 34 p.

Tarbuck, Edward J. and Gredorick K. Lutgens, *Earth Science*, MacMillian College Publishing Company: New York, 1994, pp. 31-38.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team.

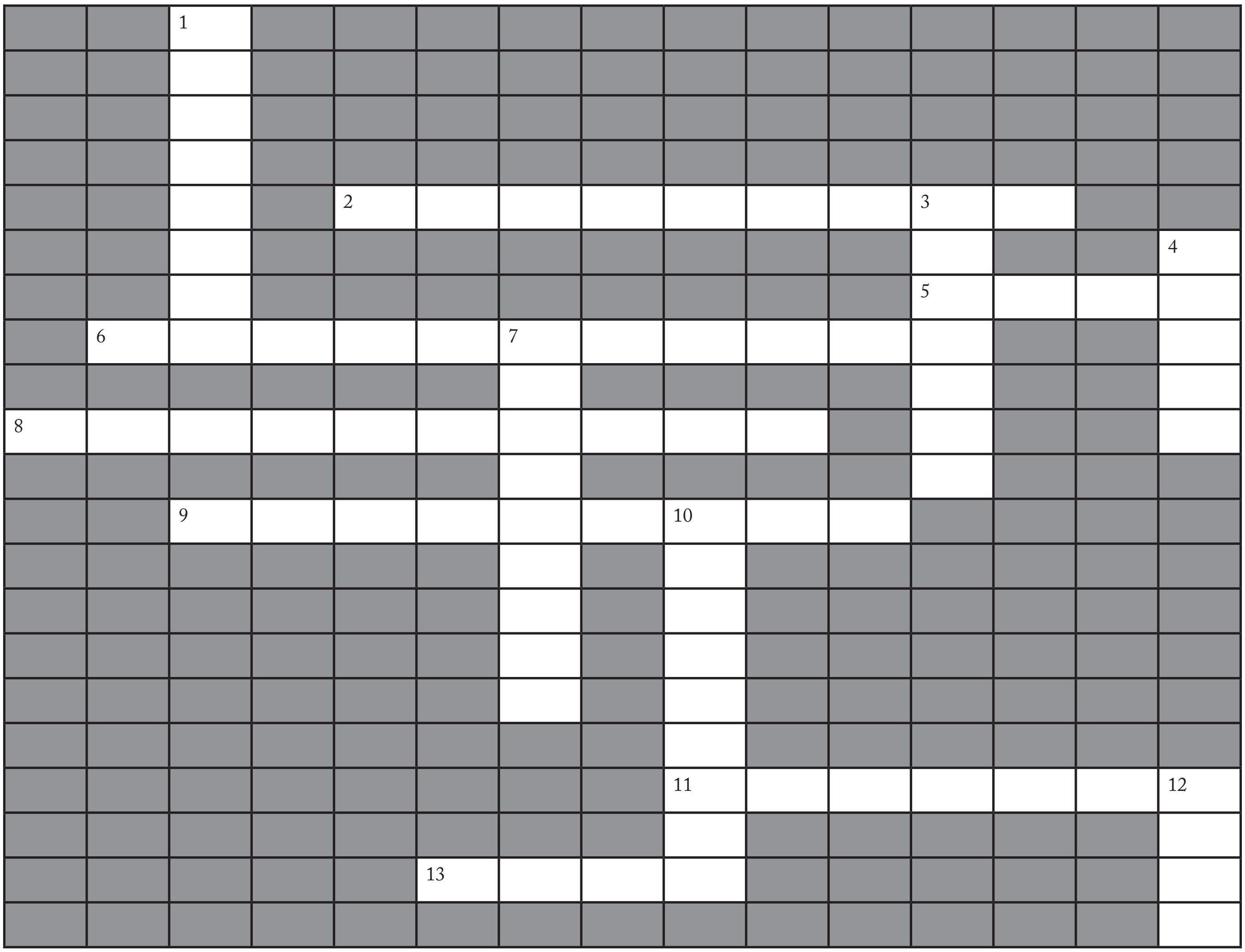
Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Igneous Bodies

Activity Sheet 33, Igneous Bodies Crossword Puzzle

Rocks — Geology, Level II



Word List:
Batholith
Cinder Cone
Dike
Extrusive
Igneous
Intrusive
Lava
Laccolith
Magma
Porphyry
Pyroclastic
Sill
Volcano

1. Any igneous rock containing larger crystals in a relatively fine-grained mix.
2. Igneous rock that forms at the Earth's surface.
3. A hill or mountain formed from No. 5 and rock fragments ejected through a vent.
4. Molten rock or liquid beneath the Earth's surface that is mostly silica.
5. Molten rock that has flowed out onto the Earth's surface.
6. Rock formed when No. 4 or solid rock erupts explosively.
7. A mushroom-shaped body of intrusive igneous rock that has domed up the overlying rock and has a flow that is usually horizontal in contrast to No. 9.
8. A small volcano made up of loose fragments ejected from a central vent.
9. A large body of igneous rock formed underground.
10. Igneous rock that formed below the Earth's surface.
11. Means "coming from fire." Rock formed when molten material cools.
12. A tabular, discordant intrusive structure that forms when No. 4 oozes its way into fractures in country rock.
13. A tabular, discordant intrusive structure that forms when magma oozes its way into fractures in country rock.

Igneous Bodies

Activity Sheet 34, Igneous Bodies Crossword Puzzle Answer Key

Rocks — Geology, Level II

		[1]P												
		O												
		R												
		P												
		H		[2]E	X	T	R	U	S	I	[3]V	E		
		Y									O			[4]M
		R									[5]L	A	V	A
	[6]P	Y	R	O	C	[7]L	A	S	T	I	C			G
						A					A			M
[8]C	I	N	D	E	R	C	O	N	E		N			A
						C					O			
		[9]B	A	T	H	O	L	[10]I	T	H				
						L		N						
						I		T						
						T		R						
						H		U						
								S						
								[11]I	G	N	E	O	U	[12]S
								V						I
					[13]D	I	K	E						L
														L

Igneous Rock Identification

Rocks — Geology, Level IV

What members will learn …

About the Project:

- Characteristics of igneous rocks.
- How to identify igneous rocks.

About Themselves:

- How games can help learning.
- Observation skills.

Materials:

For each member:

- Activity Sheet 35, *Igneous Rock Identification*
- Activity Sheet 36, *Rock Game Board Pattern*
- Pencil
- Enough samples of igneous rocks to provide a set of nine for each member or something else to use as a BINGO type marker.
- Member Handout 22, *Key for Identifying Common Igneous Rocks*

For group:

- Copy of *The Rock Book* or other references that have detailed information on a variety of igneous rocks.
- Igneous rocks selected from the following:

• granite*	• pegmatite*	• rhyolite
• felsite	• pumice*	• scoria
• phonolite	• andesite*	• obsidian
• diorite*	• granodiorite*	• grabbo*
• trachyte	• svenite	• basalt*
• dacite	• peridotite*	• diabase
• monzonite	• dunite	* rocks used on game board

- Activity Sheet 36, *Rock Game Board, Leader's Key*

Activity Time Needed: 1 to 3 hours, depending on if a field trip is conducted

Activity

Using the *Rock Game Board* sheet, find a rock that matches the descriptions in each of the boxes and place that rock on that box.

Advance assignment:

Members read information in *The Rock Book* on igneous rocks — pages 91 through 129 — or other selected reference.

Leader's Notes

Distribute a *Rock Game Board* sheet (Activity Sheet 36) and a pencil to each member as they arrive at the meeting.

The game board can be used three different ways:

1. Number each rock sample and list the names of rocks in the game board squares. Match the numbers of the samples with the names in the squares.
2. Match rock descriptions with names and samples.
3. Put descriptions in squares and match rock samples and/or names with the descriptions.

After members have completed the game board activity, discuss conclusions. It is interesting to note that basalt often rings like a bell when struck with a hammer.

Discuss reading assignment.

Discuss features of as many of the rocks as possible and circulate a sample of each rock.

Use questions found in dialogue for critical thinking during the discussion.

At the conclusion of the discussions, take the members on a field trip to collect igneous rock specimens or plan a field trip to be held at a later time.

Activity Sheet 35, *Igneous Rock Identification*, may be used to record identification of rocks collected.

Dialogue for Critical Thinking:

Share:

1. From your reading assignment, you had an opportunity to learn about a lot of different igneous rocks. Which igneous rock do you consider most interesting? What are the features of that rock?
2. Have you visited a volcanic area? Where was it? How would you describe the rocks you saw in the area of the volcano?
3. How many different igneous rocks can you now identify?

Process:

4. Which igneous rocks are found in your area?
5. What processes formed the igneous rocks we looked at?

Generalize:

6. How does the board game help you learn to describe igneous rocks?
7. What other games do you use to learn information? Why?

Apply:

8. How will you think or act differently in the future as a result of this activity and discussion?

Going Further:

1. As a group, develop a display of igneous rocks that can be used as an identification key. Make the display available to local teachers and/or younger 4-H geology project members.
2. Develop additional igneous rock game boards using the game board outline found with this lesson plan.
3. Study and collect the igneous rocks that can be found in the state. In Kansas, most of the igneous rocks have been carried in by wind, water, or glacier. Igneous intrusions can be found in Riley and Woodson Counties.
4. Visit interesting igneous rock formations such as the Capulin Mountain cinder cone located in northeastern New Mexico, the Crater of the Moon in Idaho, etc.

Reference:

Berendsen, P., R. L. Cullers, W. L. Mansker, and G. P. Cole, "Late Cretaceous Kimberlite and Lamproite Occurrences in Eastern Kansas," *U.S.A. Geological Society of America*, v. 17, no. 3 p. 151 (abstract), 1985.

Bickford, M.E., D. G. Mose, D. G. Wetherill, and P. C. Franks, "Metamorphism of Precambrian Granitic Xenoliths in a Mica Peridotite at Rose Dome, Woodson County, Kansas, Part 1, Rb-Sr Isotopic Studies," *Geological Society of America Bulletin*, v. 82, pp. 2863-2858, 1971.

Byrne, F. E., K. L. Parish, and C. F. Crumpton, "Igneous Intrusions in Riley County, Kansas," *American Association Petroleum Geologists Bulletin*, v. 7, pp. 481-488. 1956.

Fenton, Carroll Lane and Mildred Adams Fenton, *The Rock Book*, Doubleday and Company, Inc.: Garden City, New York, 1940.

Franks, P. C., "Ozar Precambrian-Paleozoic Relations: Discussion of Igneous Rocks Exposed in Eastern Kansas," *American Association of Petroleum Geologists Bulletin*, v. 50, pp. 1035-1042, 1966.

Hay, R., "The Igneous Rocks of Kansas," *Kansas Academy of Science Transactions*, v. 8, pp. 14-18, 1883.

Mottana, Annebale, Rodolfo Crespi and Giuseppe Liborio, *Simon and Schuster's Guide to Rock and Minerals*, Simon and Schuster, Inc.: New York, 1995.

Snyder, F. G., and P. E. Gerdeman, "Explosive Igneous Activity Along an Illinois-Missouri-Kansas Axis," *American Journal of Science*, v. 263, pp. 465-593, 1965.

Twenhofel, W. H., and B. H. Bremer, "Intrusive Granite of the Rose Dome, Woodson County, Kansas," *Geological Society of America Bulletin*, v. 37, pp. 403-412, 1926.

__________, and B.H. Bremer, "An Extension of theRose Dome Intrusives, Woodson County, Kansas," *American Association of Petroleum Geologists Bulletin*, v. 5, pp. 757-762, 1928.

__________, "Granite Boulders in the Pennsylvanian Strata of Kansas," *American Journal of Science*, v. 43, pp. 368-380, 1917.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team.

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Igneous Rock Identification

Activity Sheet 35, Igneous Rock Identification Sheet

Rocks — Geology, Level IV

Rock Number	Texture	Composition		Other Distinguishing Features	Rock Name
		Major Minerals	Minor Minerals		

Igneous Rock Identification

Activity Sheet 36, Rock Game Board Pattern

Rocks — Geology, Level IV

Igneous Rock Identfication

Activity Sheet 37, Rock Game Board Leader's Key

Rocks — Geology, Level IV

Granite
- Pink, white, shades of gray
- Quartz and feldspar abundant
- Orthoclase exceeds plagioclase
- Coarse-grained

Grandodiorite
- Shades of gray
- Quartz and feldspar abundant
- Plagioclase exceeds orthoclase or are nearly equal
- Coarse-grained

Pegmitite
- Feldspar and quartz
- Mineral grains larger than 1 centimeter across
- "Giant granite"

Pumice
- Gray
- Frothy mass
- Abrasive
- Light weight

Diorite
- Light and dark minerals present
- Plagioclase abundant
- Iron-magnesium minerals present
- Coarse-grained

Gabbro
- Dark gray, green or black
- Pyroxene abundant
- Plagioclase common
- Coarse-grained

Basalt
- Dark gray, green or black
- Plagioclase abundant
- Pyroxene common
- Some olivine
- Fine-grained

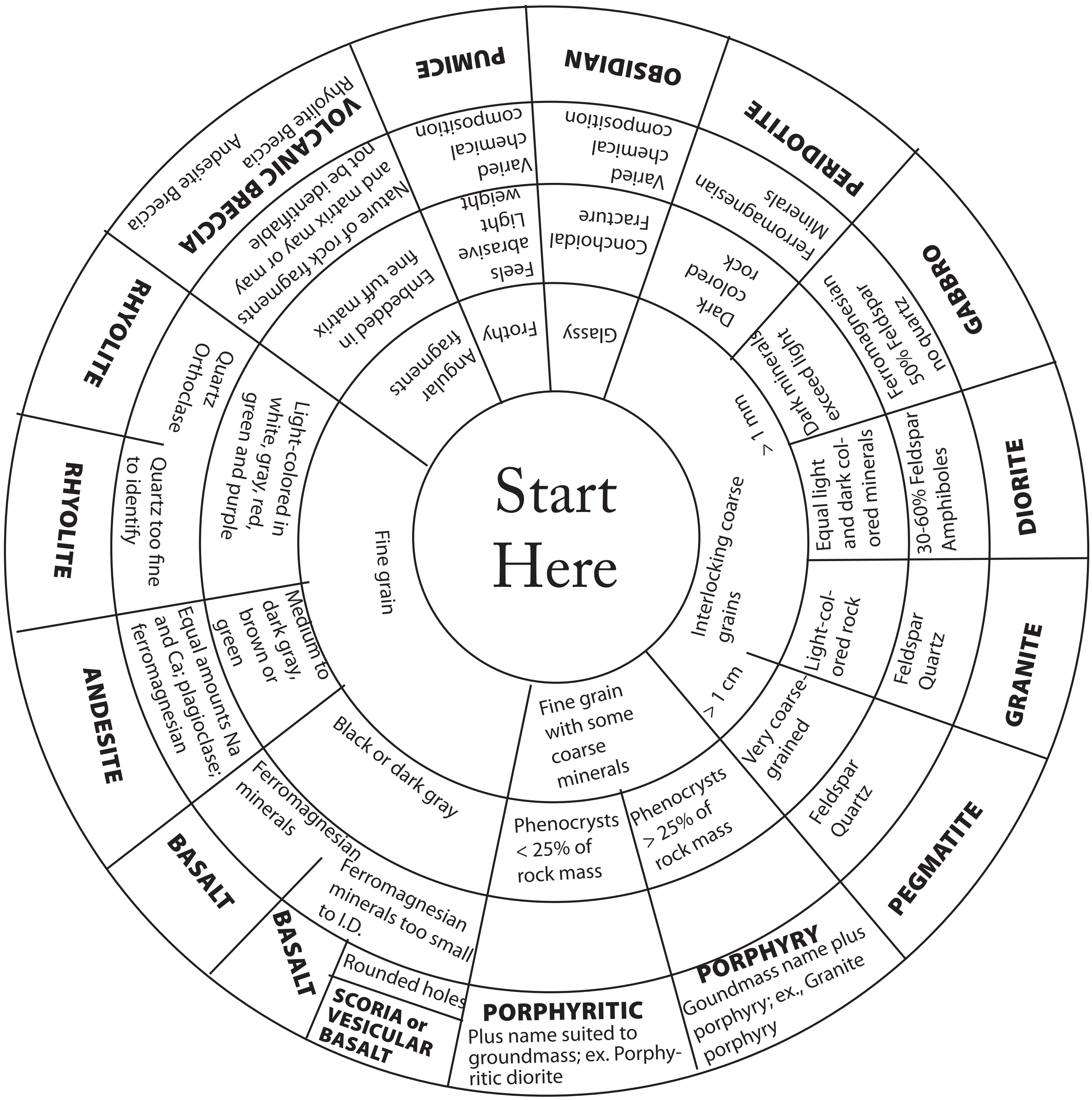
Andesite
- Shades of gray and green are common
- Plagioclase exceeds orthoclase
- Pyroxene or hornblende may be present
- Fine-grained, may have phenocrysts of feldspar and dark minerals

Peridotite
- Dull green to black
- Olivine abundant
- Pyroxene common to abundant
- Quartz absent
- Coarse-grained

Igneous Rock Identification

Member Handout 22, Key for Identifying Common Igneous Rocks

Rocks — Geology, Level IV



Composition Plus Texture

Rocks, Igneous — Geology, Level IV

What members will learn …

About the Project:

- Igneous rocks are classified and named on the bases of texture and composition.
- Ninety-nine percent of the total bulk of igneous rock is made up of only eight elements.
- Six minerals or mineral groups make up the bulk of all common igneous rocks.
- How to use some information for simple identification of some igneous rocks.

About Themselves:

- Characteristics they use to identify people and things.
- What makes each person unique?
- How to improve observation skills.

Materials:

For each member:

- Pencil
- Member Handout 23, *Common Igneous Rock Forming Minerals/ Bowen's Reaction Series*
- Member Handout 24, *Glossary*
- Member Handout 25, *Classification of Igneous Rocks*

For group:

- one or more of each of the following igneous rocks
  - rhyolite
  - granite
  - andesite
  - diorite
  - peridotite
  - gabbro
  - basalt
- newsprint pad
- magnifying lens
- easel
- felt-tip marker

Activity Time Needed: 60 to 90 minutes

Leader's Notes

Write texture terms on newsprint pad.

Circulate specimens displaying each type of texture.

Phaneritic: granite, granodiorite, diorite, gabbro, peridotite, dunite,

Vesicular: pumice, scoria

Porphyritic-phaneritic: granite porphyry

Aphanitic: rhyolite

Porphyritic-aphanitic: basalt porphyry

Glassy: obsidian

Pyroclastic: volcanic breccia or tuff

Note: Some may prefer to distribute Member Handout 24, *Glossary*, before discussing textures.

Give Member Handout 23, *Common Rock-Forming Minerals/Bowen's Reaction Series*, to each member.

Refer to *Bowen's Reaction Series*

Activity

Igneous rocks can be classified or identified on the basis of texture and composition. The texture gives important insight into the cooling history of the magma. Mineral composition of an igneous rock is the result of the chemical make-up of the parent magma and the environment of crystallization.

The major textures in igneous rocks are:

Phaneritic – course-grained where most minerals are recognizable by eye

Vesicular – igneous rocks that contain small cavities called vesicles, which are formed when gases escape from lava

Porphyritic-phaneritic – rock texture that shows two distinctively different crystal sizes

Aphanitic – dense or very fine grained texture. Few minerals may be recognizable.

Porphyritic-aphanitic – some of the grains are much larger than the majority

Glassy – contains no cryastals because molten-obsidian lava cooled too rapidly to permit crystallization

Pyroclastic – produced by volcanic explosion

Rocks named solely on the basis of texture include:

- obsidian – volcanic glass
- pumice – frothy volcanic glass
- volcanic breccia – coarsely fragmental volcanic rock
- tuff – volcanic rock composed of fine fragments
- pegmatite – very coarse-grained granite

Porphyritic and vesicular (a rock containing holes created by gas trapped in the cooling lava) may be used as adjectives to give a more complete description of igneous rocks.

Approximately 99 percent of the weight of the earth's crust is made up of eight elements:

- oxygen (O)
- silicon (Si)
- aluminum (Al)
- iron (Fe)
- magnesium (Mg)
- potassium (K)
- sodium (Na)
- calcium (Ca)

These are the major elements which make up the six minerals or mineral groups which make up the bulk of all common igneous rocks.

Those minerals/mineral groups include:

- quartz
- feldspars
- mica
- olivines
- amphioles
- pyroxenes

Crystallization of minerals from magma occurs between 600 degrees and 1200 degrees C. The cooling of magma in forming igneous rocks follows a complicated chemical path, where various silicate minerals are formed at particular temperatures in a definite sequence. The sequence, which is called a reaction series, was first recognized by N.L. Bowen in 1922. His experimental studies of silicate melts showed how a wide range of igneous rocks can be developed from a single magma.

Bowen's Reaction Series groups the chemical reactions between crystals and melt into two series. In the continuous series, minerals such as the plagioclase feldspars change their chemical composition from calcium-rich at high temperatures to sodium-rich at low temperatures, but do not change their crystal structure. In the discontinuous series, early formed crystals react with the melt and recombine to form entirely new minerals. Mafic rocks tend to form at higher temperatures. These rocks are so named because of their high content of magnesium (Mg) and iron (Fe). They contain ferromagnesian minerals such as olivine, pyrozenes, and amphiboles. Felsic rocks form at the lower temperatures and contain the quartz, feldspar, and mica minerals.

This 'Classification of Igneous Rocks' is a simplified version identifying the more common igneous rocks. The texture is divided into fine grain and coarse grain and the chart shows the major mineral content of each listed igneous rock. The granite-rhyolite family is composed of:

Distribute and refer to Member Handout 25, *Classification of Igneous Rocks*.

- 32-42% quartz.
- 8-30% orthoclase.
- 15-33% plagioclase (high Na).
- 8-15% biotite and amphibole.

The magmas that produce these rocks are high in potassium, silicon, and sodium, and low in iron, magnesium, and calcium. Granites and rhyolites are therefore light colored. Rhyolite is an uncommon extrusive rock. Granite is a very common intrusive igneous rock.

The diorite-andersite family is intermediate in composition between the granite-rhyolite and gabbro-basalt families. The composition of the family include:

- 45-70% plagioclase.
- 15-40% amphibole and biotite.

Orthoclase and quartz are present in minor amounts. The igneous rocks in this family are gray in color. The rock is diorite if parallel lines of plagioclase feldspar are seen. Also diorite frequently has a salt and pepper appearance.

The gabbro-basalt family is composed of:

- 10-60% plagioclase (high in Ca).
- 40-70% Ferromagnesian minerals (olivine, pyroxene, and amphibole).

These rocks crystallize from magmas that are relatively high in iron, magnesium, and calcium, but deficient in silica. Rock coloration is commonly dark gray to black or dark green. Basalts are heavy and often rings like a bell when struck with a hammer. Basalt is the most common extrusive igneous rock. Although gabbro is not a common constituent of the continental crust, it is believed to make up a significant percentage of the oceanic crust.

Rocks of the peridotite family are dark green or black in color. They are composed of:

- 65-100% olivine.
- 0-25% pyroxene.
- 0-5% plagioclas (Ca high).

Since this family contains over 65% olivine it falls near the very beginning of Bowen's Reaction Series. Peridotite is rare in the earth's crust; however, Use an igneous rock from the materials list. Use Member Handout ____, *Classification of Igneous Rocks* to:

- determine its texture
- determine its mineral content
- determine its name

Distribute remainder of rocks after dividing the group into pairs. Allow time for each group to identify their rocks. Then as a group check for correct identification and discuss any problems.

it is believed that most of the upper mantle is composed of peridotite.

Using what we have learned, let's use one of these rocks and work as a group to identify it.

I'm now going to distribute the remainder of the rocks and let you work in pairs to determine the name of each rock. After you have named all the rocks we will discuss what you decided.

Dialogue For Critical Thinking

Share:

1. What is your favorite igneous rock?
2. What igneous rocks could you find in your home?

Process:

3. When identifying igneous rocks, what properties do you look for?
4. What eight elements make up most of the earth's crust?
5. What six minerals or mineral groups make up the bulk of igneous rocks?

Generalize:

6. What characteristics do you observe when identifying different individuals?
7. What makes you a very special individual?

Apply:

8. How are igneous rocks important to you now? In the future?
9. How can your observation and classification skills help you in the future?

Going Further:

1. Go on a field trip to find and identify igneous specimens.
2. Visit a rock shop or a geology department at an university or college to view the various igneous rocks.
3. Take a trip to the library to look for available resources giving information on the classification of igneous rocks.

References:

Dole, Hollis M., "A Description of Some Oregon Rocks and Minerals", Miscellaneous Paper No. 1, State of Oregon Dept. Of Geology and Mineral Industries: Portland, Oregon, 1950 — revised in 1976 by Lawrence L. Brown.

Hamblin, W. Kenneth and James D. Howard, *Exercises in Physical Geology*, Prentice Hall, Inc.: Englewood Cliffs, New Jersey, 1995.

Plummer, Charles C. and David McGeary, *Physical Geology,* Wm. C. Brown Publishers: Dubuque, Ia., 1991.

Thompson, Graham R. and Jonathan Turk, *Modern Physical Geology*, Saunders College Publishing: Chicago, 1991.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Committee.

Reviewed by: Rex Buchanan, Kansas Geological Survey;

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Composition Plus Texture

Member Handout 23, Rock-Forming Minerals/Bowen's Reaction Series

Rocks, Igneous — Geology, Level IV

Silicate Material	Composition	Physical Properties
Quartz	Silicon dioxide SiO_2	Hardness of 7; will not cleave but has conchoidal fracture; specific gravity — 2.65
Feldspars		
Potassium feldspar	$KalSi_3O_3$	Hardness 6.0-6.5, two directions of cleavage; specific gravity — 2.5-2.6; color: pink or white
Plagioclase feldspar		Hardness 6.0-6.5, two directions of cleavage; may show striations on cleavage planes; specific gravity — 2.6-2.7; color: white and gray
Sodium rich	$Na(AlSi_3O_8)$	
Calcium rich	$Ca(Al_2Si_2O_8)$	
Micas		
Muscovite	$KAl_3Si_3O_{10}(OH)_2$	Hardness 2-3; one direction of cleavage, with thin, flexible plates; specific gravity — 2.8-3.0; colorless, transparent in thin sheets
Biotite	$K(Mg, Fe)_3AlSi_3O_{10}(OH)_2$	Hardness 2.5-3.0; one direction of cleavage, with thin, flexible plates; specific gravity — 2.7-3.2; color: black to dark brown
Pyroxenes	$(Mg, Fe)Si_2O_6$	Hardness 5-6; two directions of cleavage at 90°, specific gravity — 3.1-3.5; color: black to dark green
Amphiboles	$Ca_2(Mg, Fe)_5Si_8O_{22}(OH)_2$	Hardness 5-6; two directions of cleavage at 56° 124°, specific gravity — 3.0-3.3; color: black to dark green
Olivines	$(Mg, Fe)_2SiO_4$	Hardness 6.5-7; specific gravity — 3.2-3.6; color: light green

Temperature	BOWEN'S REACTION SERIES	Igneous rock types
High temperature (first to crystallize)		Ultramafic
	Olivine *Discontinuous series* Pyroxene *Continous series* Calcium	Mafic
Low temperature (last to crystalize)	Amphibole rich Biotite Sodium rich	Intermediate
	Potassium feldspar Muscovite Quartz	Felsic

Composition Plus Texture

Member Handout 24, Glossary

Rocks — Geology, Level IV

Amphibole: In igneous rocks are long black to dark green crystals in a light colored matrix. The two directions of cleavage occur at approximately 60 to 120 degrees. Hornblende is a common amphibole.

Aphantic: (Greek for not visible) Very fine texture in which the crystals of a rock can only be recognized with the aid of a hand lens.

Biotite: Mica that appears in igneous rocks as small black to dark brown flakes. It has perfect cleavage in one direction and reflects light.

Bowen's Reaction Series: A concept that illustrates the relationship between magma and the minerals crystallizing from it during the formation of igneous rocks.

Felsic: (Siliac) A general type of igneous rock that consists mainly of feldspar and silica. Last of the rocks to form, forming at a lower temperature.

Glassy: Texture of an igneous rock that is produced by very rapid cooling of the magma.

Mafic: A general type of igneous rocks so called because of their high content of magnesium (Ma) and iron (Fe).

Muscovite: A mica in igneous rocks that has brass-colored or colorless flakes and is associated with quartz or potassium feldspar. Has a perfect cleavage in one direction.

Olivine: Appears as glassy, light green grains in igneous rocks.

Phaneritic: (Greek for visible) Coarse texture that has crystals large enough to be recognized without the aid of a hand lens.

Phenocryst: A relatively large, early formed crystal in a finer matrix of igneous rock.

Plagioclase: Mineral group containing sodium silicate and/or calcium silicate. Appears as gray or white in granite and dark bluish color in gabbro. Striations are common and it has two cleavage directions at right angles.

Porphyritic: An igneous rock texture characterized by the distinctively different crystal sizes.

Potassium feldspar: May be known as orthoclase. Commonly colored pink, white or gray with a porcelain luster. Cleavage is in two directions at right angles and may be detected by a reflection of light when the specimen is rotated.

Pyroclastic: Rock fragments produced by volcanic explosion such as tuff and volcanic ash.

Pyroxene: Short, dull greenish black minerals in darker rocks. Cleave is in two directions at 90 degrees.

Quartz: Silicon dioxide (SiO_2) mineral that occurs in igneous rocks as irregular, glassy grains, commonly clear to smoky appearance and has no cleavage.

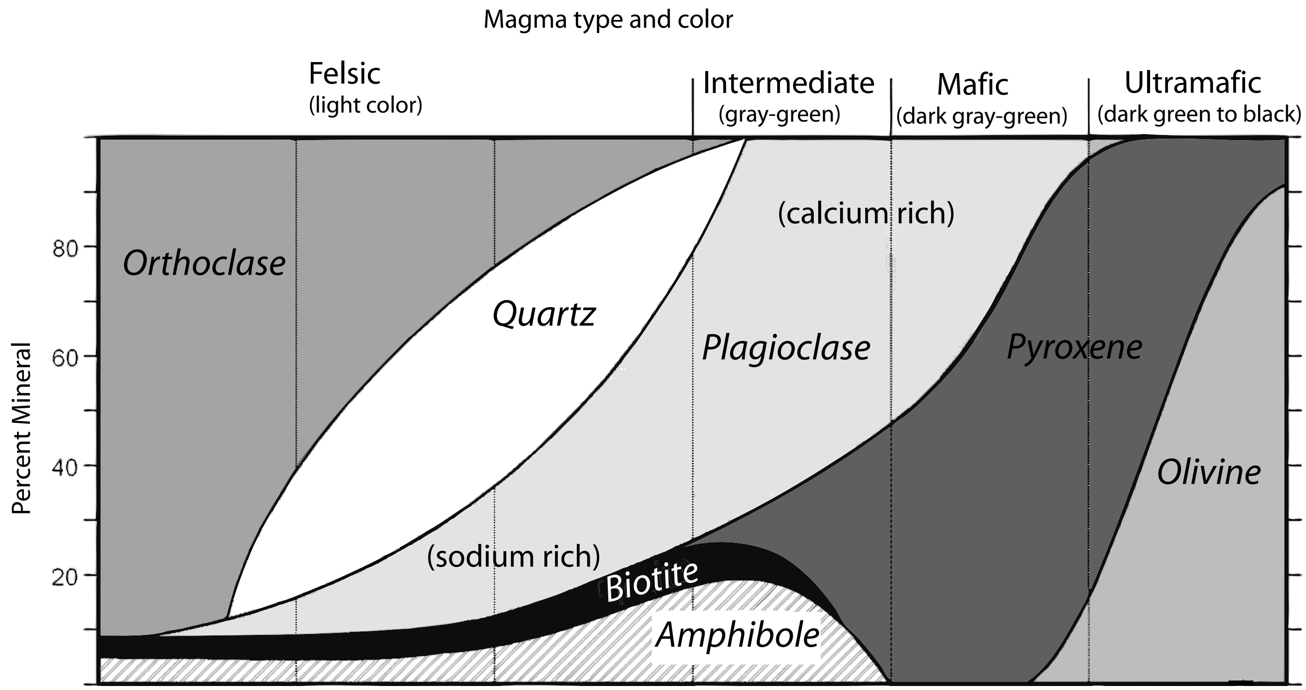
Silicate: A substance that contains silica as part of its chemical formula.

Vesicular: A term applied to igneous rocks that contain small cavities created by gas trapped in the cooling lava.

Composition Plus Texture

Member Handout 25, Classification of Igneous Rocks

Rocks, Igneous — Geology, Level IV



Texture						
Phaneritic (coarse)	Syenite	Alkali Granite	Plagio-granite	Diorite	Gabbro	Peridotite Dunite
Aphaneritic Porphoritic (fine)	Rhyolite (Porphyry)			Andesite (Porphyry)	Basalt (Porphyry)	
Vesicular		Pumice		Scoria		
Glassy		Obsidian				

The table at the top of the page is read vertically, from zero% at the bottom to 100% at the top (scale on left and right sides). For example, the composition of the rock on the farthest right side of the chart is (bottom up) about 92% olivine, and the remaining composition to the top about 8% pyroxene.

Igneous Rock Classification chart adapted from http://csmres.jmu.edu/geollab/Fichter/IgnRx/IgnRx.html

Lynn S. Fichter © 2000 (fichtels@jmu.edu) Department of Geology and Environmental Science; James Madison University, Harrisonburg, Virginia 22807

Changed Rocks

Rocks, Metamorphic — Geology, Level II

What members will learn …

About the Project:

- Metamorphic rock is a rock that has been changed by the action of heat and/or pressure without melting.
- Metamorphic rocks are classified on the basis of texture (foliated and non-foliated) and composition.
- There are two types of metamorphism, regional and contact.

About Themselves:

- How they react to change.
- Change is constantly occurring.

Materials:

For each member:

- Activity Sheet 38, *Metamorphic Activity*
- Activity Sheet 39, *Metamorphic Activity, Leader's Key*
- Activity Sheet 40, *Metamorphic Rock Identification*

For group:

- 10 dominoes
- 2 rulers
- 2 blocks of wood 4" x 4" x 3/4"
- 1 flat board, 5" x 4" x 3/4"
- 1 or 2 slab(s) of modeling clay or play dough, 4" x 4" x 1"
- newsprint pad
- easel
- felt tip marker
- samples of the following metamorphic rocks

• slate	• quartzite
• argillite	• hornfels
• phyllite	• marble
• schist	• mica schist
• gneiss	• schistose marble

Activity Time Needed: 90 minutes

Advance Preparation:

Secure from library or science teacher books which have information on metamorphic rocks. Give members reading assignments from those books or let them read portions at the meeting.

Leader's Notes

Play Dough Recipe

Heat to boiling:

Food Color

1 ½ cups water

½ cup salt

1 tablespoon oil

Stir boiling liquids into:

2 cups flour

2 tablespoons alum

Knead until smooth. Store in airtight container.

*Review lessons *How Rocks Change* and *Igneous Bodies*, from Level II.

Activity

When rocks are exposed to temperatures and/or pressures higher than those at which sedimentary rocks form, they can undergo some dramatic changes.

Today we are going to study about rocks that change, metamorphic rocks. You each had a reading assignment. Would each one of you please share with the group something you learned from your assignment?

Allow time for each to respond.

What types of rocks can change or go through the process of metamorphism?

Igneous, sedimentary, and metamorphic.

How do you think the changes occur?

Heat and pressure

What are two very important change agents or causes of change?

How does pressure change rocks?

Let's do an activity that might illustrate how pressure changes rocks. (See illustration in Leader's Notes.)

Will need:

10 dominoes

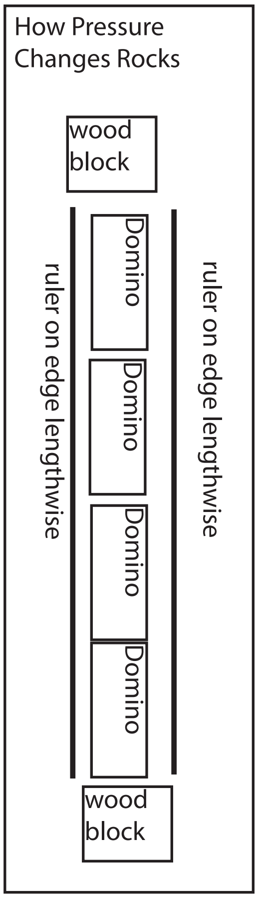
2 rulers

2 small blocks of wood

1 board

2 slabs modeling clay or play dough

Have members assist with activity.



1. With a block at one end arrange the dominoes end-to-end between the two rulers which are standing on edge. Have a member hold rulers and another hold block at end of dominoes.
2. Have a member measure length of the line of dominoes and record it.
3. Slowly and strongly push against the free end of the dominoes with the second piece of wood. Have a member measure and record new length of the domino line and note the direction of the movement.
   - Why are the rulers necessary?
   - What do they represent?
   - What changed the position of the dominoes?
   - What is the energy source in this activity? In the earth?
   - What direction did the dominoes move when pushed against by the second piece of wood?
   - What does this indicate about the directions and strengths of the pressures to which rocks are subjected when they show evidence of flowing or rupture?
4. Rearrange the dominoes, record the length of the line, and place the board on top of the rulers. Repeat the pressure with the small block. Observe and discuss any change in the position of the domino line. Measure its length and have a member record. What is the direction of movement? How did movement differ from Step 3?
   - How did pressure from all three sides affect the behavior of the dominoes?
   - Did the dominoes change position as freely as they did when there was no top pressure?
5. Have a member record the length and width of a strip of modeling clay or play dough. Arrange the clay between the rulers and again hold one end firmly with a block.
6. Push slowly and firmly against the free end of the clay with the other block. Discuss the observations, have a member record length and width of the altered clay, and sketch appearance of the clay on the newsprint pad.
7. Record measurements of second piece of clay, place between rulers, then place board on top of and repeat the end pressure. Ask a member to record the data.

Have following chart on newsprint pad.

Length of dominoes

before	after	drawing of results

Length of clay or play dough

before	after	drawing of results

What is the difference in the behavior of a solid and a plastic (clay or play dough) material under pressure?

How do you think this relates to changes in rocks?

Does complete melting occur during metamorphism? Why or why not?

In general, metamorphic changes require deep burial. While the rock is still solid, the original rock material may undergo the following changes:

1. Rearrangement of mineral grains (minerals begin to line up in bands or layers)
2. An enlargement of crystals (this occurs as the temperature around the rocks continues to rise)
3. Chemical reactions (additional rise in temperature and pressure plus a third agent of change — chemically active fluids — will all act in producing a chemical reaction change)

There are two types of metamorphism.

1. Regional Metamorphism

Regional metamorphism takes place at considerable depths over an extensive area and is associated with the process of mountain building. During mountain building great quantities of rock are subjected to the intense stresses and high temperatures associated with large scale deformation. These rocks are found deep within the interior of mountain chains and are believed to constitute the lower parts of the crust.

Based on texture, there are three groups of rocks that are among the rocks formed by regional metamorphism.

a. **Fine-grained rocks include: slate, argillite, phyllite**
These rocks are considered low-grade metamorphic rocks and are believed to result from metamorphism of shale or claystones. These rocks are all harder than shale.

b. **Intermediate-grained rocks**
These rocks have obvious foliation. Schist is an example of this type of rock. It commonly contains layers of mica alternating with layers of other minerals such as quartz and feldspar. This rock has a tendency to split along parallel planes and the minerals grow with flat surfaces perpendicular to the applied forces.
The increase in crystal size represents a higher grade of metamorphism in which chemical reactions can occur to form garnet, amphibole and other non-platy minerals.

c. **Coarse-grained rocks**
Rocks formed by regional metamorphism in this group represent a higher grade of metamorphism in which the minerals are recrystallized, stretched, crushed, and rearranged completely. Feldspar and quartz commonly form light colored layers that alternate with dark layers of ferromagnesium minerals such as biotite and hornblende. Gneiss is an example of a rock from this group of rocks formed by regional metamorphism.

A second type of metamorphism is known as

2. Contact metamorphism

This type of metamorphism develops at the margins of igneous intrusions. Heat is the most important influence in contact metamorphism

No, if complete melting occurred you would have magma, which would form an igneous rock.

Have following listed on newsprint pad:

1. re-arrangement of mineral grains
2. recrystallization
3. chemical reactions

Have the following written on newsprint pad:

Types of Metamorphism

- regional
- contact

During this discussion circulate the following rock samples:

- slate
- argillite
- phyllite
- schist

Foliation is from the Latin word meaning leaf. It means the parallel alignment of minerals in a rock.

Amphibole is one of the rock forming mineral groups containing iron, magnesium, calcium, and aluminum silicates.

Circulate a sample of gneiss (nice).

Ferromagnesium minerals are iron/magnesium bearing minerals which include biotites, amphiboles, pyroxenes and olivines.

because when rock is in contact with, or near, a mass of magma, contact metamorphism takes place. The high temperatures of the molten material in effect "bake" the surrounding rock. Hornfels are common contact metamorphic rocks. Hornfels can form from shale or from basalt.

Circulate a sample of hornfels.

Limestone recrystallizes during metamorphism into marble. Marble is a coarse-grained rock composed of interlocking calcite crystals.

Circulate sample of marble and quartzite.

Quartzite is produced when grains of quartz in sandstone are welded together while the rock is subjected to high temperature. This makes it as difficult to break along grain boundaries as through the grains.

Marble and quartzite can form under either contact or regional metamorphism. Marble and quartzite formed under regional metamorphism can be distinguished from those formed by contact metamorphism by their foliation as in schistose marble.

Circulate sample of schistose marble.

(Schistose is the texture of a rock in which visible platy or needle-shaped minerals have grown parallel to each other under the influence of directed pressure.)

The characteristics of a metamorphic rock are determined by:

1. Composition of the parent rock
2. Particular combination of temperature and pressure.

These factors cause different textures in rocks formed under different sets of conditions. For this reason, texture is usually the main basis for naming a metamorphic rock. Determining the mineral content is necessary for naming some rocks such as quartzite, but for others the minerals present are used as adjectives to describe the rock, such as mica schist.

Circulate mica schist sample

Looking at the locations of these igneous bodies, where would you expect contact metamorphism to occur? Regional metamorphism?

Distribute Activity Sheet 38, *Metamorphic Activity*.

Number the metamorphic rock samples. Distribute Activity Sheet 40, *Metamorphic Rock Identification*.

Dialogue for Critical Thinking:

Share:

1. What happened in the domino demonstrations? How were they different?
2. What was different when play dough was used?

Process:

3. What are the major differences between regional and contact metamorphism?
4. How would you distinguish between schist and gneiss? Between quartzite and marble?
5. Why is a building with blocks of quartzite more durable than one built of marble blocks?

Generalize:

6. Where else do you see change occurring?
7. How do you adapt to change? Is it easy or difficult for you to adapt to change? Why?

Apply:

8. What changes do you expect to make in the next five years? What factors will influence those changes?

9. Where in this state might you find a metamorphic rock? How did it get there?

Answer for No. 9:
In Kansas, the Rose Rome and Silver City Dome located in Woodson County.

Going Further:

1. Make a snowball and discuss the changes that occurred in the snow crystals. The recrystallization that takes place is very close to the metamorphic process. To make the snowball, pick up a handful of snow and compress it to form a lump sturdy enough to be used as a missile. Because of the pressure of your hands, the light fluffy crystals of snow in the center of the snowball will have re-crystallized in a more compact form.
2. Visit an igneous intrusion where metamorphic rocks are also exposed at the surface.
3. Collect, identify, study and discuss metamorphic rocks found in the state.
   In Kansas, the pink quartzite found in northeastern Kansas is the metamorphic rock that is generally available. This glacial erratic was carried from outcrops around Sioux Falls, South Dakota, about a million years ago during the periods of glaciation.
4. The only metamorphic rocks that originated in Kansas are found in Woodson County. The quartzite of Woodson County is a thin-bedded, slab-like hard rock of different colors — pink, gray, black and green. Hornfels is also found in Woodson County. Use resources from the Kansas Geological Survey, Kansas Academy of Science and Kansas 4-H Geology State Field Trips to further study metamorphic rocks found in Kansas.

Some people refer to quartzite found in the Kiowa Shale and Dakota Sandstone formations of the Cretaceous in Western Kansas, but it is not metamorphic. It is sedimentary rock cemented with calcite.

References:

For Youth:

Buchanan, Rex. *Kansas Geology, An Introduction to Landscapes, Rocks, Minerals, and Fossils*, University Press of Kansas: Lawrence, Kansas, 1984.

Dole, Hollis M., "A Description of Some Oregon Rocks and Minerals," *State of Oregon Dept. of Geology and Mineral Industries*: Portland, Oregon, revised 1976.

For Adults:

Barnes, John H., *Rocks and Minerals of Pennsylvania*, Pennsylvania, Geological Survey: Harrisburg, Pennsylvania, 1991.

Berendsen, R., "Kansas Academy of Science Multidisciplinary Guidebook 10 — Fall Field Trip in Greenwood, Woodson, and Wilson Counties Southeast Kansas," *Open-File Report 97-61, Kansas Geological Survey*: Lawrence, Kansas, October 4, 1997.

Brice, James C., Harold L. Levin, and Michael S. Smith, *Laboratory Studies in Earth History*, Wm. C. Brown:Debuque, Iowa, 1989.

Cullers, R.L., S. Ramakrishnan, P. Berendsen, and T. Griffin, "Geochemistry and Petrogenesis of Lamproites, Late Cretaceous Age, Woodson County, Kansas," *U.S.A. Geochemica et Cosmochemica Acta*, 49, p. 1383-1408,1985.

Frank, P.C., M. E. Bickford, and H.C. Wagner, "Metamorphism of Precambrian Granitic Xenoliths in a Mica Peridotite at Rose Dome, Woodson County, Kansas: Part 2, Petrologic and Mineralogic Studies." *Geological Society of America Bulletin*, v. 82, p2869-2890, 1971.

Hambleton, W.W., and D.F. Merriam, "Magnetic Anomalies in Wilson and Woodson Counties, Kansas," *Kansas Geological Survey Bulletin 114*, *Part 3*, p. 113-128, 1955.

Hamblin, W. Kenneth and James D. Howard, *Exercises in Physical Geology*, Prentice Hall, Inc.: Englewood Cliffs, New Jersey, 1995.

Mudge, B. F. "Metamorphic Deposit in Woodson County, Kansas," *Kansas Academy of Science Transactions*, v.7, p 11-13, 1981.

Tarbuck, Edward J. and Frederick K. Lutgens, *Earth Science*, Macmillan College Publishing Co.: New York, 1994.

Thompson, Graham R. and Jonathon Turk, *Modern Physical Geology*, Holt, Rinehart and Winston, Inc.: Orlando, Florida, 1991.

Wagner, H.C., "Geology of Fedonia Quadrangel, Kansas," *U.S. Geological Survey*, Map GQ 49, 1954.

Zartman, R.E., M.R. Brock, A.V. Heyl, and H.H. Thomas, "K-Ar and Rb-Sr Ages of Some Alkalic Rocks from Central and Western United States," *American Journal of Science*, V. 265, p. 848-870, 1967.

Author: Lois C. Bartley, Kansas 4-H Geology Curriculum Team.

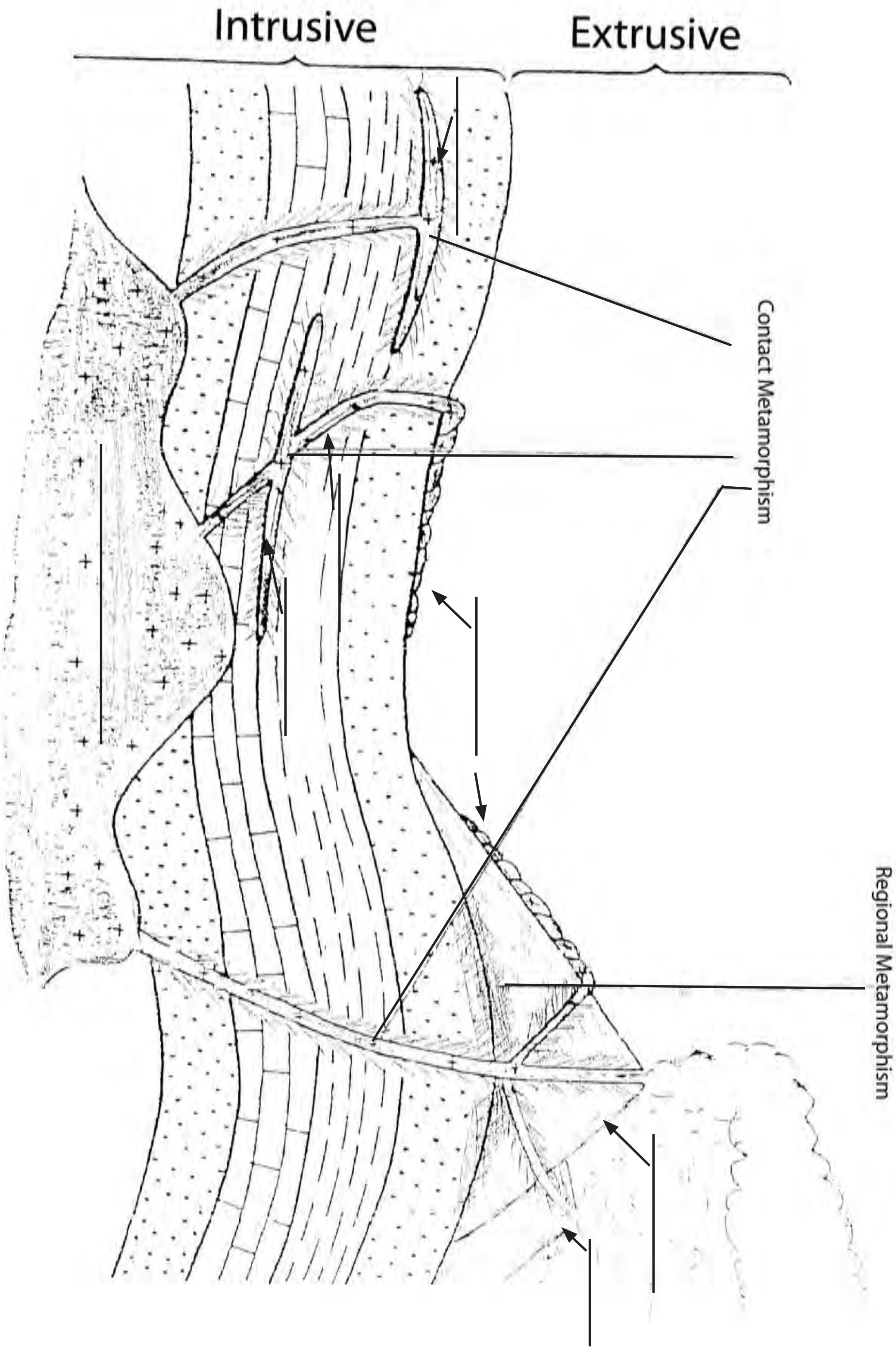
Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Changed Rocks

Activity Sheet 38, Metamorphic Activity

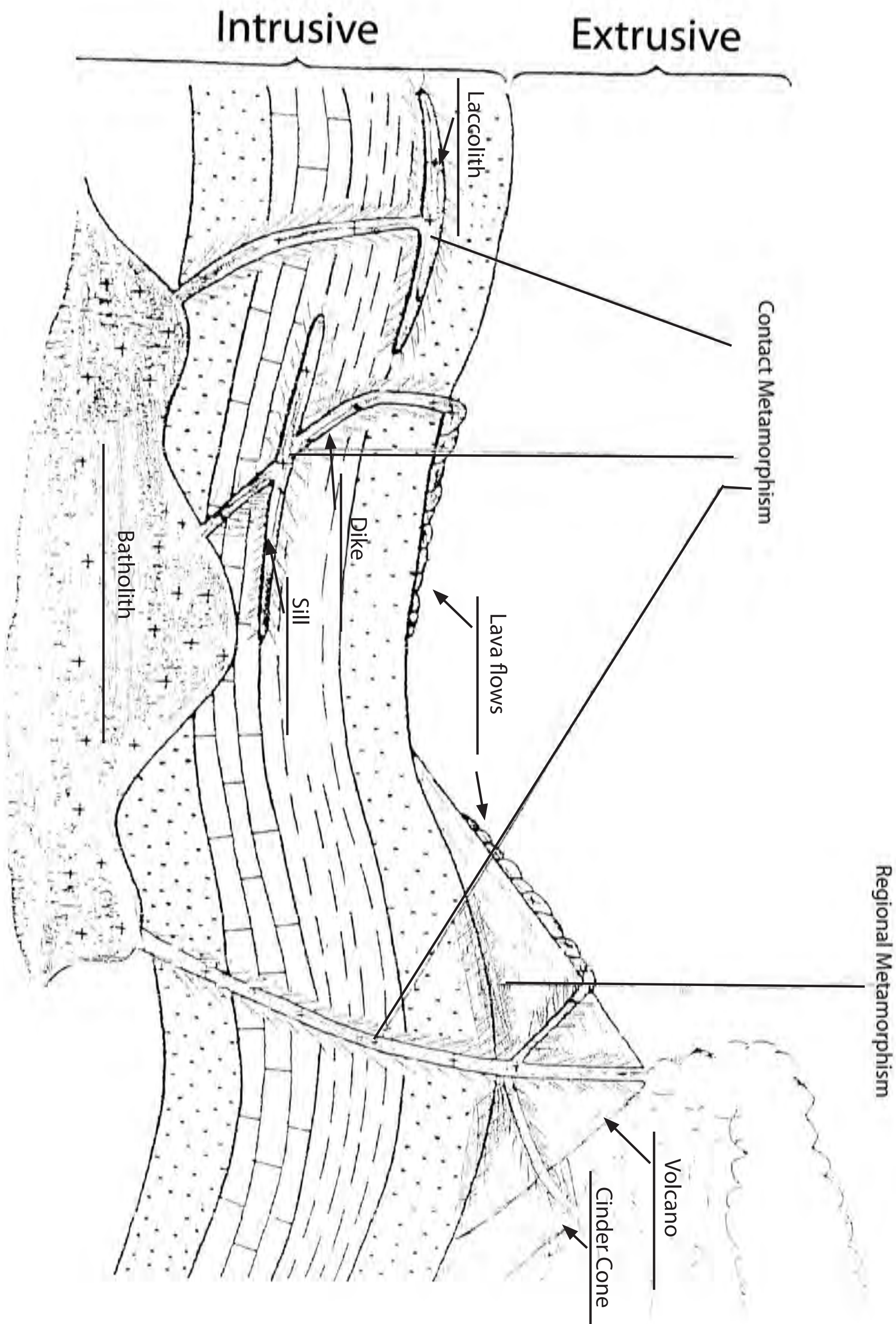
Rocks — Geology, Level II



Changed Rocks

Activity Sheet 39, Metamorphic Activity, Leader's Key

Rocks — Geology, Level II



Changed Rocks

Activity Sheet 40, Metamorphic Rock Identification

Rocks — Geology, Level II

Rock Number	Color	Texture: Grain Size	Texture: Foliated or Non-foliated	Common Minerals	Rock Name
Example	*Greenish to greenish-gray*	*Medium to coarse (granoblastic rock)*	*Nonfoliated rock*	*Dolomite, serpentine*	*Serpentine marble*

They Have a Name

Rocks, Metamorphic — Geology, Level III

What members will learn …

About the Project:

- Metamorphic rocks can be identified by determining texture and mineral composition.
- The texture may be foliated or nonfoliated.

About Themselves:

- How to identify and describe items.
- How to develop patience in learning.

Materials:

For each member:

- Member Handout 26, *Classification of Metamorphic Rocks*

For the group:

• easel	• metamorphic rocks
• newsprint pad	• slate
• dilute HCl	• schist
• nail	• gneiss
• magnifying lens	• marble
• quartzite	• phyllite
• hornfels	• mica schist

Activity Time Needed: 60 to 90 minutes

Activity:

The classification of metamorphic rocks is governed by structural features or texture, and mineral composition.

Texture is usually the main basis for naming a metamorphic rock. First determine if the rock has a foliated or nonfoliated texture. As a “parent” rock undergoes stress the reorientation of the mineral grains into a layered or banded appearance known as foliation may occur.

Foliation may be expressed as:

1. Slaty cleavage

Slaty cleavage is a type of foliation expressed by the tendency of a rock to split along closely spaced parallel planes. It is a product of a relatively low intensity of metamorphism. An example of this type of foliation is slate.

Leader’s Notes

Ask each member to bring a metamorphic rock to the meeting.

Ask each member to describe the rock he/she brought. As each rock is described have the following questions answered about each rock.

1. Does the rock show parallel or nearly parallel structure (foliation)?
2. Can you see some minerals in the rock? Can any of the minerals be identified?
3. Where did you obtain the rock?

As each member describes his or her rock make sure it is metamorphic.

Place on newsprint pad:

METAMORPHIC TEXTURE

1. Foliated
    - slaty cleavage
    - schistosity
    - gneissic layering
2. Nonfoliated

Circulate a sample of slate.

Circulate a sample of schist.

2. Schistosity

Schistosity is similar to slaty cleavage, but the platy mineral crystals are much larger, and the entire rock appears coarse grained. The increase in crystal size represents a higher grade of metamorphism in which garnet, amphibole and other nonplaty minerals also develop.

3. Gneissic layering

Circulate a sample of gneiss (nice).

This is a coarse-grained, foliated texture in which different minerals form alternating layers, each of which can be several centimeters thick. Rocks with gneissic layering represent a higher grade of metamorphism in which the minerals are recrystallized, stretched, crushed and rearranged completely. Feldspar and quartz commonly form light-colored layers that alternate with dark layers of ferromagnesium minerals.

Circulate a sample of marble.

Nonfoliated rocks appear massive and structureless. They are commonly formed from a parent rock composed largely of a single mineral, such as limestone. The resulting rock, marble, still consists of calcite but marble is a dense rock with coarse, irregularly shaped, interlocking grains.

Circulate a sample of quartzite.

Determining the composition or mineral content is necessary for naming some rocks such as marble, which consists of calcite or quartzite. Since quartzite was originally sandstone the main mineral is quartz. Therefore quartzite will scratch glass and consists of interlocking grains of quartz. When broken it will break through the quartz grain, not around the quartz grain as it does in sandstone.

In other metamorphic rocks the minerals present are used as adjectives to describe the rock such as mica schist.

Circulate mica schist

Here is a chart that helps to identify metamorphic rocks by taking into consideration the rock texture and composition.

Distribute Member Handout 26, *Classification of Metamorphic Rock*s

Slate is a very fine-grained rock, which will split into sheet-like slabs. The constituent minerals are commonly so small they can only be seen under high magnification. Slates are dense, brittle and have an earthy luster. Colorations may be bluish-gray, red, green or black. Slate is a low-grade metamorphic rock derived from the metamorphism of shale. We have already looked at some slate. Which of the specimens is slate?

Circulate a sample of phyllite.

Phyllite is similar to slate but has a satin or silky sheen. The mica flakes responsible for the luster can be seen only with magnification, but the mineral grains are coarser than in slate.

Schist is a metamorphic rock in which foliation is due to the parallel arrangement of relatively large crystals of platy or needle-like minerals. Mica, chlorite and talc are the important platy constituents. Quartz, garnet and hornblende are common accessory minerals. Schist may be further classified on the basis of the more important minerals present such as chlorite schist, mica schist, hornblende schist, etc.

Schists are produced by a metamorphism of higher intensity than that which produces phyllite. A variety of parent rocks — including basalt, granite, sandstone, and shale may be converted to schist. Which specimen was schist? What do you think its parent rock was?

Gneiss is a coarse-grained, foliated metamorphic rock, commonly with marked layers composed of different minerals. Feldspar and quartz are the chief minerals in gneiss, with significant amounts or mica, amphibole, and other ferromagnesian minerals. Gneiss resembles its parent rock — granite or diorite — in composition but is distinguished from these igneous rocks by the foliation. Which specimen is gneiss?

Quartzite is a nonfoliated rock developed from sandstone. Quartzite has a mosaic texture of interlocking grains of quartz and will easily scratch glass. Which specimen is quartzite?

Marble is a nonfoliated fine- to coarse-grained rock composed of calcite or dolomite. It is relatively soft in that it can be scratched with steel and it displays effervescence with hydrochloric acid. Which specimen is marble?

Hornfels is a very dense, hard, nonfoliated metamorphic rock in which the granules are too small to be seen without a microscope and all traces of original stratification or structure have been destroyed. Colors range from light gray and pale green to very dark gray with dark hues being more common.

Circulate a sample of hornfels.

Hornfels forms near intrusive igneous bodies where the invaded rock such as shale, slate, limestone and basalt is greatly altered by high temperature. A hornfels may have a few larger crystals of uncommon minerals enclosed in the fine-grained mass.

Looking at the chart and using the information about composition and texture, what do you think a nonfoliated rock that consisted of 95 percent quartz and 5 percent rock fragments would be called?

Refer to Member Handout 26, *Classification of Metamorphic Rocks*.*

Quartzite

What would be the origin rock?

Sandstone

What is the name of a foliated rock with visible flaky or elongate minerals? It consists of 70 percent biotite and 25 percent garnet.

Probably a mica schist because it is rich in mica with visible minerals.

Each of you described your rock earlier. Look at it again. How many of you would say the texture of your rock is foliated? Nonfoliated?

All of you who have a foliated rock please form a group and as a group determine the name of each of your rocks.

The same is to be done by those of you who have nonfoliated rocks. After you have all identified your rocks we will go back over them.

Form two groups:

- A foliated group
- A non-foliated group

Let members know you have supplies available to help identify specimens. Allow time for identification. Have each group report rock names and identifying features.

* **Note:** The following information helps explain Member Handout 26, *Classification of Metamorphic Rocks*.

The formation of metamorphic rocks is so complex that developing a satisfactory classification system is difficult. The most convenient scheme is to group metamorphic rocks by structural feature, with further subdivision based on composition. Using this classification, two major groups of metamorphic rocks are recognized: (1) those that are foliated (possess a definite planar structure), and (2) those that are non-foliated, that is, massive and structureless. The foliated rocks can then be subdivided further, according to the type of foliation. Finally, a large variety of rock types can be recognized in each group, according to the dominant minerals.

Dialogue For Critical Thinking:

Share:

1. Which was the largest group formed, foliated or non-foliated? Why do you think that occurred?
2. What did you discover helped you most in identifying the mineral contents?

Process:

3. Name some metamorphic rocks that are foliated.
4. How does gneiss differ from the rock from which it was formed?
5. What are the two types of textures metamorphic rocks may display?
6. What happens when a metamorphic rock is melted by heat?

Generalize:

7. Where in this state can metamorphic rocks be found?
8. What method of classifying do you prefer? Key? Samples? Why?

Apply:

9. How will classifying skills help you in the future?
10. What other metamorphic rocks might you use?

Possible answers to No. 10:

- Anthracite (coal)
- Serpentinite (schistose)
- Soapstone (talc and chlorite plus other minerals)
- Greenstone (gabbro and dolerite with chlorite)

Going Further:

1. Visit the geology department of a university where metamorphic rocks are on display.
2. You, or a member of your group, could develop a Metamorphic Rock Game Board that members can use to strengthen skills of identifying metamorphic rocks. **Refer to game board outline found in *Igneous Rock Identification* — Level IV.**

References:

Hamblin, W. Kenneth and James D. Howard, *Exercises in Physical Geology*, Prentice Hall, Inc.: Englewood Cliffs, New Jersey, 1995.

Plummer, Charles C. and David McGeary, *Physical Geology,* Wm. C. Brown Publishers: Dubuque, Ia., 1991.

For Youth:

Fenton, Carroll Lane and Mildred Adams Fenton, *The Rock Book*, Doubleday and Company, Inc.: Garden City, New York, 1945.

Author: Lois C. Bartley, 4-H Geology Curriculum Team.

Reviewed by: Rex Buchanan, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

They Have a Name

Member Handout 26, Classification of Metamorphic Rocks

Rocks, Metamorphic — Geology, Level IV

	Texture	Composition	Rock Name	Usual Parent Rock	Identifying Characteristics
Foliated	Very fine-grained; slaty	Chlorine, Mica, Quartz	Slate	Shale	Splits into thin flat sheets. Has earthy luster.
	Fine-grained; between slaty and schistose	Chlorine, Mica, Quartz, Feldspar, Amphibole	Phyllite	Shale	Usually splits along wavy surfaces. Has a silky luster.
	Coarse-grained; schistose	Chlorine, Mica, Quartz, Feldspar, Amphibole, Pyroxene	Schist	Basalt Quartzite Sandstone Shale	Composed of visible platy minerals that show parallel alignment. A wide variety of minerals can be found in various types of schist.
	Coarse-grained; gneissic	Mica, Quartz, Feldspar, Amphibole, Pyroxene	Gneiss	Granite Diorite	Light and dark minerals are found in separate, parallel layers. Usually the dark layers include biotite and hornblende; the light colored layers are composed of feldspar and quartz.
Nonfoliated	Fine- to coarse-grained	Quartz	Quartzite	Sandstone	Has a sugary appearance, vitreous luster, scratches glass
		Calcite Dolomite	Marble	Limestone Dolomite	Hardness is between glass and fingernail. Calcite effervesces in weak acid.
	Fine-grained	Clay, micas Clay, ferromagnesium minerals, plagioclase	Hornfels Hornfels	Shale Basalt	Dark rock that generally will scratch glass. May have a few coarser minerals present.

Rock Identification Member Reference

Rocks — Geology, All Levels

Rocks and Their Identification

Rocks are the essential building materials from which the earth is constructed. Any naturally occurring mass that forms a part of the earth's crust is a rock. You can classify rocks in four ways: By their texture; their mineral content; their color, which is associated with mineral content; and their origin.

Rocks are mixtures of various kinds and amounts of minerals, and the size of the individual particles that make up the rock determines its texture. The rock name is related to the most abundant mineral. For example, a limestone must contain more than 50 percent of the mineral calcite. Shale must contain more than 50 percent clay, etc.

The three main types of rock are: Igneous, Sedimentary, and Metamorphic.

Igneous (Fire) Rocks

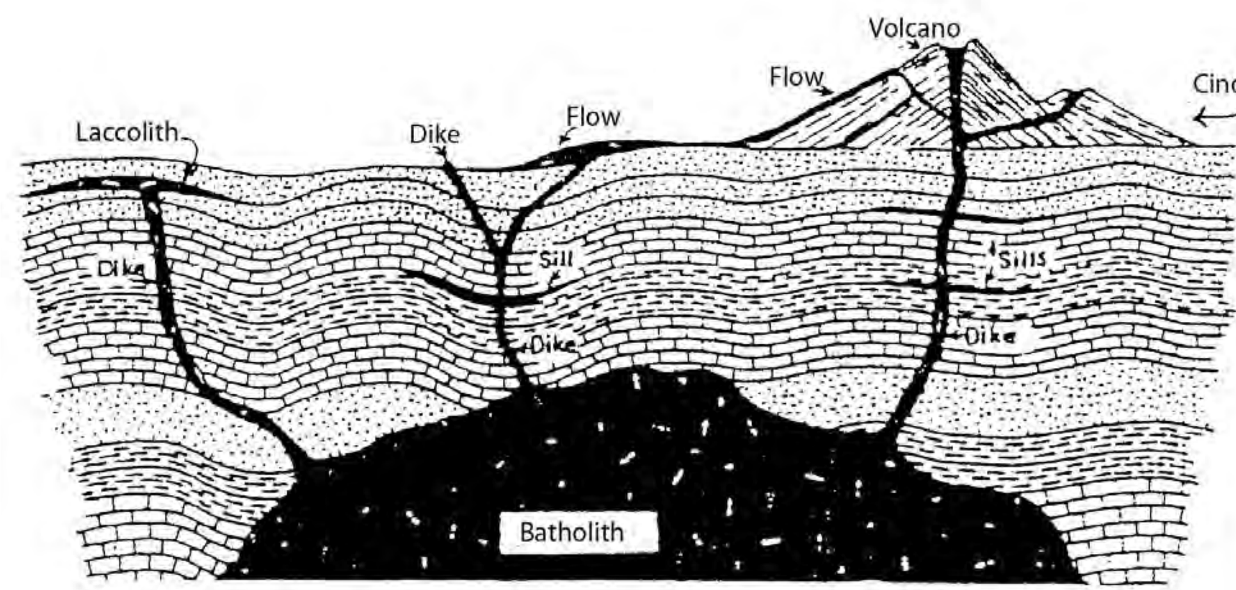
Igneous Rocks are those that have been formed by the cooling and hardening of molten rock material. The word molten means melted and signifies a hot liquid. This liquid is called magma - a Greek word meaning dough.

This magma is deep within the earth, and is the first stage in the rock cycle. It explains how various minerals in the rocks got together.

If magmas cool deep within the surface of the earth, they form "intrusive igneous rocks," ones that stay under the surface. If they later are exposed at the surface of the earth, they may be identified as intrusive igneous rocks because their slow cooling formed coarsely crystalline rocks.

Magmas which reach the earth's surface form "extrusive igneous rocks." These rocks are finely crystalline or glassy because they cooled rapidly.

A major reason for the differences in intrusive and extrusive igneous rocks is the rate at which they cooled.



This illustration shows ways in which magmas reach the earth's surface.

Igneous rocks are not common in Kansas. With the exception of five small areas of igneous rocks in Riley County and two areas in Woodson County, all igneous rocks were formed elsewhere and brought to Kansas by ice or water. Many boulders of igneous rocks were deposited by glaciers in northeast Kansas. Most gravel pits of the western and south central parts of the state contain pebbles and cobbles of igneous rocks in deposits of out-wash materials from the Rocky Mountains.

Batholiths are massive areas of magma that cooled very slowly far beneath the surface of the earth. As a consequence, very large crystals or particles are a usual characteristic by which we can recognize batholiths when erosion exposes them to view. These rocks are called intrusive igneous rocks.

Laccoliths are formed by irregular masses of magma intruded between layers of sedimentary rock. Because they are formed nearer the surface or because of their smaller size, they cool more quickly than batholiths, and have finer textures.

Sills are layers of igneous rocks "sandwiched" between layers of sedimentary rocks. **Dikes** are layers of igneous rocks formed from magma which flows on the surface and cools very rapidly. These rocks are called **extrusive igneous rocks**.

The magma which spills out of a volcano is called **lava**. Because of the gases formed by the volcanic action, lava is often quite porous. One example is **pumice**, which is so porous it is frequently light enough to float on water.

In most cases when volcanos erupt a cloud of fragments and fine particles are thrown far into the air. **Volcanic ash**, formed in this way, may be carried by the wind and deposited hundreds of miles from the site of the volcano. Kansas has several volcanic ash deposits originating millions of years ago from volcanos in the Rocky Mountain area to the west.

If you are just beginning your collecting experience, you do not need to classify your samples of igneous rocks according to origin, texture, etc. If you are in a more advanced group, however, use the following simplified classification of igneous rocks to help you classify your sample.

Simplified Classification of Igneous Rocks

Texture or grain size	Light colored: Principal material: orthoclase feldspar, some biotite or amphibole		Intermediate: Principal minerals: plagioclase and orthoclase feldspar amphibole, biotite, pyroxene		Dark colored: plagioclase feldspar, pyroxene, amphibole, olivine
	with quartz	no quartz	with quartz	no quartz	
Very coarse-grained	Pegmatite				
Coarse- to medium-grained	Granite	Phonolite Syenite (1)	Granodiorite Quartzdiorite	Diorite	Gabbro Pyroxenite (pyroxene only) Peridotite
Fine-grained (2)	Rhyolite	Trachyte	Dacite	Andesite	Basalt
Porous	Pumice		Pumice		Pumice
Glassy	Obsidian				
Fragmented or broken	Fine-grained: ash or tuff Coarse-grained: breccia or agglomerate				

(1) Contains a soda-rich orthoclase and pyroxene.

(2) If mixed-grain or crystal sizes occur, then the rock is called a porphyry — for ex., Andesite porphyry.

Sedimentary (Layered) Rocks

Sedimentary rocks are by far the most common rocks in Kansas. In fact, all the surface exposures of the state, with very few exceptions, consist of this type of rock.

As soon as rocks were formed at the surface of the earth, they began to be worn down by the abrasive action of wind, water and ice. Rain pouring down the mountains washed away loose chunks and small particles. Streams carried the stones along, bumping and scraping and banging them together, crushing some of them into sand and some into fine powder. The wind, filled with tiny sharp-edged grains of hard quartz, cut away at the rocks.

Water seeped into rocks, freezing and splitting them apart. Glaciers crept down mountains, crushing and grinding rocks and ice together, until even the hard pebbles of quartz were ground to sand.

Water carried the clay, silt and sand down to quieter lakes and oceans. There the material was dropped in the form of sediments. Layer after layer of sediment settled to the bottom of the lakes and oceans. Because of the great weight of sediments over a long period of time, the pressure hardened the sediments into rocks. This process of forming sedimentary rocks by compaction and cementation is continuing today as erosion levels the surface of the land. Rocks formed in this manner are called **clastic sedimentary rocks**.

There are two other groups of sedimentary rocks. The second group includes those formed from chemical action. Chemicals present in the waters of lakes and oceans are precipitated in the water and settle to the bottom in layers of sediments. Or they are precipitated in other rocks through evaporation. Later, pressure or the cementing action of the chemicals hardens them into rocks. Chemical deposits include gypsum, salt beds, some siliceous rocks (such as chert), some iron ores and some carbonate spring deposits (travertine).

The third group of sedimentary rocks are deposits from organic origin. They represent the bodies of plants and animals that decayed in the water and were laid down in layers. These rocks include many limestones, some siliceous oozes, diatomaceous earth, many iron ores and coal.

Sedimentary rocks are classified by means of texture, structure, color, acid tests, mineral content and, in the case of coal, by burning.

The size, shape and pattern of the grains, or particles, in a rock are included in the term **texture**.

If the particles are predominantly clay size (smaller than 0.005 millimeter in diameter), the sedimentary rocks are called shales. When the particles are slightly larger (0.005 to 0.05 millimeter in diameter) than clay, the rocks are called siltstone. Those still larger (0.05 to 1.0 millimeter) are called sandstone.

Sometimes the sizes of the particles are mixed. Clays and sands may be found in the same deposits with pebbles, cobbles or boulders. In this case the rock is called a conglomerate (if the edges of the pebbles, etc., are rounded) and named for the particle that is predominate. An example would be sandstone conglomerate.

Structure is a term reserved for the larger features of rocks. A layered or laminated structure generally indicates that the rocks are of sedimentary origin.

If the rock contains numerous spherical or almond shaped cavities or vesicles (formed by the expansion of gases in molten rock matter), it has a vesicular structure and is of igneous rather an sedimentary origin.

Many rocks will split into specific geometric shapes and layers when struck with a hammer. According to whether or not these specific patterns occur, we call the rock cleavable or not cleavable.

Color is not always a reliable guide to the classification of rocks. Many minerals, each with a different color, may compose one rock. When the mineral grains are small, a rock may present to the naked eye or hand lens an overall color easy to describe. This may help with broad classifications but not the detailed separations used by professional geologists in naming rocks.

Acid tests are particularly helpful in identifying sedimentary rocks containing calcium carbonate. Limestone rocks will effervesce, or fizz, when hydrochloric acid is dropped on them. If you use hydrochloric acid for this purpose, remember that it must be handled carefully. To make its use safer, use a dilution to 10 percent normal strength.

If a sedimentary rock contains more than 50 percent calcium carbonate, it is called limestone. Dolomite is a sedimentary rock containing magnesium carbonate as well as calcium carbonate. It will not fizz unless it is finely ground and the hydrochloric acid is hot.

Mineral content can be the best means of identifying rocks when the individual mineral particles are visible. This method requires knowledge of the physical properties of the minerals.

Burning in an ordinary fire is one way to distinguish organic rocks like coal from rocks composed entirely of mineral particles.

Metamorphic (Changed) Rocks

Metamorphic rocks are the third main kind of rocks. You remember that magma can flow underground. As it changes to igneous rocks, the surface rocks are squeezed and pressed until they actually bend and fold. Several layers of rocks can be squeezed and compressed in this way. The pressure and heat make them change into a new kind of rock. This is called recrystallization. Most metamorphic rocks show this distinctive characteristic. You will find small bands that are distinctive in some of the metamorphic rocks.

Following is what happens to certain rocks when they are changed over into metamorphic rocks:

Granite changes into a rock called gneiss, which is pronounced "nice." Gneiss appears streaked, not speckled like granite. It has light and dark streaks. Each mineral is sorted into its own layer.

Limestone changes into marble. When you break a piece of marble, it often looks like a lump of sugar. You can see shiny clear grains in it. Very often you will find wavy twisted bands of color in marble. They are the same colors you will find in limestone — gray, yellow, red and black.

Shale changes to slate. Remember that shale is compacted and cemented mud and clay. It is usually crumbly and soft. Heat and pressure make it over into a hard rock that does not crumble. Slate can be split into thin layers, so it is often used on the roofs of houses. It is so smooth that long ago children did their lessons on thin pieces of slate at school. Slate is usually gray or black but may be brown, red, green or purple.

Many pebbles and boulders of metamorphic origin are found in Kansas, but with the exception of two areas in Woodson County, they are not native to the state. There are quartzites in Woodson County, but there apparently are no surface exposures of either marble or slate in Kansas.

Reference: Jones, Harold E. *Exploring the World Through Geology*. Cooperative Extension Service: Manhattan, KS, 1971, pages 12-15.

Sedimentary Structures Member Reference

Rocks — Geology, All Levels

In addition to rocks and minerals, a number of other formations are best labeled "sedimentary structures." These formations, although composed of rocks and minerals, require additional explanation. Some, such as concretions or cone-in-cone, may be mistaken for fossils. Others, such as geodes, can be spectacularly beautiful. Some structures, such as ripple marks, give clues about the climate and geology during geologic history. Some states may have all of these while other states may have only a few of these structures.

Casts of salt crystals

When salty mud dries, its surface becomes more or less covered with crystals of halite. Many of these crystals are cubes, but some have hollow faces and are known as "hopper" crystals. As they are covered up by more sediments, the salt itself may be dissolved, but the crystal outlines are commonly preserved (filled with mud or silt) and are known as salt casts.

Concretions

A hard, compact aggregate of mineral matter, subspherical to irregular in shape, formed by precipitation from water solution around a nucleus, such as a shell or bone, in a sedimentary or pycroclastic rock.

Cone-in-Cone

A structure in thin, calcareous shale layers that resembles a set of nested cones with apexes downward; generally of fibrous calcite.

Conglomerate

A coarse-grained clastic sedimentary rock, composed of rounded to subangular fragments larger than 2 mm in diameter (granules, pebbles, cobbles, boulders) set in a fine-grained matrix of sand or silt, and commonly cemented by calcium carbonate, iron oxide, silica, or hardened clay.

Geode

A hollow, more or less globular body, found in certain limestone and volcanic rocks. Significant features include a thin outer layer, partial filling by inward-projecting crystals.

Mud Crack

An irregular fracture in a crudely polygonal pattern, formed in loose sand by the shrinkage of clay, silt, or mud, generally in the course of drying under surface conditions.

Oolith

One of many small rounded accretionary bodies in a sedimentary rock, resembling fish eggs, with a diameter of 0.25 to 2.0 mm. It is generally formed of calcium carbonate, in concentric layers around a nucleus such as a sand grain.

Pseudomorph

A mineral exhibiting an outward crystal form of another mineral, it is described as being "after" the mineral whose outward form it has. Example: Limonite is a pseudomorph after pyrite.

Ripple Marks

Small scale subparallel ridges and troughs formed in loose sand by wind, water currents, or waves; also, such forms preserved in consolidated rock.

Septarian — A concretion that has fractured and re-cemented. May resemble a turtle shell.

Source: *Kansas Rocks and Minerals*; Kansas Geological Society
Dictionary of Geological Terms; The American Geological Institute

Author: Sara Murphy, 4-H Geology Curriculum Team.
Reviewed by: Rex Buchanan, Kansas Geological Survey

Note: Sedimentary structures may be exhibited in 4-H Geology boxes provided the correct rock or mineral is listed before the structure. Example: Calcite Cone-in-cone

Kansas 4-H Geology Leader Notebook

Chapter 5 — Fossils, Table of Contents

You Ol' Fossil

Fossils — Geology, Level I

What members will learn …

About the Project:

- What is a fossil?
- Steps a plant or animal go through to become a fossil.
- How long it takes to make a fossil.

About Themselves:

- How learning can be fun.
- The importance of learning and sharing historic stories.

Materials:

- 5 chicken bones
- 1 cup vinegar
- 1 cup salt water
- 2 cups dirt
- 2 cups clay
- 2 cups peat moss
- Activity Sheet 41, *How Fossils are Formed*
- Activity Sheet 42, *How Fossils are Formed, Word Blocks*
- Activity Sheet 43, *Fossil Enrichment*
- Activity Sheet 44, *Fossil Enrichment, Leader's Key*
- Baggies

Activity Time Needed: 30 minutes

Activity

Have you ever heard someone referred to as an "ol' fossil?" Today we are going to find out just what fossils are. Do you know what a fossil is? The definition of a fossil is: "Any naturally preserved, part, trace or all parts of an animal or plant that lived a very long time ago."

A fossil is evidence of prehistoric life, either plant or animal, which gives some indication of the shape, structure, or habit of the plant or animal. A fossil has been buried for a *long* time. Petrify is another term used sometimes when talking about fossils, *petrify* means turn to stone.

Leader's Notes:

Explain that it is a term for someone very old or their opinions are extremely antiquated.

Is it feasible for the members to collect millions of something? Explain that it might take more than their lifetime to collect such large numbers as a million.

Hand out Activity Sheets 41, *How Fossils are Formed,* and 42, *Word Blocks*. Let members cut fossil pictures and word blocks apart and then try to match the picture to the word blocks in the correct order of how a fossil is formed before you give the answers of discussion. After you give them the answers, have them clear the table, mix up the answers and pictures, and see how fast they can match them again.

Answers: Sequence and Word Block Match — 5-F; 6-C; 1-E; 3-D; 4-A; 2-B.

This experiment can be started one week and checked at the project meetings over a period of time. You may also want to assign this as a home project with members recording results and comparing at a project meeting. This experiment can also be done in different locations outdoors, or use other mediums. You may consider using covered containers. You may also need to add more liquids as time goes on, such as salt or vinegar, as it evaporates.

How do we learn about the past through fossils? Millions of years ago there were no people to tell us about the plants and animals that lived, so we have to learn from the fossils. A million years is a short time in the span of the earth's history. Do you know of a building that has a million bricks in it?

Fossils tell us about when they lived (by the age of the rocks they are found in); where they lived (in water or on the land); what they ate (by the shape of their teeth or the absence of teeth); and their enemies or predators (marks left on shell or bones from other animals).

Most plants and animals did not become fossils when they died. The conditions were not right to be preserved as fossils. They simply rotted or crumbled, dried up and blew away, or were eaten by other animals. No trace was left of them. Countless plants or animals were never preserved as fossils so there are whole groups of plants and animals unknown to us. It is estimated that only 1 to 2 percent of all things that ever lived on earth have been preserved and found. Conditions have to be just right to make a fossil.

What are the steps a plant or animal goes through to become a fossil?

1. The animal dies.
2. It is buried immediately by sand or mud, tar, ash, etc.
3. It remains buried in one place for a long time.
4. Circulating water containing calcium carbonate or silica will react with its hard parts to make a fossil. (This is the replacement process.) It is the exchange process of mineral matter for animal parts or plant matter.

A bone or imprint stands a better chance of being preserved in some environments than others. Try this experiment.

1. Place five chicken bones in five containers containing different materials such as vinegar, peat moss, salt water, clay, and dirt.
2. Check on the bones once a week and record any changes.
3. After four weeks, which bone showed the least amount of change? The greatest amount of change?
4. What are the reasons for any differences among the bones?

Why study and collect fossils?

1. They tell us what animals of the past were like.
2. They tell what the environment and conditions were like.
3. If we know what fossils are found in one rock formation we can identify it at other places.
4. We can compare the age of rocks in different parts of the continent.

The record of life on earth is preserved in the fossils in rocks. Most fossils represent only the hard parts of plants and animals. However under ideal conditions, soft tissue and soft-bodied organisms can be preserved. What animals have no remains on the rock? A few living things such as jellyfish, the slugs or shell-less snails, etc. have soft bodies, which at death dissolve and seldom leave fossils.

Hand out Activity Sheet 43, *Fossil Enrichment*. This activity may work better in your group as a discussion and answer activity.

Dialogue for Critical Thinking:

Share:

1. How difficult was it to match the descriptions and arrange the order of fossil formations?
2. What major changes did you see in the chicken bones (After four weeks)? Why?

Process:

3. What is the most significant aspect of an animal that helps form fossils? Why?
4. What types of things can we learn from fossils?

Generalize:

5. What did you enjoy most from this lesson? Why?
6. How are fossils like remembering special events or activities?

Apply:

7. How do your parents record, remember, and share family history?
8. How do you think history will be recorded in the future?

Going Further:

Another experiment to show how a fossil could be preserved can be done at home.

1. Put about 2 inches of fine, clean sand in a container.
2. Arrange a fresh flower on the sand in its natural position.
3. Sprinkle sand carefully between the flower parts.
4. Cover with several inches of sand.
5. Allow about 3 weeks for the drying process.
6. Carefully remove the specimen, brush sand off with a soft brush. The flower should look like a fresh cut flower.

A few organisms are covered by wind blown sand on deserts or beaches or by falling ash from volcanic eruptions.

References:

Culver, Diann, *Dinosaurs*, 1993, Teacher Created Materials, Inc., Huntington Beach, CA 92647 (Thematic Unit)

Ramsey, Gabriel, McGuirk, Phillips, Watenpaugh, *Holt Earth Science Exercises and Investigations, Teacher's Edition*, Holt, Rinehart and Winston, Publishers, 1986.

Author: Sara Murphy, 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

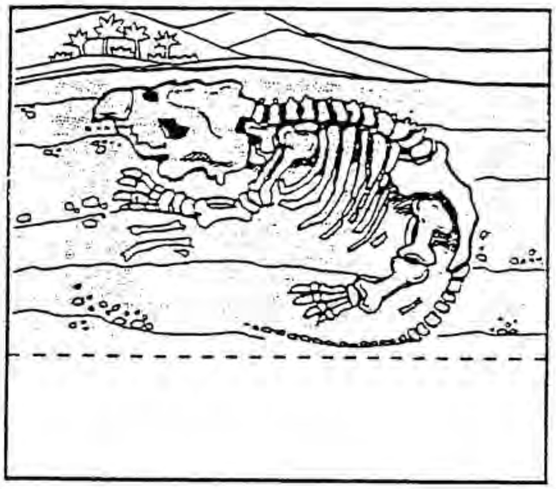
James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

You Ol' Fossil

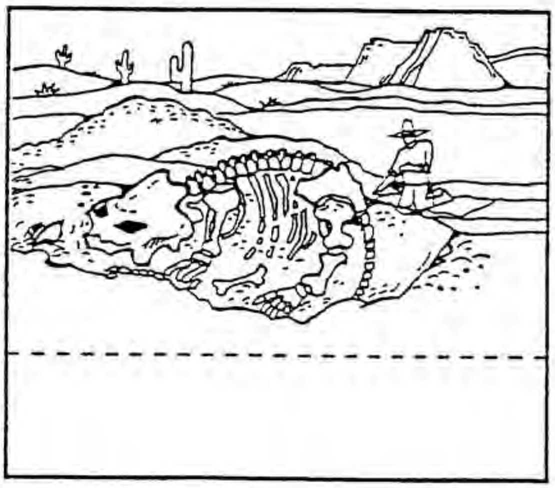
Activity Sheet 41, How Fossils Are Formed

Fossils — Geology, Level I

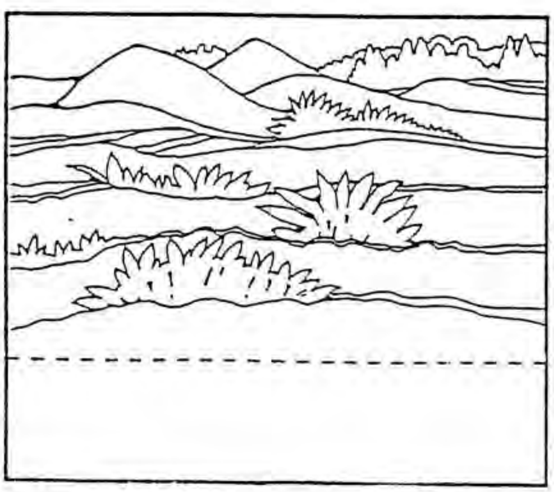
1



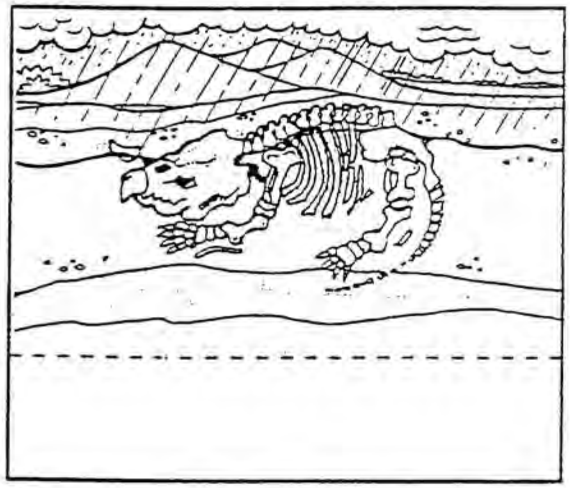
2



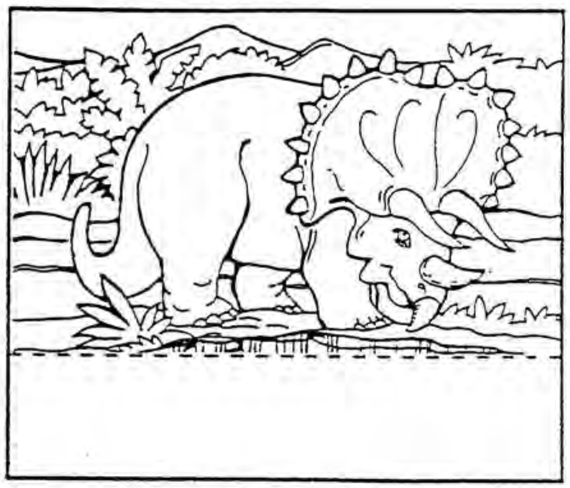
3



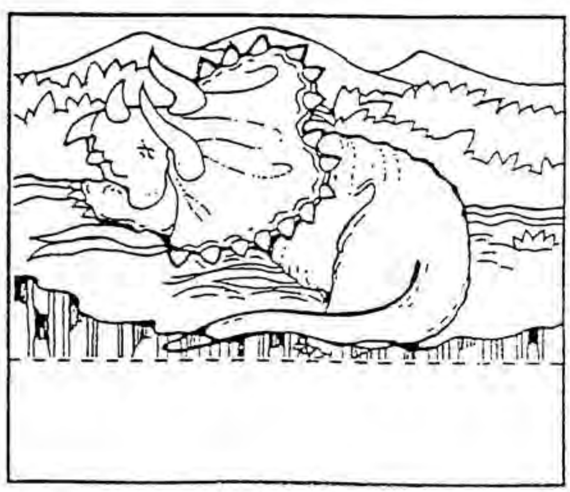
4



5



6



You Ol' Fossil

Activity Sheet 42, How Fossils Are Formed, Word Blocks

Fossils — Geology, Level I

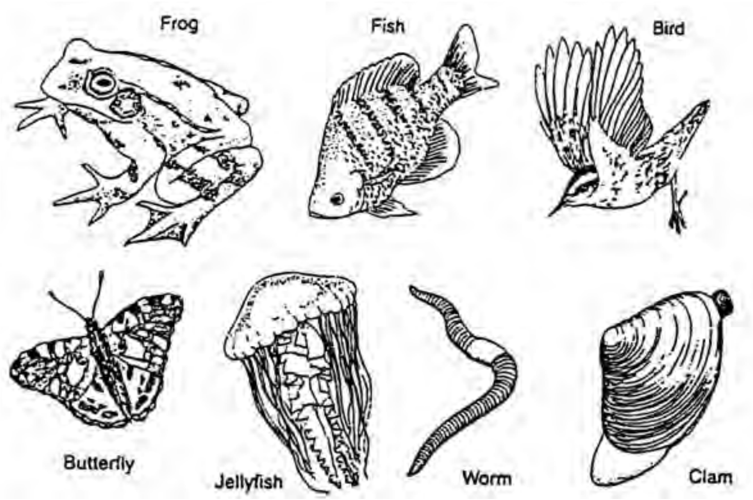
Cut out these blocks and tape or glue them to the matching drawing on Activity Sheet 41, *How Fossils Are Formed*.

A.	Heavy wind and rain wash away part of the sand and dirt. Then a part of the dinosaur can be seen.	The bones are hidden for millions of years. Water and minerals seep through sand and slowly turn the bones to stone.	D.
B.	A scientist finds the fossil of a dinosaur and carefully digs it out of the stone to take to a museum and study.	The bodies of some of the dinosaurs were covered by sand and dirt after they died.	E.
C.	All the dinosaurs died suddenly 65 million years ago.	Dinosaurs lived on Earth for 160 million years.	F.

You Ol’ Fossil

Activity Sheet 43, Fossil Enrichment

Fossils — Geology, Level I



Answer the following questions about the figures at left.

1. Which of the living things above would most likely leave a fossil? Why? ______________________________

____

2. Which of the living things would only leave fossils in the form of molds or casts? Why? ____________________

____

3. Explain how each of these living things could form a fossil:

Butterfly: ____

____

Earthworm: ____

____

Fish: ____

____

Bird: ____

____

Clam: ____

____

Frog: ____

____

Jellyfish: ____

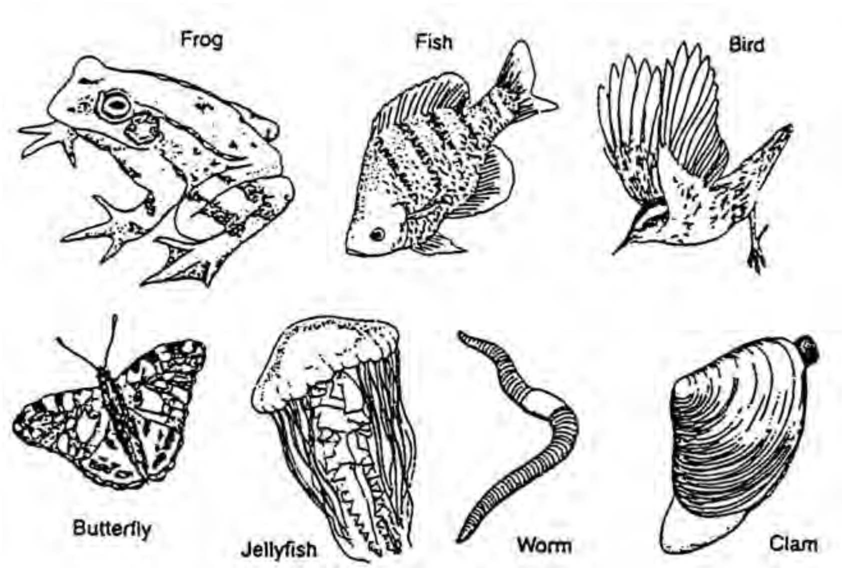
____

Holt Earth Science. Holt, Rinehart and Winston, Publisher

You Ol' Fossil

Activity Sheet 44, Fossil Enrichment Leader's Key

Fossils — Geology, Level I



Answer the following questions about the figures at left.

1. Which of the living things above would most likely leave a fossil? Why?

Fish, bird, clam, frog. These living things have hard body parts, which are easier to preserve than soft body parts.

2. Which of the living things would only leave fossils in the form of molds or casts? Why?

Earthworms and jellyfish. The earthworms and jellyfish only have soft body parts, which can only be preserved as a cast or mold.

3. Explain how each of living things could form a fossil.

Butterfly: **The butterfly could be preserved if it were trapped in tree sap or amber.**

Earthworm: **The earthworm could become buried in soft mud. After the earthworm decayed, it would leave an impression. If the impression became filled with mud or mineral material, a cast would be formed.**

Fish: **The fish could die and then sink to the bottom where it would be covered by mud.**

Bird: **The bird could become trapped in tar. The bones would be preserved.**

Clam: **The clam could become buried in soft mud and leave a mold as it decays.**

Frog: **The frog could die and sink to the bottom where it could become buried by mud.**

Jellyfish: **The jellyfish could become buried in soft mud and leave a mold as it decayed.**

Holt Earth Science. Holt, Rinehart and Winston, Publisher

The Great Divide

Fossils — Geology, Level I

What members will learn …

About the Project:

- Fossils are divided into groups (classified)
- Fossils were once a living organism
- Fossils can be identified by comparing to pictures

About Themselves:

- How to divide and match objects
- How to make decisions by comparing items.

Materials:

For each member

- Pencil and Paper
- Activity Sheet 45, *Fossil Game Board*
- Activity Sheet 46, *Fossil Game Board Pictures*

Activity Time Needed: 20 –30 minutes

Activity

Today we are going to learn about classifying fossils

Review what a fossil is. (*The remains or traces in rock of earlier plants and animals that lived many years ago, some even millions of years.*)

What is a living thing? (*A living thing can breathe, eat, grow, and move on its own.*)

What is a non-living thing? (*Something that has never been alive.*)

What is a once lived thing? (*Something that was once a part of a living thing but is not alive now.*)

Why is a green plant a living thing? (*It can breathe, eat, grow, and move on its own.*)

Why is a squirrel a living animal? (*It can breathe, eat, grow, and move on its own.*)

Why is a rock a non-living thing? (*It isn't able to breathe, eat, grow, and move on its own. Crystals grow and rocks move by sliding down hills but they can't breathe or eat.*)

What category would a fossil fit in? (*It once lived, it breathed, ate, grew, and moved on its own.*)

Leader's Notes:

A living plant must have water and soil to stay alive. We can demonstrate how it moves by placing it by a window and leaving it for several days-it moves toward the light-then if turned the other way will lean or move toward the light again.

For safety sake if there are no sidewalks in the neighborhood you may just sit outside or decide on another group of things to classify. Have each member keep track of one of the special features. Explain to them they are dividing into groups or classifying, as we would group together fossils.

We are going for a walk around the neighborhood. Observe all the vehicles you see in driveways or on the street. Let's divide them into groups. How will you classify (divide into groups) the vehicles? You may place all cars in one group, all vans in another, and all trucks in another. Then you may divide them into colors, number of doors, number of passengers, etc. What did you see the most of?

Why is it helpful to know how to group or classify like things together? (*Organizing information makes understanding and solving a problem such as classifying and identifying fossils easier.*) Probably primitive people made the first classification when they differentiated animals into those that were suitable to eat and those that were not. The ancient hunters divided animals into those found on land and those found in or around water.)

Hand out Activity Sheets 45, *Fossil Game Board*, and 46, *Game Board Pictures*. You may put it on card stock or have it laminated and reuse. Give members a few minutes to place pictures on the board in the correct column. Discuss answers. Gather your own items it you don't want to use game pieces.

The problem for us is to be able to put the proper name or identification with each fossil specimen. Once you know something is a fossil (once lived) how do you find out what kind of fossil it is? How is it identified? One way you can identify a fossil is by matching a fossil with a sketch of a once-living organism or picture of the fossil in a book. There are snails, corals, and organisms living today that are like ones that lived long ago. How do we know this? We find fossils that have the same characteristics and the same shape. These fossils tell us what the earth was like, and if they lived on land or water, at the water's edge or in deep water. We know this because we know where the modern organisms are found. Can you find pictures that show similarity between fossil life and things living today?

Another way to learn the proper identification of fossils is to learn the modern biological classification of organisms. This classification allows us to divide organisms into groups that have general characteristics. The first groups are very general and then are divided into more specific groups.

The two main fossil divisions of kingdoms are plants and animals. (Kingdom is the largest unit of division of organisms.)

Refer to vertebrate and invertebrate lessons.

Another major division under the group of animals is-does it have a backbone (vertebrate) or does it live without one (invertebrate)? As we continue to divide using more specific characteristics we can determine exactly what fossils we have found. There are more kingdoms (6), which you will learn as you advance in the lessons but these are the two most common ones.

Have pictures available and books if possible for the members to look at — you may have to check some out from the library.

The classification scale of division is:

Kingdom (Plant or animal)

Phylum (A group of closely related classes of plants or animals)

Class (A biologic unit — a subdivision of a phylum)

Order (Arrangement with respect to importance)

Family (A group of closely related genus)

Genus (A group descending from a common direct ancestor)

Discuss how things are recognized. Give example.

Would your grandmother recognize your teacher? (*Not unless you have showed her a picture or she had met her.*)

Would you recognize the President of the U.S.? (*You probably would because you have seen him on TV or in the newspaper.*)

How something is recognized depends upon how familiar you are with it and if you have seen something like it before. A visual match of a fossil with a sketch or picture is a simple quick way to make a primary identification using the classification key. You will learn more in later lessons about how to do this.

Dialogue for Critical Thinking

Share:

1. What was the most interesting thing about the Fossil Game Board? Why?
2. Which column on the Fossil Game Board was the most difficult to identify? Why?

Process:

3. Why is it important to know how to arrange things that look alike or have something in common?
4. What should you do if you can't find a picture or information about a fossil you have found?
5. How would the place where you found the fossils make a difference or help you identify them?

Generalize:

6. How does it help to match things that are alike?
7. Why does it help to compare and rank items based on certain facts or descriptions or use?

Apply:

8. How has the interest in dinosaurs helped draw attention to fossils?
9. Why should you be careful and take care of fossils you have found?
10. How can grouping like things help you in arranging your closet?

Going Further:

1. After your field trip divide fossils into groups that are alike. Are they all water animals or are there some plants or land animals in the collection? Try to find pictures in a fossil book that look like what you found. Is there an animal living today that looks like it?
2. Have members use their first name and add Asaurus (example: Johnasarus) to create an imaginary dinosaur or fossil name, then draw a picture of this dinosaur and its fossil.

References:

Featherby's Fables – Teachers Guide

Author: Sara Murphy, 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

The Great Divide

Activity Sheet 45
Fossil Game Board

Fossils — Geology, Level I

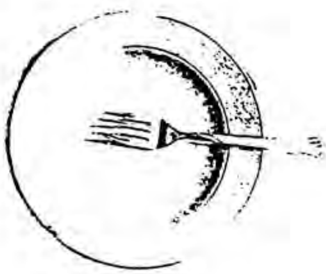
Living	Non-Living	Once Lived

The Great Divide

Activity Sheet 46, Fossil Game Board Pictures

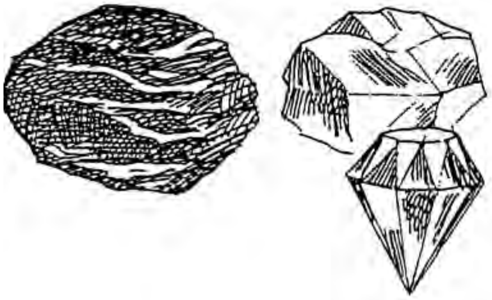
Fossils — Geology, Level I









Vertebrate Fossils

Fossils — Geology, Level I

What members will learn …

About the Project:

- The definition of a vertebrate fossil.
- How vertebrate fossils are formed.
- The rarity of vertebrate fossils.

About Themselves:

- The importance of their backbone.

Materials:

For each member

- One package of Lifesavers candy for each member.
- One large diameter pipe cleaner for each member.
- Blackboard, flipchart or poster board.

Activity Time Needed: 30 minutes

Activity

Vertebrates are animals with backbones. They include the familiar animals on earth — the fishes, frogs, lizards, snakes, birds and mammals, including, of course, humans. Vertebrates belong to the phylum Chordata.

A backbone is made up of vertebrae, which are bones that protect the spinal cord of an animal. The vertebrae are stacked around the spinal cord, allowing flexible movement.

Let's use these materials to help us visualize a backbone of an animal. Stack the candy on the pipe cleaner by pushing the pipe cleaner through the hole. Bend the ends of the pipe cleaner to keep the stack together.

Bend the "backbone." Does it break? Is it flexible? Twist the "backbone." How is this movement like your own back?

Vertebrate fossils are much more rare than those of the major invertebrate fossil group. This makes it more difficult to find and collect these fossils. Many vertebrates lived on land so their bones decayed before they could become fossilized. Since bone is porous, even those animals that died in water were not likely to fossilize since the bone could dissolve before the sediments would bury them. Most of the vertebrate fossils found are teeth, which are not very porous, are hard to begin with and fossilize easily.

One relatively common vertebrate fossil in Western Kansas is shark teeth. Sharks could produce many teeth in their lifetimes, since they replaced them as they were lost. As one fell out, another was already behind it pushing its way out.

Leader's Notes:

Use the blackboard, flipchart or poster board to highlight key words in this lesson and the members' ideas.

Provide a package of Lifesavers candy and a pipe cleaner to each member.

Point out that the bones allow flexibility while protecting the spinal chord.

Ask members if they have collected vertebrate fossils and what types.

Ask members to describe vertebrate fossils they have seen in museums.

Dialogue for Critical Thinking:

Share:

1. How are the lifesavers on the pipe cleaner like the bones in your back?
2. How are actual backbones different from your candy “backbone”?

Process:

3. What are vertebrae?
4. What are some animals with vertebrae?
5. Why are vertebrate fossils hard to find?
6. Were land or water animals more likely to become fossils? Why?
7. Why are sharks teeth easier to find than other fossils?

Generalize:

8. Why should you take care of your back?
9. What would happen if your back was broken?
10. Why do you think people have backbones?

Apply:

11. Can vertebrate fossils be found in the area where you live? If not, where could you go to look for some?

Going Further:

1. Visit a museum and observe the various types of vertebrate fossils and write a brief report on your findings.
2. Write a brief report on the types of vertebrate fossils that can be found in your state.

References:

Thompson, Ida, *The Audubon Society Field Guide To North American Fossils*, Alfred A. Knopf, Inc., New York, 1982.

Buchanan Rex, *Kansas Geology and Introduction to Landscapes, Rocks, Minerals, and Fossils*, University Press of Kansas, Lawrence, Kansas, 1984.

Authors:

Jeff and Georgiann McCoy, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Invertebrates

Fossils — Geology, Level I

What members will learn …

About the Project:

- What are invertebrates.

About Themselves:

- The importance of soft body parts.

Materials:

- Large balloon with water in it
- A chair

Activity Time Needed: 15 minutes

Activity

Today we are going to talk about invertebrates. Does anyone know what this means? (*This means they lack a backbone or the cartilage that make up a backbone.*) Invertebrate is a name used for the largest lower section of the animal kingdom. Many in this group probably lived in or near the warm shallow water near the shore of an inland sea or ocean. Let's try an experiment to better understand what happens when animals lack a backbone or vertebrae.

Questions for Discussion:

Why do you think so many invertebrate animals live in water? (*Because of the support the water gives them.*) Examples: sponges, snails, and corals.

In the vertebrate (animals with backbones) group, what part is usually preserved by fossilization? (*The hard parts such as bones, teeth, and vertebraes.*)

Since there are no backbones in the invertebrates, what part would be fossilized? (*Their hard shells fossilize quite easily.*)

The majority of the fossils we collect are from invertebrates and are the most abundant.

Leader's Notes

Fill a balloon about $2/3$ full of water. Now put it over the back of a chair. There is no backbone to support it. What happens? It just flops around. Now lay it on a table. It stays straight because it has support. Put it in a pan of water — it will not flop around because the water holds it up.

You may want to talk about the different phylums.

Dialogue for Critical Thinking:

Share:

1. What happened when you put the balloon over the chair?
2. What did you think would happen?

Process:

3. How is the balloon like an invertebrate?
4. Do invertebrates have an advantage over vertebrates? Why? Why not?
5. How do invertebrates protect their bodies?

Generalize:

6. What non-bony parts of your body help protect you?

Apply:

7. What do you do to protect your skin, hair, etc.?
8. What type of invertebrate fossils can be found your area?

Author:

Sara Murphy, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Paleobotany

Fossils — Geology, Level I

What members will learn …

About the Project:

- Paleobotany is the study of ancient plants.
- How plants become fossilized.
- Who did some of the first collecting and studies of fossil plants in Kansas.

About Themselves:

- The concept of time.
- The importance of patience.

Materials:

- A geologic map of Kansas
- A geologic timetable
- A modern, small green leaf or fern
- Items needed to make homemade play-dough
- Example(s) of fossil fern, fossil leaf and petrified wood (if available)

Activity Time Needed: 2 to 2 ½ hours

Activity:

What is plaeobotany? (The word *paleo* is Latin meaning "ancient" and the word *botany* means "study of plants.")

Let's try an experiment with play-dough and modern leaves or fern. You can quickly duplicate the appearance of plant fossils. This process normally takes millions of years, but you can do it in about two hours.

Step 1) Make play-dough by using the following recipe.

1 cup flour

1 cup water

½ cup salt

2 teaspoons cream of tarter

1 tablespoon cooking oil

Mix the dry ingredients in a saucepan; add the oil and water to the dry ingredients. Cook three minutes or until the mixture pulls away from the sides of the pan. Store in an airtight container. It will keep for two weeks.

Step 2) Make a patty (¼" thick) large enough in diameter to press your modern leaf on.

Leader's Notes:

You will want to start this experiment first as it does take two hours to bake. You could have the play-dough made up ahead of time. Also, you may wish to perform this experiment ahead of time to show members completed example(s). This way the members do not need to be present for the entire two hours while they are baking.

Step 3) Gently press the leaf onto the surface of the play-dough being careful to make sure the leaf does not curl away from the play-dough and is completely flat.

Step 4) Place the patty with the leaf on a lightly oiled pie tin or cookie sheet and bake at 350 degrees for two hours.

Step 5) Remove the leaf from the oven and let it cool. After it cools, lightly spray the leaf and play-dough with a clear laquer to protect and preserve it.

Plants become fossilized in three ways.

Compression and Impression

You may wish to have a poster made up ahead of time with the definitions and examples of each if you have them.

This is the most common way of preservation. The fossilization process was started by leaves or small pieces of leaves falling into water, becoming waterlogged and sinking to the bottom of a swamp, river, lake or sea. As time passed, they were surrounded and then covered by fine soil particles, which pressed out the water and air until only the plant material remained. Deeper burial resulted in heat and pressure, which sometimes turned the plant material into a thin carbon film. While this was happening, the surrounding particles were being transformed into rock, usually shale or siltstone. In Kansas it is possible to have leaves fall into a sandy area and have the same thing happen.

Casts and Molds

These were formed when a plant part, usually some bulky part such as a trunk, branch or root was buried in the sand or mud. As time passed, the plant material rotted, and water carried the residue away. When, by chance, the walls of the cavity left by the plant parts were strong enough to resist crumbling, a hollow mold with the exact details of the outside of the plant part was created. When the cavity again filled with mineral matter, such as sand, a cast of the original specimen was formed. It is possible to find an empty mold and fill it with plaster-of-Paris and make your own cast of a specimen.

Petrification

This happened when plant material, usually a trunk or branch, fell into highly mineralized water. As the water slowly went away and the mineral formed, each cell of the original plant material was replaced leaving a hardened copy. Usually, the petrification is exact in every detail of the original cell structure. Calcite and quartz are examples of minerals that cause petrification.

Charles Sternberg Sr. in the late 1800s was one of the first persons that showed an interest in collecting fossil plants in Kansas. His discoveries in Ellsworth County, Kansas, started an interest by the best-known scientists in the country. These scientists in turn contacted him to collect other fossils in Kansas and later around the world. This is how the world famous Sternberg family of fossil collectors got their start.

Ask if any of your group have visited the Sternberg Museum in Hays, Kansas.

The age of a fossil plant can be closely estimated with the aid of a geologic map and geologic timetable. For example, a fossil fern is found in Douglas County, Kansas. The geologic map shows that Douglas County is in the Pennsylvania Period. By using the geologic timetable, you can see that the Pennsylvania Period was from 286 to 320 million years ago. Therefore, the fossil fern you have must be within that range.

Dialogue for Critical Thinking:

Share:

1. What happened when you made play-dough fossils?
2. How did your baked leaf compare to a real fossil?

Process:

3. How do plants become fossilized? (*Three methods*)
4. Why is the age of a plant fossil important?
5. How can you determine the age of a plant fossil?

Generalize:

6. If you spent two hours baking a leaf fossil, what did you learn about being patient?
7. Most fossils take millions of years, how can you explain how long a million might be? (**Note:** try to compare a million seconds, etc.)

Apply:

8. How can you better understand periods of time in relation to what you do? (*Consider fast food, computers, etc., to help them understand time.*)
9. How will this lesson help you be more patient in the future?

Going Further:

1. Visit a museum or rock shop and look at the plant fossils on display. Write a brief paragraph about the plant fossils you saw and share it with your group.
2. Make an educational display for your classrooms or county fair using your baked specimens and some plant fossils you have collected.

References:

Andrews, Henry, *Studies in Paleobotany*, John Wiley and Sons, New York, 1961.

Arnold, Chester, *An Introduction to Paleobotany* , McGraw-Hill, New York, 1947.

Bates, Robert and Jackson, Julia, *Dictionary of Geological Terms*, Doubleday, New York, 1984.

Case, Gerard, *A Pictorial Guise to Fossils*, Van Nostrand Reinhold, New York, 1982.

Fenton, Carrol, and Fenton, Mildred, *The Fossil Book*, Doubleday, New York, 1989.

Gillespie, William, Clending, John and Pfefferkorn, Herman, *Plant Fossils of West Virginia,* West Virginia Geological and Economic Survey, Morgantown, 1978.

Lapidus, Dorothy, *Dictionary of Geology and Geophysics*, Facts on File Publications, New York, 1987.

Authors:
Jeff and Georgiann McCoy, Kansas 4-H Geology Curriculum Team
Reviewed by:
Rex Buchanan, Geologist, Kansas Geological Survey
James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

How Did They Do That?

Fossils — Geology, Level II

What members will learn …

About the Project:

- How did bones and shell get in the rocks?
- Difference between molds, casts, imprints, and fossils.
- How fossils are preserved.

About Themselves:

- How to learn using comparisons.
- How to learn by experimenting.

Materials:

- Paper cup
- Paper plate
- Modeling clay
- Seashell
- Petroleum jelly
- Plaster-of-Paris
- Plastic spoon
- 2 dead insects or worms (flies, ants, etc)
- Varnish, sealer or laminating paper
- Small brush
- Activity Sheet 47, *Fossils: True and False*
- Activity Sheet 48, *Fossil Prints*
- Activity Sheet 41, *How Fossils are Formed* (from Level I Lesson: "You Ol' Fossil")

Activity Time Needed: 30 to 45 minutes

Activity

How is it possible for the imprint of a leaf or the footstep of a bird or beast or the bones and teeth of a fish to get shut up in the rocks?

They got in before the rocks became hard. The animals and bones got in when the rocks were still forming or in the making when they were just loose sediments. Those sediments on which they fell or were dropped in when they died were then the surface. Sand, mud, and usually water filled in and covered them rapidly. Sediments continued to make layers on top of each other and later the mud and sediments turned to stone sealing in the fossils (dead animals or plants).

Leader's Notes:

See lesson using the Peanut Butter Sandwich experiment to help them understand the process of fossils getting sealed up in the rocks. Use raisins or a leaf to show fossils.

Activity Sheet 41, *How Fossils are Formed*, from the Level I lesson "You Old Fossil" will help review this process.

A great majority of fossils are found in sediments that were deposited under water. The marine sedimentary rocks were deposited under conditions that were favorable for organisms during life and which helped preservation after death.

Mount St. Helen erupted in 1980 with ash covering 150 square miles north of it. A good magazine to check out of the library would be *Earth,* April 1995 issue.

A few organisms are covered by wind blown sand on deserts or beaches or by falling ash from volcanic eruptions. Can you think of a volcano that erupted in the United States and ash covered trees, animals and everything around it for miles? Why don't volcanoes leave many good fossils? (*Usually the ash and lava is too hot to preserve the dead organisms.*)

A fossil is any natural preserved part, trace, or entire remains of an animal or plant that lived in the past.

Let's think about the different ways a fossil can be formed and the difference between these groups.

You may want to hand out the Activity Sheet 47, *Fossils: True & False* to do as you talk about this lesson, or you may want to wait until the end to do it.

There are five ways a fossil can be made:

1. Preservation without change.
2. Replacement by a mineral.
3. Hollow space in a shell or bone is filled in by a mineral.
4. Imprint is formed or filled.
5. Thin carbon film is formed.

Organisms or parts of organisms are commonly preserved (fossilized) in four general conditions:

1. With the hard parts unaltered or slightly altered
2. With the hard parts completely remineralized
3. As a mold
4. As casts and steinkerns

Mold

Hand out the Activity Sheet 48, *Fossil Prints*. This experiment will help members understand molds and casts.

A mold is when a shell, plant, or animal would be buried in soft mud. The mud would harden into rock, then the shell or animal would rot or dissolve away and leave an impression of the shell in the rock. The handprint you made to give your parents or grandparents at Christmas is an example of a mold.

Cast

Sometimes material fills a mold and then hardens. The hardened material is the same size and shape of the plant or animal that left the mold. A cast does not contain any part of the original animal. It was formed inside the mold fossil. It is shaped like the living thing. (Soft bodied plants and animals leave fossils in the form of molds and casts.)

The definition of a steinkern is the consolidated mud or sediment that filled the hollow interior of a fossil shell or other organic structure (such as a bivalve shell).

Petrification and Permineralization

The replacement by minerals is when a plant or animal remains are covered over and decay is taking place. When the water that passes through the soil carries dissolved minerals, the minerals can enter the remains of the dead plants or animals and replace some or all of the original plant or animal. It is petrified and has a mineral replacement. The minerals are deposited in the empty space where the organic substances have decayed away. This process may happen very slowly and the mineral matter duplicates the structures or it may be so fast that no trace of the original structure remains. Calcium carbonate, silica and iron sulfide are common replacement compounds.

Burial

When a plant or animal is covered by sand or soil the decay the process is slower than when it is exposed to the air. Teeth, shells, bones and other hard parts do not decay as fast as soft parts.

Find two dead insects (flies, ants, etc.) and place each on a board. Leave one as it is but the other one you are going to preserve by keeping the air from it. Cover it with several coats of varnish or sealer or seal it with self-applying laminating film. Which do you think will last longer?

Bring examples or do at the meeting.

Tar, Amber, Ice

Discuss other ways prehistoric life was preserved. For example, skeletons of saber-toothed tigers have been found in the tar pits of California, and mammoth elephants have been frozen in the glaciers of Siberia. Flesh and other soft parts, sometimes whole plants or animals, have been preserved under these unusual conditions, but this is not common. Another unusual preservation process is displayed when you find insects in amber.

Amber is the fossil resin from coniferous trees. It is usually yellow or brown and transparent. Insects would become stuck in it and die. The library may have pictures that show amber and fossils in ice or from the tar pits. Amber is very popular for jewelry.

Distillation — Carbon Imprints

Many plant fossils have been preserved when the nitrogen, oxygen and hydrogen have been removed, leaving only a black carbon film preserved in the rock.

Prints — Trace Fossils

Animals walking over soft mud have left footprints. Some animals laid down in mud and left body prints that were preserved. These prints are outlines that were made on soft mud that later hardened. Footprints can tell us how an animal walked and how big it was. Body prints tell us the shape of the body and, sometimes, how skin looked. Look for footprints, animal tracks or writing on concrete driveways or sidewalks. You may also see footprints of birds or animals in a dry riverbed or shoreline. These simulate very well how fossil impressions are made. If you put a footprint in cement it would remain, but if it were put in snow it would soon disappear. Other examples of trace fossils are: teeth marks, excrement, stomach stones and trails.

Burrows are often found in Kansas. They were likely formed by shellfish, etc. burrowing in mud. Trails and burrows are the most common trace fossils in Kansas.

The following are commonly mistaken for fossils, but are not:

Pseudofossils are inorganic objects that bear a superficial resemblance to things of organic origin, but have never been alive.

Dendrites are dark branching patterns that occur on the surface of different rocks. They resemble ferns and plant fossils. They are mineral deposits of some manganese oxide or iron oxide. They are usually much smaller then true ferns.

As you go through these descriptions continue to remind the members what a fossil is. Emphasize these are not fossils.

Bring samples to show when possible.

Note: Glacial Striations can only be found in the Northeast corner of Kansas.

Glacial Striations and Slickensides are grooves produced by glaciers moving over a rock. Striations are produced when two rock units move past each other along a fault. Slickensides is a polished rock surface caused by one rock sliding over another.

Concretions and Weathering Products often resemble fossils. They are the results of inorganic forces rather than the remains of animals. Septarian concretions and core-in-core are the two things most commonly mistaken for fossils in Kansas.

Vertical Tubes look like burrows made by worms usually in sedimentary rocks. Some of these may be from the escape of gas bubbles through the sediment while it was changing into sedimentary rock.

Raindrop Prints, Ripple-marks, and Mud Cracks are formed through natural, inorganic phenomena. The use of the word fossil for these is inaccurate.

Dialogue for Critical Thinking:

Share:

1. What happened when you made your cast and mold prints?
2. What types of fossils do you like to collect? Why?

Process:

3. What are some of the ways fossils are made?
4. What is the difference between a mold and a cast? (*In a mold the area where the fossil was is empty. A cast is filled in part of a mold. Mold is outside, cast is inside.*)
5. What happens in petrification? (*Mineral replaces original material.*)

Generalize:

6. What did you learn about yourself as you compared different fossilization processes?
7. How do comparisons and experimentation help you learn about other things?

Apply:

8. How can you use comparisons, processes, and experimentation to learn in the future?

Going Further:

1. Find some specimens that look like fossils but aren't.
2. Find examples of the various fossil look-alikes discussed above.
3. See how many different mineral replacements you can find in your fossils.

References:

Van Cleave, Janice, *Earth Science for Every Kid*, John Wiley & Sons, Inc., 1991

Culver, Diann, *Dinosaurs, Thematic Unit*, Teacher Created Materials, Inc., Huntington Beach, CA 1993.

Matthews, William H., III, *Texas Fossils: An Amateur Collector's Handbook — Guidebook 2*, Bureau of Economic Geology, The University of Texas, 1960

Author: Sara Murphy, 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Activity Sheet 47, *Fossils: True and False*,

True/False Answers:

1. F
2. T
3. F
4. F
5. T
6. F
7. F
8. T
9. T
10. F

Word Scramble Answers:

1. Fossil
2. Mold
3. Cast
4. Print
5. Sediment

Matching Answers:

1. D
2. A
3. E
4. B
5. C

How Did They Do That?

Activity Sheet 47, Fossils: True and False

Fossils — Geology, Level II

True/False

True — Write T on the line next to the number of the sentence that is true.

False — Write F if the sentence is false.

1. ____ Every organism becomes a fossil.
2. ____ There are more teeth fossils than skin fossils.
3. ____ Most fossils were found in igneous rock.
4. ____ All fossils were laid down in water.
5. ____ Most fossils were laid down in water.
6. ____ Dinosaurs left footprints wherever they walked.
7. ____Molds and casts are actual remains.
8. ____ Molds were made before casts.
9. ____ Molds and casts show the actual size of organisms.
10. ____ There are some fossils of every organism that ever lived.

Word Scramble

Unscramble each of the following to form a word or term that you have just learned.

1. SLOSFI ______________________________
2. LOMD ______________________________
3. TACS ______________________________
4. TRIPN ______________________________
5. TEDMINSE ______________________________

Matching

Match the two lists. Write the correct letter on the line next to each number.

1. ____ fossil	a) always laid down on land
2. ____ fossil prints	b) least likely to become fossils
3. ____fossil molds	c) most likely to become fossils
4. ____organisms with no hard parts	d) any clue to past life
5. ____organisms with hard parts	e) most are formed in water

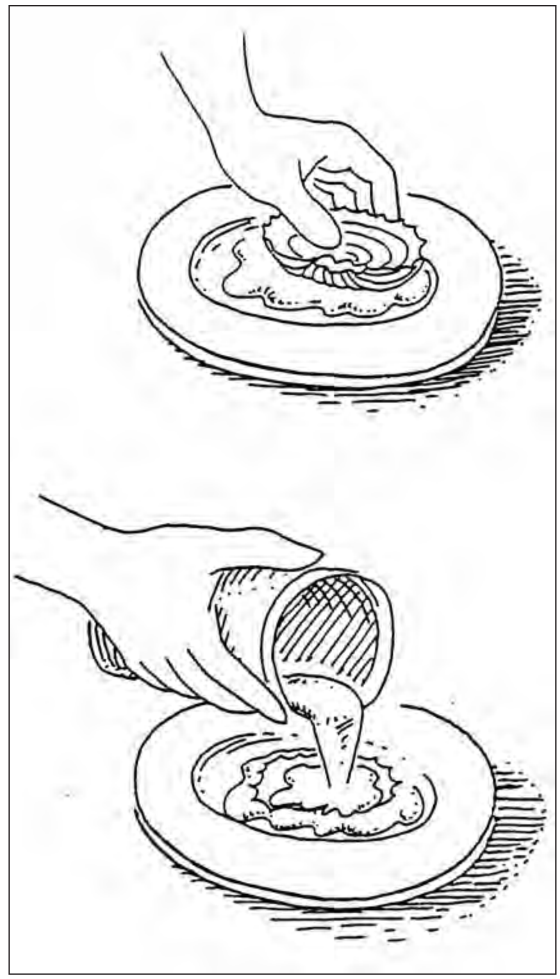
How Did They Do That?

Activity Sheet 48, Fossil Prints

Fossils — Geology, Level II

Purpose:

To determine how fossils were preserved.



Materials Needed:

- paper cup
- paper plate
- modeling clay
- seashell
- petroleum jelly
- plaster of Paris
- plastic spoon

Procedure:

- Place a piece of clay about the size of a lemon on the paper plate.
- Rub the outside of the seashell with petroleum jelly
- Press the seashell into clay.
- Carefully remove the seashell so that a clear imprint of the shell remains in the clay.
- Mix 4 spoons of plaster of Paris with 2 spoons of water in the paper cup.
- Pour the plaster mixture into the imprint in the clay. Throw the paper cup and spoon away.
- Allow the plaster to harden, about 15-20 minutes.
- Separate the clay from the plaster mold.

Results:

The clay has an imprint of the outside of the shell, and the plaster looks like the outside of the shell.

Why?

The layer of clay and the plaster are both examples of fossils. The clay represents the soft mud of ancient times. Organisms made imprints in the mud. If nothing collected in the prints, the mud dried, forming what is now called a mold fossil. When sediments filled the imprint, a sedimentary rock formed with the print of the organism on the outside. This type of a fossil is called a cast fossil.

Fossil Detective: Fossil Classification

Fossils — Geology, Level II

What members will learn …

About the Project:

- How to identify fossils.
- To develop an understanding of the basis of classification of fossils.
- How symmetry helps identify fossils.
- How to tell the difference between vertebrates and invertebrates.

About Themselves:

- How each fossil belongs to a family like people do.
- How dividing a large group into smaller subgroups by similarities and differences helps to understand classification.
- How fossils record life like your diary.

Materials:

- A collection of fossils that members have collected
- Newspapers
- A magnifying glass
- A fossiliferous limestone slab
- Member Handout 27, *Vertebrate and Invertebrate Animals*
- Member Handout 28, *Symmetry*
- Member Handout 29, *Mollusks*
- Activity Sheet 49, *Vertebrate and Invertebrate Animals Chart*
- Activity Sheet 50, *Vertebrate and Invertebrate Animals Chart, Leader's Key*

Activity Time Needed: 30-45 minutes

Activity

Plants and animals are unique, just as humans are. Everything, every group, needs a name. What is your family name? Who gave it to you? Were you named after someone else? Do you have a special nickname?

Today we are going to talk more about names and how to identify fossils by grouping them together. Fossil hunters are like a detective solving a crime. They must gather clues, assemble them, and finally determine what they mean. In this lesson, you will have a chance to be a "fossil detective." You will become familiar with various types of evidence found in the rock record and you can use information to learn about past environments, history, and types of plants and animals that lived, which will help us to learn to classify and identify our fossils.

Leader's Note

Be especially sensitive to the children, i.e. some may come from families with several names and members may not live with their parents, etc.

You may want to give each member a magnifying glass and use some props, such as a cap, to pretend to be detectives.

Most fossils are found in sedimentary rocks. Sedimentary rocks are layers of settled sediments. Igneous and metamorphic rocks do not have favorable conditions for preserving fossils because of the way these rocks were formed, the heat and pressure.

Imagine you are examining a rock outcrop. There are several types of rocks here. What type would you most likely find fossils in? Why? The most common feature of sedimentary rock is layering. Each layer or bed of rocks gives clues to the conditions under which it was originally deposited as sediment. As the different layers were deposited, plants and animals died and were trapped in them. They left clues or traces behind to help us solve the mystery.

The distance between the footprints is a stride. A large animal takes long strides, while a small animal takes very small strides.

Fossils are unique storehouses of information. The level or rock in which fossils are found provide clues as to when and where the animal lived. Teeth are clues to what kind of food it ate. The dimensions of the internal cavities in the skull may reveal the size and shape of the brain, which helps us determine how intelligent the creature may have been. Footprints hint at how their maker walked and at what speed, whether it traveled in herds or alone, and if it moved on two feet or four. We can tell if the corals lived in shallow or deep water and the temperatures and reef conditions.

Perhaps you can give some examples of Latin names, or you may want to talk to a Latin student or teacher to understand this better. Perhaps an older member is taking a Latin course at school and would like to share some terms and names, as well as pronounce the fossil names.

Common names change from place to place, but scientific names are universal. Latin names were used because they could be understood around the world. This system is used around the world. Latin names (scientific) may seem hard to pronounce because we don't commonly use them, but scientists use this system to communicate their finds and understand each other clearly.

Have you had much luck at identifying fossils up to this point of the project, or did you have someone help you or do it for you?

The Linnaean System of Classification is based on structures that indicate relationships among groups of living things. This system is used both for living and fossil forms of organisms.

One way to become familiar with a large group of things, is to divide the larger group into smaller groups, based on similarities and differences. Grouping, or classifying, makes it easier to remember how the members of the small group are alike and how they are different from other groups.

Spread newspaper on the tables because most fossils will not be clean. You may wish to bring some extra fossils for someone who doesn't have very many, or for those who have forgotten theirs.

Now, focus on the fossils that you have brought to the meeting. First, group all specimens that are alike together. Determine the Kingdom. There are six Kingdoms:

Kingdom:	Organism:
Archaebacteria	Primitive bacteria
Eubacteria	Cyano bacteria
Fungi	Mushrooms and relatives
Protists	Single cells
Plantae	Plants
Animalia	Animals

Determine which of the six Kingdoms the fossil belongs to. The two main kingdoms are the plant and animal kingdoms, so this should be pretty easy. The majority of the fossils collected will be from these Kingdoms.

Provide Member Handout 27, *Vertebrate and Invertebrate Animals*, and Activity Sheet 49, *Vertebrate and Invertebrate Animals Chart*.

Refer to the lesson on Vertebrates and Invertebrates that explains the difference between them.

Next, decide whether it is a vertebrate or invertebrate organism. An animal with an internal skeleton of cartilage or bone is said to have vertebrae (backbone) or a spinal cord. Invertebrate animals don't have a backbone — mollusks, arthopods, brachiopods, cnidarias, and the bryozoas. Invertebrate animals are the most abundant fossils and are the most useful to geologists in studying sedimentary rocks. Fossils are like a picture book. The story of life and clues are there for us to see and study in the fossil bearing rocks.

Next, divide your groups into smaller groups, taking out the brachiopods and mollusks. You may do this by looking at the symmetry. Each valve of the pelecypods is nearly a mirror-image of the other, so that the plane of symmetry lies along the line at which the valves join. This is true of most clams. Brachiopods are quite different. Their valves are seldom similar, the plane of symmetry that divides the animal into mirror-image halves passes vertically down the midline of cuts between the valves of a clam (mollusks) and across the valves of a brachiopod.

Use Member Handout 28, *Symmetry* to help members understand this. Symmetry is the orderly arrangement for the parts of an object with reference to lines, parts, or points. A valve is the device that is used to open or close the shell. Show the diagram of brachiopod and mollusks.

Brachiopods are further divided into the articula and then inarticulates. The articulates have two valves that have a well-developed hinge and muscle system. The inarticulateshave a hing that is poorly developed and the pedicle emerges from between the valves instead of from an opening in one valve. (Can you see a hole in the articulates? Can you see the difference?) The valves are commonly held together by muscles and have no hinge-teeth or dental sockets.

Use Member Handout 29, *Mollusks* to show the differences.

The three main classes of Mollusks are:

Gastropods or snails: have a single valve shell that is typically coiled.

Bivalves (Pelecypods): clams, oysters and fresh water mussels have shells composed of two halves, usually, but not always of equal size.

Cephalopods: squids, nautilus and the ammonoids have a shell of one valve, usually coiled and partitioned by septa.

Septa is wall separating two cavities or masses of softer tissue in an organism.

Now group all specimens of each phylum and class into smaller categories so the fossils in each category are essentially the same. You will now be identifying to the genus level. Pay special notice to the size and individual characteristics. Sometimes you will not be able to classify down to the genus.

You will now need a magnifying glass to examine specimens.

Some good books you might use are:

Ancient Life Found in Kansas Rocks (from the Kansas Geological Survey)

Invertebrate Fossils (Moore, Lalicker, Fischer)

Fossils (A Golden Guide)

Record in Rock (University of Nebraska)

Dialogue for Critical Thinking

Share:

1. What portion of the activity was the hardest? Why?
2. What type of fossil is easiest to identify? Why?

Process:

3. Why is fossil history important?
4. Why are most fossils found in rocks laid down by water?
5. How do you tell the difference between vertebrate and invertebrate fossils?

Generalize:

7. How does dividing items into groups help you learn?
8. What is the importance of symmetry in things other than fossils?

Apply:

9. Why is family history important?
10. How does you family keep track of their ancestors' history?

Going Further:

1. Talk to your grandparents or some older member of the family. Have they kept a diary from long ago? Perhaps someone has researched their family tree. Have them share something interesting about this.
2. Encourage members to learn about their family history when they are with their relatives, just as we are learning the history left by fossils, it's as if the fossils kept a diary for us. Each family has its history.
3. Observe a fossiliferous rock. Try to see how many different kinds of specimens you can find. It is suggested that younger members learn the Kingdom and Phylum of the fossils. As the members get older and their knowledge increases, they should learn the class and genus of fossils.
4. Explore why there are now six kingdoms instead of four.

References:

Van Cleave Janice, *Earth Science for Every Kid*, John Wiley & Sons, Inc., 1991.

Culver, Diann, *Dinosaurs. Thematic Unit,* Teacher Created Materials, Inc. Huntington Beach, CA, 1993.

Matthews, William H III, *Texas Fossils: An Amateur Collector's Handbook — Guidebook 2*, Bureau of Economic Geology, The University of Texas, 1960.

Williams, Roger B., *Ancient Life Found in Kansas Rocks*, Kansas Geological Survey, Kansas University Printing Service, 1975.

Author:

Sara Murphy, 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Developement, Kansas State University

Fossil Detective: Fossil Classification

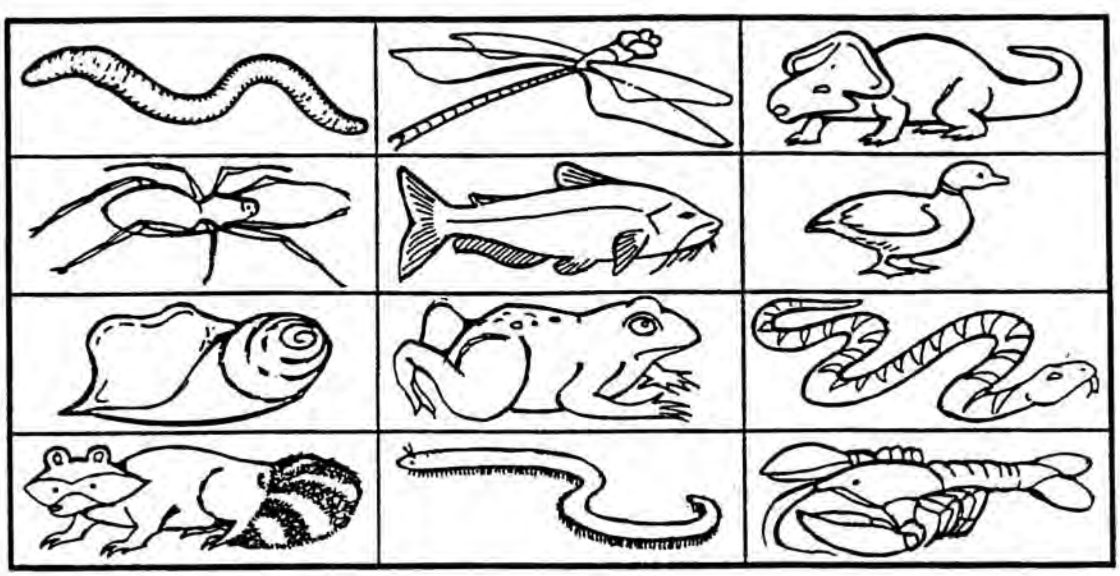
Member Handout 27, Vertebrate and Invertebrate Animals

Fossils — Geology, Level II

All animals are classified into two major groups: vertebrate and invertebrate. Vertebrate animals include all animals that have a backbone or spine. Invertebrate animals include all animals without a backbone or spine. Classify the animals below (on the activity sheet, next page) into vertebrate/invertebrate groups, then into a subgroup, then by the name of the animal, and finally by the picture of the animal. (Cut out the picture and glue it to the chart.) Use the words from the word box th help identify the animals.

Word Box

Animal Subgroups		Animal Names	
Mammal	Insect	dragonfly	conch
Bird	Snail	earthworm	snake
Reptile	Spider	thousand leg	raccoon
Dinosauria	Crustacean	brown spider	catfish
Fish	Worm	protoceratops	lobster
Amphibian	Centipede/Millipede	duck	frog



Fossil Detective: Fossil Classification

Activity Sheet 49, Vertebrate and Invertebrate Animals Chart

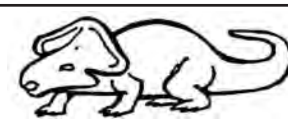
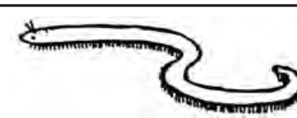
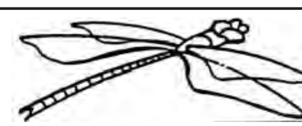
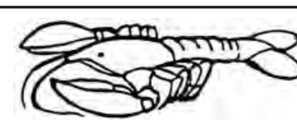
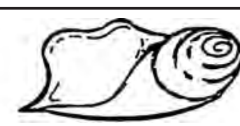
Fossils — Geology, Level II

Major Group	Subgroups	Name	Picture

Fossil Detective: Fossil Classification

Activity Sheet 50, Vertebrate and Invertebrate Animals Chart, Leader's Key

Fossils — Geology, Level II

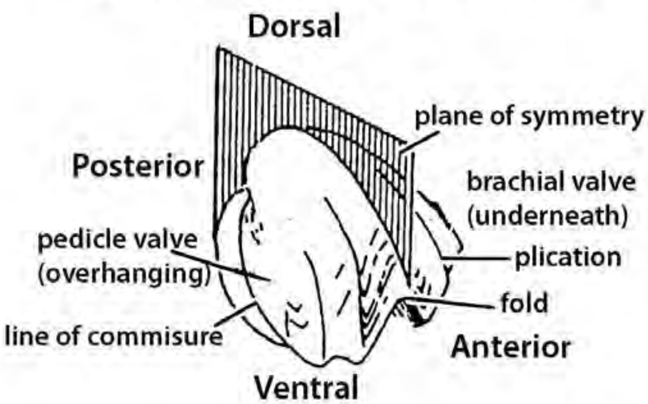
Major Group	Subgroups	Name	Picture
vertebrate	Reptile	snake	
vertebrate	Bird	duck	
vertebrate	Fish	catfish	
vertebrate	Amphibian	frog	
vertebrate	Mammal	raccoon	
vertebrate	Dinosauria	protoceratops	
invertebrate	Worm	earthworm	
invertebrate	Centipede/Millipede	thousand leg	
invertebrate	Insect	dragonfly	
invertebrate	Crustacean	lobster	
invertebrate	Snail	conch	
invertebrate	Spider	brown spider	

Fossil Detective: Fossil Classification

Member Handout 28, Symmetry

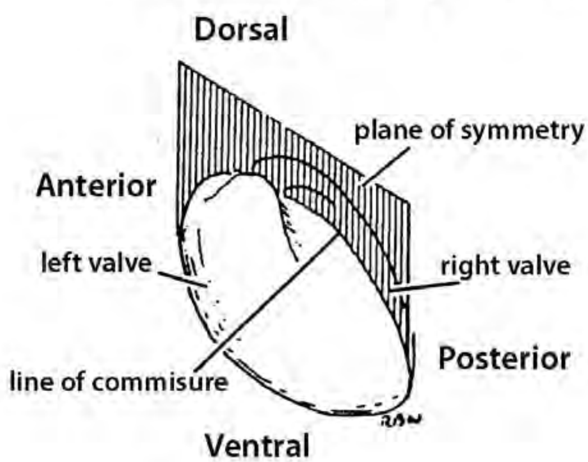
Fossils — Geology, Level II

Equilateral Symmetry (Brachiopod)



Right and left are the same; valve halves are different.

Bilateral Symmetry (Clam)



The two valve halves are the same.

Fossil Detective: Fossil Classification

Member Handout 29, Mollusks

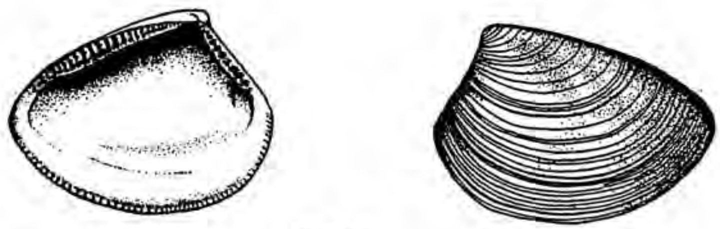
Fossils — Geology, Level II

Note: When you see an X beside a fossil picture, such as X1 or X2, it means the picture has been enlarged that much from the actual size of the fossil.

1. Gastropods

Turritella
x1

Bivalvia
2. Pelecypods

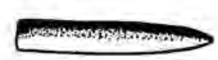


Nucula
x2

3. Cephalopods

Acanthoceras
x 1/2

Baculites
x 1/2



Belemnite
x 1/2

Paleobotany

Fossils — Geology, Level II

What members will learn …

About the Project:

- Terminology for identifying plant fossils.

About Themselves:

- Observation techniques.

Materials:

- Member Handout 30, *Plant Fossil Terminology*
- Member Handout 31, *The Classification of Kansas Plant Fossils*
- Activity Sheet 51, *Plant Fossil Identification*
- Activity Sheet 52, *Plant Fossil Identification, Leader's Key*

Activity Time Needed: 45 minutes

Activity

To identify plant fossils it is necessary to understand the terminology associated with fossil and modern plants. Understanding the plant fossil classification handout will make it easier to identify the fossils. We will go over the terms before we do the activity sheet.

Member Handout 31, *The Classification of Kansas Plant Fossils*, can also be used to help you identify specimens. **Plant classifications often use the term "division" instead of the term "phylum" used in the animal classification. Plant classification is not as consistent as animal classification so you may find different arrangements in different books.**

Dialogue for Critical Thinking

Share:

1. What fossil terms did you know?
2. What fossil terms were difficult to learn? Why?

Process:

3. What are angiosperms?
4. What are gymnosperms?
5. What are monocots?
6. What are dicots?

Leader's Notes

Review the Member Handout 30, *Plant Fossil Terminology*.

Provide Activity Sheet 51, *Plant Fossil Identification*.

Use Member Handout 31, *The Classification of Kansas Plant Fossils* to aid with this lesson.

Generalize:

7. How do you prefer to learn identifying characteristics of plant fossils? Why?
8. What observation techniques do you use to identify fossils?

Apply:

9. What reference do you use most to help identify plant fossils? Why?
10. What plant types are found in your area?
11. What other areas do you use the observation skills learned in geology?

Going Further:

Take a field trip to a local museum or university to see their collections of fossil plants and with their help, try to determine into which of the terminologies they fall. Look for modern or fossil examples of as many terms as you can find.

References:

Andrews, Henry, *Studies in Paleobotany*, John Wiley and Sons, New York, 1961.

Arnold, Chester, *An Introduction to Paleobotany*, McGraw-Hill, New York, 1947.

Bates, Robert and Jackson, Julia, *Dictionary of Geological Terms*, Doubleday, New York, 1984.

Case, Gerard, *A Pictorial Guide to Fossils,* Van Nostrand Reinhold, New York, 1989.

Gillespie, William, Clendening, John, and Pfefferkorn, Hermann, *Plant Fossils of West Virginia,* West Virginia Geological and Economic Survey, Morgantown, 1978.

Lapidus, Dorothy, *Dictionary of Geology and Geophysics*, Facts on File Publications, New York, 1987.

Authors:

Jeff and Georgiann McCoy, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Developement, Kansas State University

Paleobotany

Member Handout 30
Plant Fossil Terminology

Fossils — Geology, Level II

Algae: Algae is a widely diverse group of photosynthetic plants, almost exclusively aquatic, that includes seaweeds and fresh water forms. They range in size from one cell to the giant kelps which can be 30 feet long. Although they are considered primitive because they lack true leaves, roots, stems and vascular systems, they have varied and complex life cycles.

Moss: Mosses are various small, green, non-flowering plants that often form a dense matlike growth.

Club Moss: Club Mosses are small plants that creep on the ground, send up stalks and branches, and reproduce by means of spores borne in cone-like organs.

Horsetail: Horsetails are also called Scouring Rushes. Horsetails have long, slender and straight stems that are jointed. The genus Calamites is the most common Pennsylvanian period Horsetail. Some of the species of Calamites grew to a height of 40 feet and stems 3 inches in diameter are common. Their stems were upright and grew from roots. The roots of Calamites are like the roots of modern corn plants. Clusters of slender leaves also grew from the joints, especially on young branches. Generally found in shales.

Seed Fern: Seed Ferns resembled tree ferns in shape, while some others grew close to the ground or formed vines. Fronds were normally arranged spirally on the stems and/or trunks. Seeds or seed-like structures were situated on the foliage and were not borne in cones, thus they are different from the conifers.

True Fern: True Ferns had a great variety of growth forms, ranging from small to some that formed trees. True Ferns look similar to Seed Ferns, but there are differences. True Ferns reproduce by spores, not seeds. Also, the fronds were at the end of the stem or at the top of the trunk.

Cycad: A Cycad is a palm-like tree. They have stout trunks. They were both small plants and large trees. Seeds and pollen-bearing organs are situated on cone-like structures called STROBILI and on cones. Pollen is borne on one plant, while seed cones are borne on another.

Cycadeoids: Cycadeoids are another group of palm-like trees. They originated and became extinct during the Mesozoic Era.

Ginkgoes: Ginkgoes (Ginko) are another form of palm-like trees. They originated and became almost extinct during the Mesozoic Era. Only one living species remains, Ginkgo biloba (maidenhair tree).

Cordaites: Cordaites were Gymnospermous trees that existed from the upper Mississippian Period into the Triassic Period. There are no living representatives. They have strap shaped, parallel veined leaves.

Voltziales: Voltziales are conifers. It is believed that the Voltziales may have been the transitional plants between Cordaites and conifers. Voltziales leaves are needle-like and have the appearance of pine trees. A good example of a Voltziales is Walchia.

Conifer: Conifers are Gymnospermous trees having needle-like foliage and seeds borne in cones.

Monocotyledon: Monocotyledons are flowering plants with one embryonic leaf and parallel-veined leaves. In other words, a monocot has only one fertile leaf.

Dicotyleon: Dicotyleons are flowering plants with two embryonic and branching leaves. In other words a dicot has two fertile leaves.

Paleobotany

Activity Sheet 51, Plant Fossil Identification

Fossils — Geology, Level II

Draw a line to match the name with the picture.

Horsetail

Seed Fern

True Fern

Cordaites

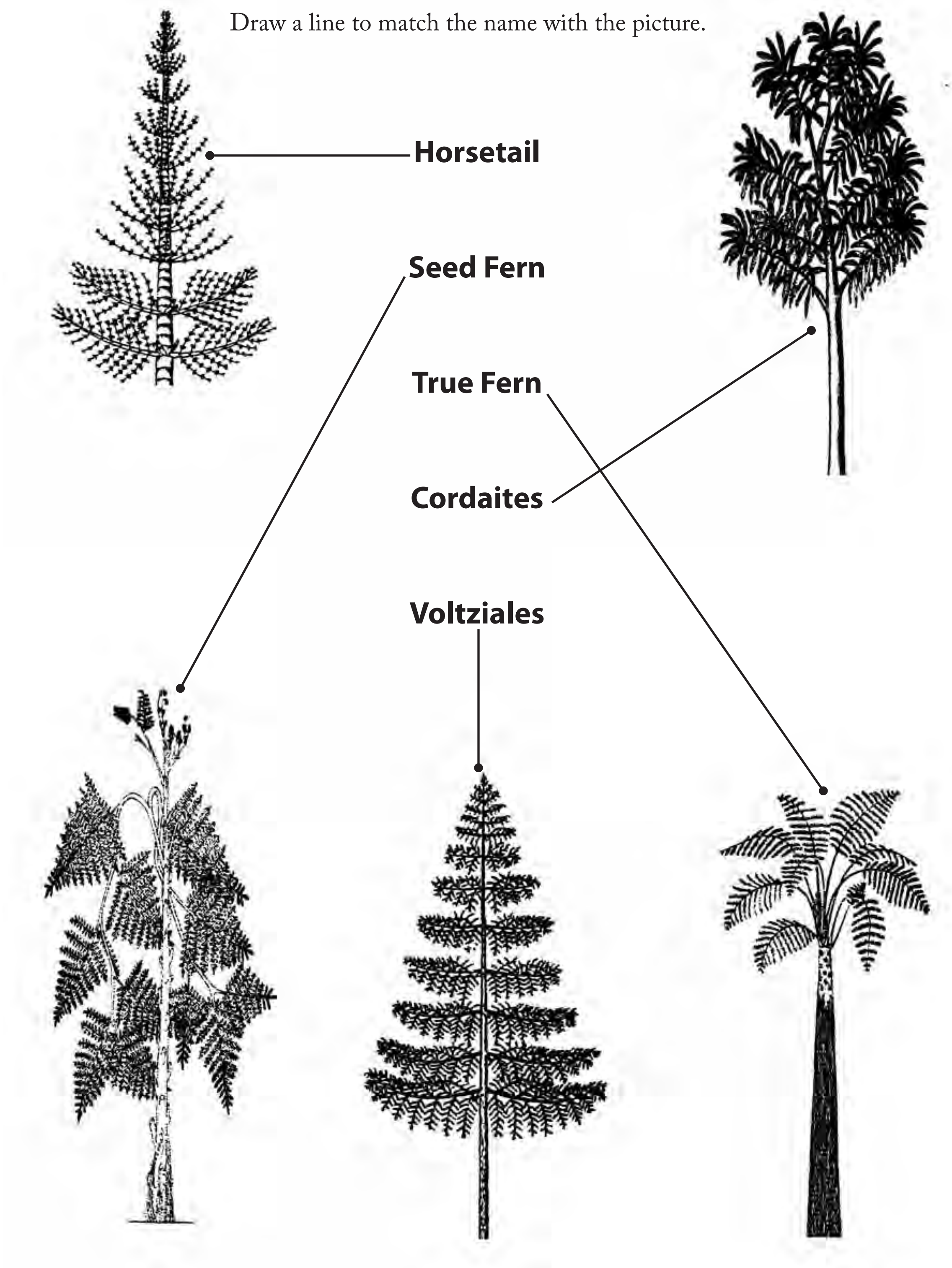
Voltziales

Paleobotany

Activity Sheet 52, Plant Fossil Identification Leader's Key

Fossils — Geology, Level II

Draw a line to match the name with the picture.



Paleobotany

Member Handout 31, The Classification of Kansas Plant Fossils

Fossils — Geology, Level II

Kingdom: Monera
- **Phylum:** Cyanobacteria (blue-green bacteria or blue-green algae)

Kingdom: Plantae
- **Phylum:** Rhodophyta (red algae)
- **Phylum:** Chlorophyta (grass – green algae)
- **Phylum:** Bryophyta (Mosses – Pennsylvania to recent)
- **Phylum:** Tracheophyta (vascular plants)
  - **Class:** Lycopsida (Club Mosses)
  - **Class:** Sphenopsida (Horsetails)
  - **Class:** Filicopsida (True Ferns – Devonian to recent)
  - **Class:** Gymnospermospida (Spore producing)
    - **Order:** Pteridospermales (Seed Ferns – Devonian to Jurassic)
    - **Order:** Cycadales (Cycads – Permian to Recent)
    - **Order:** Cycadeoidales (Cycadeoids – Triassic to Cretaceous)
    - **Order:** Caytoniales (Caytoniales – Triassic to Cretaceous)
    - **Order:** Glossopteridales (Glossopterids – Pennsylvanian to Jurassic)
    - **Order:** Ginkoales (Ginkoes – Triassic to recent)
    - **Order:** Cordaitales (Cordiates – Pennsylvanian to Permian)
    - **Order:** Voltziales (Voltziales – Pennsylvania to Triassic)
    - **Order:** Coniferales (Conifers – Triassic to recent)
  - **Class:** Angiospermopsida (Flowering plants)
    - **Subclass:** Monocotyledonae (Monocots, Grass – Cretaceous to recent)
    - **Subclass:** Dicotyledonae (dicots, higher flowering plants, Cretaceous to recent)

Note: Terms "Phylum" and "Division" are often used for the same level of classification in different references.

Vascular and Nonvascular Plants

Fossils — Geology, Level III

What members will learn …

About the Project:

- Plant fossil terminology
- Two types of plant reproductive systems (Gymnosperms and Angiosperms)

About Themselves:

- How their circulation system compares to plants.
- How plants and animals obtain vital nutrients.

Materials:

- A fresh stalk of celery
- Red food coloring
- A small glass
- 1 cup of water
- A modern leaf showing the veins
- A fossil leaf or pinna showing the veins (if available)
- A geologic map of Kansas
- A geologic timetable
- A magnifying glass
- Pencils
- Member Handout 32, *Vascular Structures*
- Activity Sheet 53, *Vascular and Nonvascular Plants*
- Activity Sheet 54, *Vascular and Nonvascular Plants, Leader's Key*
- Member Handout 33, *Plant Fossils from Pennsylvanian and Permian Periods*

Activity Time Needed: 1 hour

Activity

1) We are going to try this experiment

Step 1) Add the cup of water to a small glass or jar

Step 2) Add a few drops of red food coloring to the water

Step 3) Cut a fresh stalk of celery at both ends and stand one end in the glass or jar.

Notice, after a while, that the red color will work its way to the end of the celery that is not in the water.

Leader's Notes

Have your group work in pairs to perform this experiment. As the celery sits in the colored water, discuss the terms on Member Handout 32, *Vascular Structures*. Then check the experiment.

This is how nutrients travel through the veins and feed the plants.

Pass around a modern leaf and point out the veins.

2) Discuss the terms Vascular and Nonvascular

a) **Vascular:** A vascular plant is a plant that has a fully developed circulatory system that can carry nutrients through the roots, trunk, branches, leaves, seeds, fruit or flowers. The nutrients are carried throughout the plant by way of veins, which can easily be seen on a leaf. A good example of a Vascular plant would be a tree.

Use Member Handout 33, *Plant Fossils from the Pennsylvanian and Permian Periods*.

b) **Nonvascular:** A Nonvascular plant is a plant that does not have a fully developed circulatory system, in other words it would not have roots, a trunk, branches or leaves. A good example of a Nonvascular plant would be algae.

3) Discuss the terms Angiosperm and Gymnosperm

a) **Angiosperm:** An Angiosperm is a plant that reproduces via flowers and fruits. The Angiosperm originated during the Cretaceous Period. A good example of an Angiosperm would be an apple tree.

b) **Gymnosperm:** A Gymnosperm is a plant that reproduces by way of seeds and spores which are held in cones, but does not flower or bear fruit of any kind. A good example would be a pine tree.

Use the diagram on Member Handout 32, *Vascular Structures* to explain terms. Distribute Activity Sheet 53, *Vascular and Nonvascular Plants* to each member. Discuss answers.

4) Discuss the terms Leaf, Pinna, Pinnule, Frond, and Lobe.

a) **Leaf:** A Leaf is a flattened plant structure attached to a stem. It is the principle organ of photosynthesis.

b) **Pinna:** Pinna are the leaves that make up a Frond.

c) **Pinnule:** Pinnules are the small leaflets that make up a Pinna.

d) **Frond:** A Frond is made of several pinna.

e) **Lobe:** A Lobe is a pointed or rounded portion of a leaf that protrudes outward.

Dialogue for Critical Thinking

Share:

1. What happened to the celery stick in the experiment? Why?
2. What type of plant circulatory system is in the celery?

Process:

3. What is the difference between vascular and nonvascular?
4. What is the difference between an angiosperm and a gymnosperm?

Generalize:

5. How is a plant circulatory system similar and different from an animal circulatory system?
6. How do plants and animals obtain vital nutrients?

Apply:

7. Why do we not find fossils of many of the plants we see everyday?
8. What kinds of plants do we still have today that are also found as

fossils? Why?

Going Further:

1. Take a field trip and collect a few modern or fossil plants and try to determine whether they are Angiosperms or Gymnosperms. Also, try to determine whether they have Pinnules, Pinna, Fronds or Leaves with single or multiple Lobes.

References:

Andrews, Henry, *Studies in Paleobotany,* John Wiley and Sons, New York, 1961.

Arnold, Chester, *An Introduction to Paleobotany*, McGraw-Hill, New York, 1947.

Bates, Robert, and Jackson, Julia, *Dictionary of Geological Terms*, Doubleday, New York, 1984.

Gillespie, William, Clendening, John, and Pfefferkorn, Hermann, *Plant Fossils of West Virginia,* West Virginia Geological and Economic Survey, Morgantown, 1978.

Lapidus, Dorothy, *Dictionary of Geology and Geophysics*, Facts on File Publications, New York, 1987.

Lesquereux, Leo, *The Flora of the Dakota Group*, Government Printing Office, Washington D.C., 1891.

Authors:

Jeff and Georgiann McCoy, Kansas 4-H Geology Curriculum Team

Reviewed by:

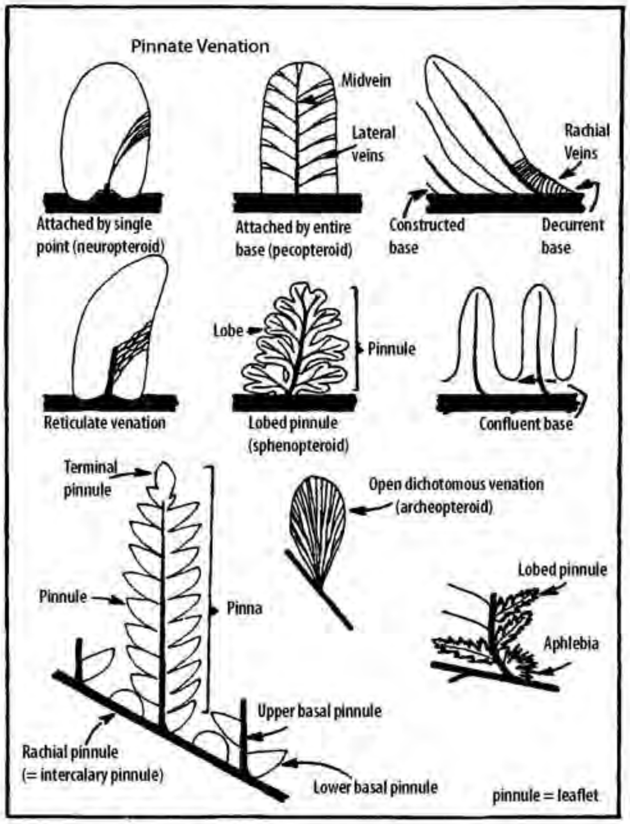
Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Developement, Kansas State University

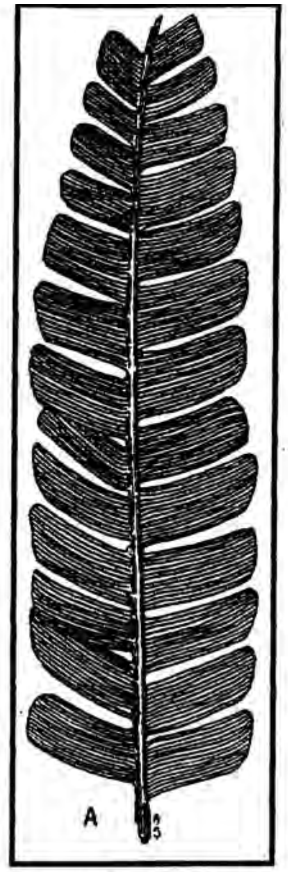
Vascular and Nonvascular Plants

Member Handout 32, Vascular Structures

Fossils — Geology, Level III



Examples of Fern Pinnules



Example of a Pinna from a fern

A leaf showing three lobes; there are three main veins

An example of a fern frond

Vascular and Nonvascular Plants

Activity Sheet 53, Vascular and Nonvascular Plants

Fossils — Geology, Level III

Vascular, Nonvascular, Angiosperm, Gymnosperm, Leaf, Pinna, Pinnule, Frond, Lobe

Instructions: Below each example pictured, write the term or terms (listed above) that best describes it.

Neuropteris

Neuropteris

Cone

Pecopteris

Sassafras

Blue-green algae
or
Cyanobacteria

Vascular and Nonvascular Plants

Activity Sheet 54, Vascular and Nonvascular Plants, Leader's Key

Fossils — Geology, Level III

Vascular, Nonvascular, Angiosperm, Gymnosperm, Leaf, Pinna, Pinnule, Frond, Lobe

Instructions: Below each example pictured, write the term or terms (listed above) that best describes it.

Neuropteris

Pinnule
Vascular

Neuropteris

Pinna
Vascular

Cone

Gymnosperm

Pecopteris

Frond
Vascular

Sassafras

Leaf
Vascular
Angiosperm
Lobe

Blue-green algae or Cyanobacteria

Nonvascular

Vascular and Nonvascular Plants

Member Handout 33, Plant Fossils from the Pennsylvanian and Permian Periods

Fossils — Geology, Level III

Bark

1. Diagonal (lipidodendron) and/or vertical rows (sigillaria) of leaf cushions, each row separated by a furrow or ridge.
2. Leaf scars near center of cushions.

Calamites

1. Branch or leaf scars at horizontal joints.
2. Vertical patterns of ribs or grooves on sections.

Annularia

1. A whorl of linear leaves.
2. Leaves attached and encircling the joint of the stem.
3. Each leaf has a midvein.
4. Whorls are generally laid out flat.

Sphenophyllum

1. Leaves are wedge shaped.
2. Leaves are narrowest and not touching at the base.

Equisetites

1. Leaves are touching for some distance above the base.
2. Leaves are long and parallel to the stem.

Asterophyllites

1. A whorl of linear leaves.
2. Leaves narrower and more sharply pointed than annularia.
3. Leaves are seen side-view and not laid out flat like annularia.

Pecopteris

1. Pinnule directly and broadly attached to rachis.
2. Sides of pinnule nearly parallel and the apex is generally rounded.
3. Midvein sharply defined and straight.
4. Midvein forks near apex.
5. Veins fork one or more times.

Alethopteris

1. Pinnules directly and broadly attached to rachis, especially on the lower side.
2. Pinnules generally robust.
3. Midvein sharply defined and straight.
4. Veins are generally close and deep.
5. Some veins enter the base of the pinnule directly from the rachis independent of the midvein on one or both sides.

Vascular and Nonvascular Plants

Member Handout 33, Plant Fossils from the Pennsylvanian and Permian Periods, continued

Fossils — Geology, Level III

Neuropteris

1. Pinnule is generally tongue-shaped, but some triangular or oval.
2. Pinnule is attached to the rachis by a short stalk.
3. Midvein terminates just below apex.
4. Venation becomes fan-shaped near the apex.
5. One or more veins enter the pinnule from rachis.

Cyclopteris

1. Oval or round pinnule.
2. Venation is generally radiating.
3. Venation varies from thin to thick and from close to distant.

Odontopteris

1. Pinnule is generally attached to the rachis by the entire width.
2. Veins enter pinnule directly from the rachis.
3. No distinct midvein.
4. Venation is thin and varies from close to distant.

Eusphenopteris

1. Pinnules are rounded.
2. Pinnules are generally attached to the rachis by the entire width.
3. Pinnules never have toothed margins.
4. The pinnules closest to the pinna vein are generally larger and more developed than the others.
5. Venation is generally radiating from the midvein.

Sphenopteris

1. Pinnule narrowly attached to rachis.
2. Pinnule margin is irregular, lobed and/or tooth-like.
3. Midvein branches off into each pinnule segment.
4. Venation is thin and fan-like.

Aphlebia

1. Very irregular shaped, lettuce-like appearance.

Cordaites

1. Long strap-like leaves, rarely found complete.
2. Leaf has a narrow and clasping base with a tapering, rounded apex.
3. Parallel veins with no midvein.

Walchia

1. Short needle-like leaves.

Paleobotany

Fossils — Geology, Level IV

What members will learn …

About the Project:

- Paleobotany can aid in the understanding of ancient, local landscapes and climates.

About Themselves:

- The value of their historical data.

Materials:

- Geologic Map of Kansas (Kansas Geological Survey)
- Geologic Timetable (Kansas Geological Survey)
- Member Handout 34, *Ancient Landscapes and Climates*
- Activity Sheet 55, *Ancient Landscapes and Climates*
- A colored Geologic Map of Kansas would be helpful and is available from the Geologic Survey
- Leader Key, Activity Sheet 56, *Ancient Landscapes and Climates*

Activity Time Needed: 45 minutes

Activity

Let's review and discuss the ancient landscapes and climates member handout. It will aid you in understanding how certain plants grew or were developed in certain environments. It will help you understand why plants became extinct or flourished.

The Activity Sheet will further help you understand these concepts.

Leader's Notes

Make sure your members have a basic understanding of how to interpret a geologic map and geologic timetable. Also, be sure they understand Member Handout 34, *Ancient Landscapes and Climates*.

Dialogue for Critical Thinking:

Share:

1. What unique characteristics did you learn about various landscapes and climates of the past?
2. How did you utilize the Geologic Map and Timetable of Kansas?

Process:

3. What is the significance of the Geologic Period?
4. How does climate affect plant life and the potential for good plant fossils?

Generalize:

5. How does paleobotany help explain history of the earth?
6. What other methods are used to record historical happenings?
7. What is the value of your personal history? (Think about genetics and medical history.)

Apply:

8. How can you use these concepts to predict where coal might be found 200 million years from now?
9. What other energy sources do you think will be significant in the near future (20-50 years)? Why?

Going Further:

If you find an area to collect fossil plants, identify them and make an educational exhibit detailing the different genera, landscape and climate.

References:

Andrews, Henry, *Studies in Paleobotany*, John Wiley and Sons, New York, 1961.

Arnold, Chester, *An Introduction to Paleobotany*, McGraw-Hill, New York, 1947.

Bates, Robert and Jackson, Julia, *Dictionary of Geological Terms*, Doubleday, New York, 1984.

Case, Gerard, *A Pictorial Guide to Fossils*, Van Nostrand Reinhold, New York, 1982.

Fenton, Carol and Fenton, Mildred, *The Fossil Book,* Doubleday, New York, 1989.

Gillespie, William, Clendening, John, and Pfefferkorn, Hermann, *Plant Fossils of West Virginia*, West Virginia Geological and Economic Survey, Morgantown, 1978.

Lapidus, Dorothy, *Dictionary of Geology and Geophysics*, Facts on File Publications, New York, 1987.

Lesquereux, Leo, *The Flora of the Dakota Group*, Government Printing Office, Washington D.C., 1891.

Authors:

Jeff and Georgiann McCoy, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Developement, Kansas State University

Paleobotany

Member Handout 34, Ancient Landscapes and Climates

Fossils — Geology, Level IV

To fully understand ancient plant life, it is necessary to give some attention to the environment, the PALEOCLOGY, under which the plants grew. The reverse is true as well. To understand the PALEOCOLOGY, it is important to understand ancient plant life.

Many inferences bearing on probable environments can be drawn from the distribution and structural changes of ancient plants. Plants are sometimes referred to as the thermometers of the past. When living species are also found as a fossil, we can assume that they grew under conditions similar to those required by the species present.

Geological history is punctuated with climatic fluctuations of major proportions. At times, much of the earth's surface was covered with ice, and other times, the luxuriant vegetation thrived almost to the North and South poles. The most intensive glaciation occurred during the Pre-Cambrian, the Permian and the Pleistocene periods. We know little about the effect of the Pre-Cambrian glaciation upon the vegetation because no land plants have been found in the rocks of this period. However, the Permian ice sheet changed the aspect of the flora over the entire earth through the eradication of the majority of the Paleozoic coal swamp plants and they were replaced by larger more hardy types, such as Sassafras, Ficus and Magnolia. The Pleistocene glaciation caused wide spread changes in the distribution and composition of modern floras.

Various climatic conditions existed in the long intervals between the periods of major glaciation. By the late Devonian Period, certain plants adapted to the different climates, and plants that earlier would only grow in wet, humid and warm climates began to grow in much drier and colder climates.

Climates during the Pennsylvanian Period were very favorable for Gymnosperm plant growth. The climate was moist and rainy and probably warm most of the time, which ferns and conifers from this period required. During the Pennsylvanian period, most of the peat, which transformed into coal through heat and pressure, was deposited. It took ten feet of peat to make a foot of coal.

Plants from the Permian are not nearly as common as those from the Pennsylvanian Period and thus those climatic conditions will not be discussed in this lesson.

Climatic conditions during the Cretaceous Period were favorable for plant growth, although there is evidence of inadequate moisture during the early part of the period. During the Cretaceous Period, plants evolved into floras closely resembling the floras of today. There were able to adapt to less moisture and colder temperatures, even mild winters. The flora of the Cretaceous were living close to streams, rivers and of course close to the Cretaceous Sea which went from the present Gulf of Mexico to the Arctic in the North. During the Cretaceous, the Angiosperms evolved.

Tertiary Period floras are very similar to today's plants. We can assume that the enviroment during that period would be similar to today's environment.

To review, it is possible, once a fossil has been found and correctly identified as to location found, geologic time period and Genus, to visualize the environment while that plant was living.

Paleobotany

Activity Sheet 55, Ancient Landscapes and Climates

Fossils — Geology, Level IV

Circle the Correct Answer for Each Period, Age, Climate:

1) A **Pecopteris** is found in Douglas county.

Geologic Period:	Pennsylvanian	Cretaceous	Pleistocene
Age in Years:	50 million	75 million	300 million
Climate:	Hot and Dry	Warm and Moist	Cold and Dry

2) A **Sassafras** is found in Ellsworth County.

Geologic Period:	Pennsylvanian	Cretaceous	Pleistocene
Age in Years:	50 million	100 million	300 million
Climate:	Hot and Dry	Cold and Dry	Seasonal

3) An **Angiosperm** is found in Barton County.

Geologic Period:	Pennsylvanian	Cretaceous	Pleistocene
Age in Years:	50 million	100 million	300 million
Climate:	Hot and Dry	Cold and Dry	Seasonal

Briefly Answer the Following (explain your answers):

1) Is it possible to find Angiosperm from the Pennsylvanian Period?

2) How is coal formed?

3) From which period is there very little fossil plant record?

4) If you collect a fossil plant that has a living relative today, what will this tell you about the environment of the era where the fossil plant grew?

Paleobotany

Activity Sheet 56, Ancient Landscapes and Climates Leader's Key

Fossils — Geology, Level IV

Circle the Correct Answer for Each Period, Age, Climate:

1) A **Pecopteris** is found in Douglas county.

Geologic Period:	**Pennsylvanian**	Cretaceous	Pleistocene
Age in Years:	50 million	75 million	**300 million**
Climate:	Hot and Dry	**Warm and Moist**	Cold and Dry

2) A **Sassafras** is found in Ellsworth County.

Geologic Period:	Pennsylvanian	**Cretaceous**	Pleistocene
Age in Years:	50 million	**100 million**	300 million
Climate:	Hot and Dry	Cold and Dry	**Seasonal**

3) An **Angiosperm** is found in Barton County.

Geologic Period:	Pennsylvanian	**Cretaceous**	Pleistocene
Age in Years:	50 million	**100 million**	300 million
Climate:	Hot and Dry	Cold and Dry	**Seasonal**

Briefly Answer the Following (explain your answers):

1) Is it possible to find Angiosperm from the Pennsylvanian Period?
No. Angiosperms evolved during the Cretaceous Period.

2) How is coal formed?
Peat is transformed into coal by heat and pressure.

3) From which period is there very little fossil plant record?
Pre-Cambrian

4) If you collect a fossil plant that has a living relative today, what will this tell you about the environment of the era where the fossil plant grew?
It was much like today's environment. The temperature, soil and rainfall would be very similar.

Kansas 4-H Geology Leader Notebook

Chapter 6 — Natural Resources and Maps, Table of Contents

Water

Natural Resources — Geology, Level I

What members will learn …

About the Project:

- Water is a continuously recyclable source.
- Water is necessary for life.
- Water can be found in three forms: gas, liquid, and solid.

About Themselves:

- The importance of observation skillss
- Why water is important.

Materials:

- Glue
- Scissors
- Crayons
- Blue Yarn
- Hole Punch
- Flip chart
- Activity Sheet 57 (three pages), *Water Cycle Mobile*
- Activity Sheet 58, *Water Watcher*

Activity Time Needed: 45-60 minutes

Activity

All over the world, water is connected in some way. The oceans, rivers, frozen ponds, puddles, water drops on plants, even drinking water from your faucet are all part of the water cycle. Our water supply is used over and over again as it moves through the Earth's atmosphere and circulates between the lands, oceans and sky.

Some of the Earth's water is frozen in polar icecaps and moves slowly through the cycle. However, the total amount of water throughout the world stays the same and the same water is used over and over again.

As users of this vital resource, we are part of the water cycle. When we wash our clothes, take a shower or brush our teeth, the water runs off and ends up in rivers, lakes, gulfs, or oceans. The sun heats the air causing some of the water to evaporate and fill the lower layer of the atmosphere with an invisible water vapor. In the process we call weather, air currents carry the water vapor higher, where clouds are formed. These clouds contain droplets of ice or water. After the clouds are filled with droplets they fall back to Earth in the form of rain, snow, sleet or hail.

Leader's Notes:

Before discussing the water cycle, have members list on a flip chart as many places as they can where they can find, see or feel some source of water.

Rain or snow runs into rivers and streams. Sometimes the water travels into reservoirs and lakes, which supply water treatment plants. These plants treat the water so that chemicals, minerals and bacteria that the water picked up on its journey are removed. Water is then pumped to your home faucet. Then the water cycle begins all over again.

Water Cycle Mobile

Hand out the three pages of Activity Sheet 57, *Water Cycle Mobile*.

We will demonstrate the principles of the water cycle by making a water cycle mobile.

We will weave yarn through the pages to represent the circulation of water. When the yarn is connected, it shows the continuous path of water as it goes through the cycle.

1. Hand out the pages
2. Color (optional) and cut the pages on the solid lines
3. Glue the pages together to make one long sheet
4. Use a paper punch to make a hole at each numbered dot
5. Cut a 50-inch length of blue yarn. Begin at hole #1 and weave the yarn in and out of the holes as numbered.
6. Glue the first and last pages together to make a wheel
7. Tie the ends of the yarn together and cut off excess.

Follow the path of the water cycle.

Water Watcher

Give each member Activity Sheet 58, *Water Watcher*, and take them for a walk. A walk after rain or snow would be one of the best times. Plan ahead of time how to organize your walk. Can several adults go with you?

Today we are going to be water watchers. We are going to take a walk to see if we see signs of the water cycle. You will each have a checklist and when you see a sign of the water cycle, you can check it off by putting an X or a checkmark in the square box in front of it. What are some things to look for? Look at the checklist before we go out to see what is on it.

Dialogue for Critical Thinking:

Share:

1. What did you enjoy most about making the water cycle mobile?
2. How many items did you see on your water watcher walk?

Process:

3. How does water get from the clouds to the river? (*Rain, snow*)
4. How does water get from the river or lake to your faucet? (*Water treatment plant cleans and pumps.*)
5. How does water get from rivers and lakes to the clouds? (*Evaporation*)

Generalize:

6. Where does the water come from that you drink?
7. Why do you need to drink water?
8. Is it wise to drink any kind of water that we see? Why not?

Apply:

9. Why would you want to take care of your water? (*Keep clean, save for later.*)
10. Is there any more water now than when the dinosaurs were around? (*No, it continues to cycle.*)

Going Further:

1. Draw pictures of water observed on the walk.
2. Take water watcher checklist home and add to the list.
3. Visit a water treatment facility
4. Visit a bottle water distillery
5. Boil water, observe and collect steam

Be prepared to discuss the variations in the supply of drinking water.

References:

Water Education for Teachers (WET), Kansas State University Extension, Copy Cat Magazine

Author:

Benetta Foster, Kansas 4-H Geology Curriculum Team

Reviewed by:

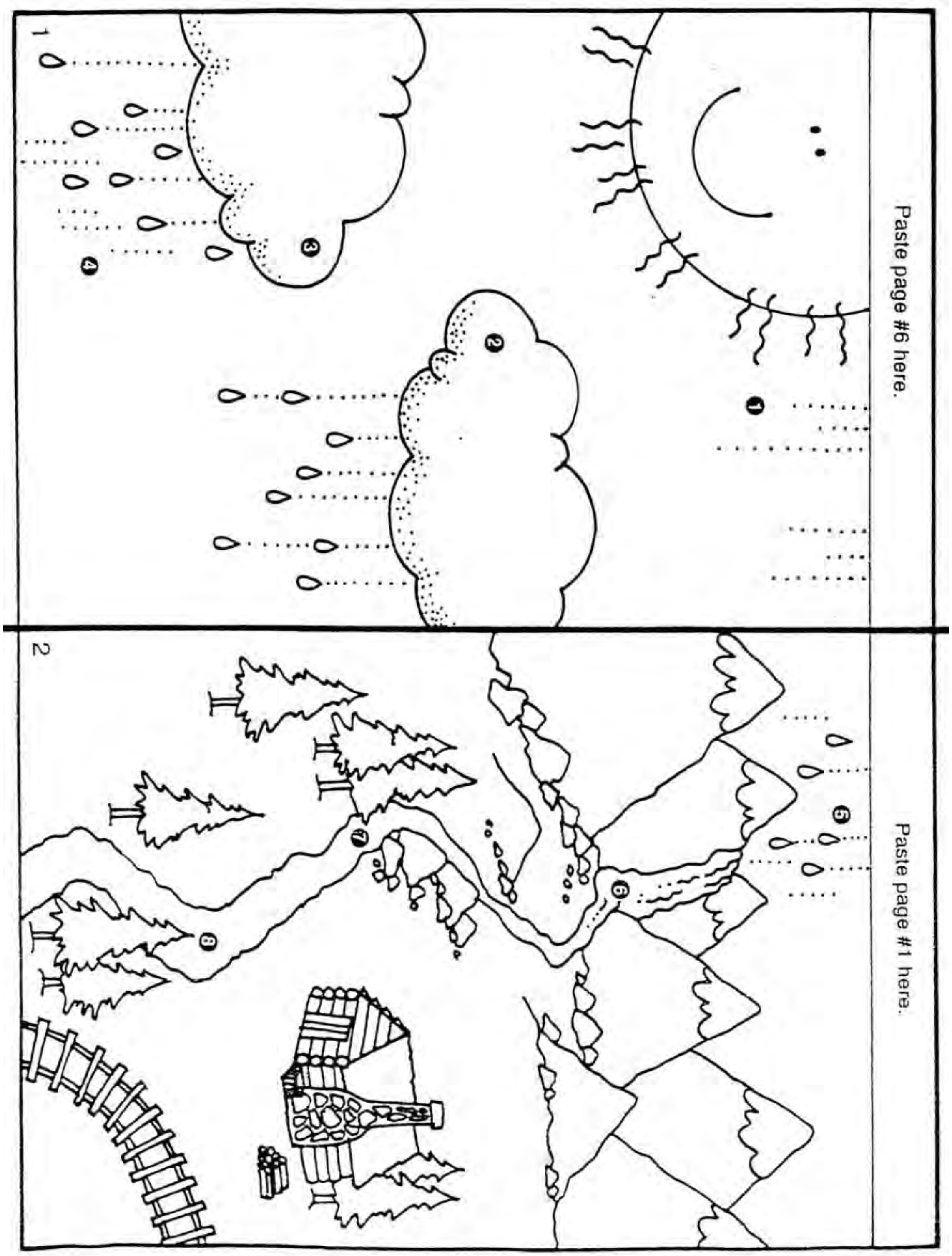
Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Water

Activity Sheet 57, Water Cycle Mobile

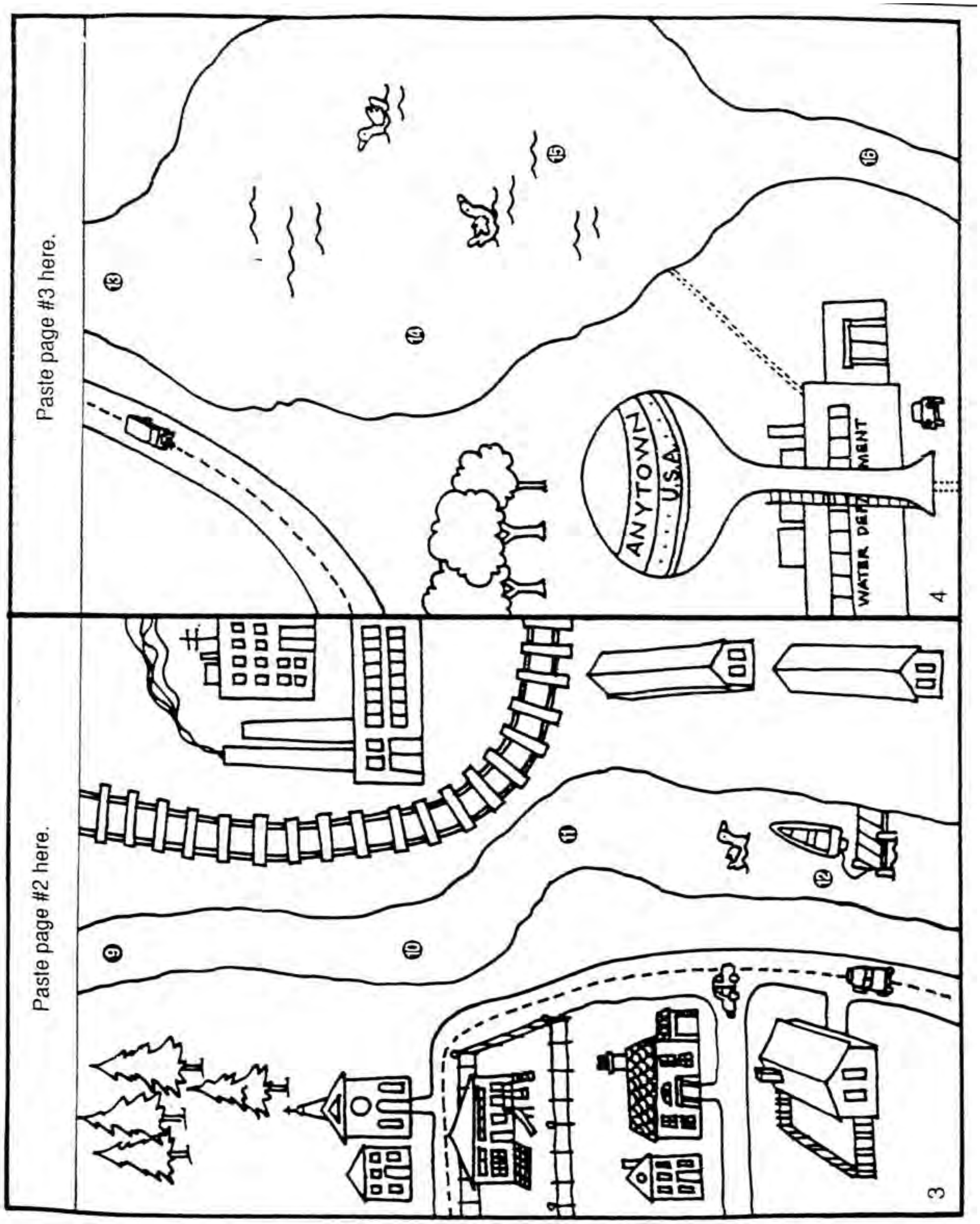
Natural Resources — Geology, Level I



Water

Activity Sheet 57, Water Cycle Mobile

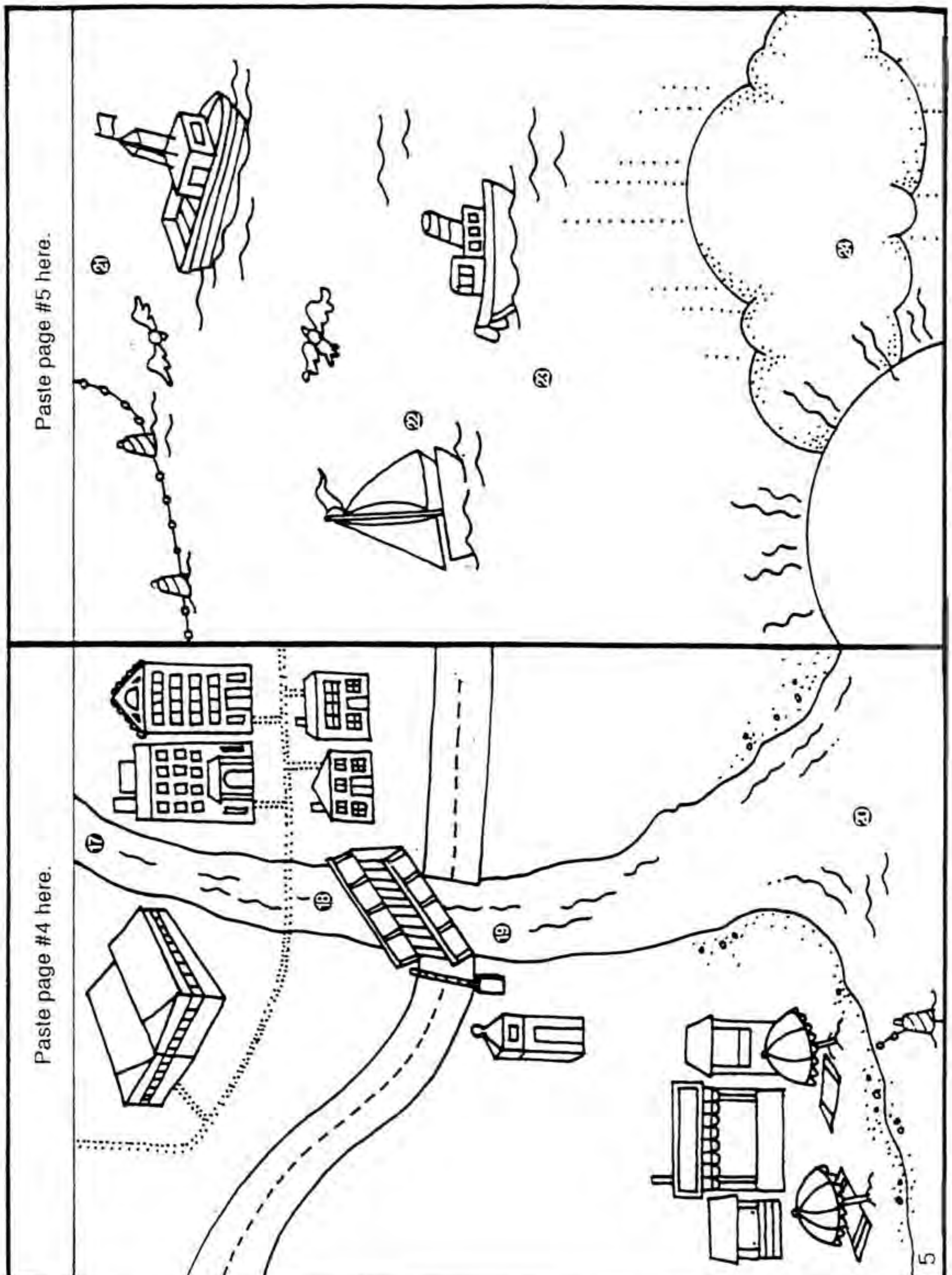
Natural Resources — Geology, Level I



Water

Activity Sheet 57, Water Cycle Mobile

Natural Resources — Geology, Level I



Water

Activity Sheet 58, Water Watcher

Natural Resources — Geology, Level I

I'm a Water Watcher

This is what I see:

- ☐ Water droplets on plants
- ☐ Water droplets on windows
- ☐ Clothes on a clothesline
- ☐ A puddle
- ☐ A muddy spot that was once a puddle
- ☐ A place that shows soil erosion
- ☐ Clouds
- ☐ A storm drain
- ☐ Water running in the gutter
- ☐ A water meter
- ☐ A water tower
- ☐ A lake
- ☐ An icicle
- ☐ A snowball
- ☐ Fog
- ☐ Other ____

Which Way?

Maps — Geology, Level I

What members will learn …

About the Project:

- How to make and use a compass rosette.
- How to find directions on a map.
- Points of geological interest in Kansas.

About Themselves:

- How to tell and give directions.
- The value of maps.

Materials:

- Highway type map with a compass rose on it
- Compass
- Activity Sheet 59, *Compass Rosette and Dino Directions*
- Activity Sheet 60, *State Landmarks*
- Pencil
- Scissors
- Blank sheets of paper
- Sidewalk chalk or regular chalk
- Yardstick
- Large open area, preferably on concrete

Leader's Notes:

Ahead of time, draw a large map of the state outdoors on concrete; or indoors, use twine or masking tape to outline the state if you are doing this activity. You may add a few features such as major rivers. The map does not need to be exact. For Kansas, a rectangle almost twice as wide can be used (ex. 10 feet by 19 feet) can be laid out. Then draw a wavy line over the Northeast corner. Keep the directions oriented the way they really are. Draw a simple compass rose nearby. There is an alternative activity that can be used if you prefer.

Activity Time Needed: 45 minutes

Activity

Who can tell me what I am holding in my hand? What is it used for? Do you know how it works?" (*A. The moving needle is magnetic and points North and South unless a closer magnet gets in the way.*)

Show compass.

Allow a little experimentation. Let each member hold and observe the compass. Then tell them they can use it more after the meeting is over.

Maps use a paper version of the compass to tell which way is which. Let's look at some maps for the compass rosette.

Show compass rose on the real map.

By using the map people can tell which way they need to go to get somewhere. We are going to fill out this page to learn how it works.

Hand out Activity Sheet 59, *Compass Rosette and Dino Directions*. Read and do each part with the members, drawing a large compass on a chalkboard or piece of paper if you have a large enough group to warrant it.

If time is short, you could explain this exercise and have them do it at home. Children without a backyard could draw something else, like the room you are meeting in, or any other area they know well.

Distribute Activity Sheet 60, *State Landmarks*.

It will probably be better to work together as one team and find the locations together. If your group is large, you may divide into teams and find the locations. In that case you may want to divide up the sites, or have each group put their initials on their pictures.

Help children who are having trouble by helping them to turn the map the proper direction and coordinate locations.

Have members find the locations only on a paper copy of the map. Cut your landmark pieces from the rest of the map and enlarge the map section of the activity sheet. Make enough copies of both parts for everybody. Then work on your paper as the students do

Next, lets turn the paper over and draw a quick map of your backyard. Which way should be up on your map? (*North*) It will be easier to draw it with the directions right, if you turn the paper so that up is the direction North really is. Now draw in a compass rose with North, South, East and West. Now draw your house and a couple of other things that are in your backyard.

The next activity will help you find some interesting things in our state. We will use this little map to find where things are in our state and then find the same locations on this big map of our state that I have drawn here on the floor (or playground) with chalk.

Each picture at the bottom of the page is a special place in Kansas. Have any of you been to any of these places? Where on this small map is our county? Where would that be on the big map? We'll put this picture of a house to show the county where we live. Where would we put the picture of the state capitol? Where is the state capital? Let's put the rest of the pictures on the big map, using the little map to show help us.

Alternate Activity:

Here is a map of our state. Cut out the landmark pieces and paste them to this map. Where is our state capitol? Paste that picture there. Which way do you live from there? Paste the picture of the house there. Now do the same for the rest of the pictures.

Dialogue for Critical Thinking:

Share:

1. Which direction is easiest for you to identify? Why?
2. How many of the state landmarks did you know?
3. What is a compass used for?
4. What happens to the compass when you turn different directions?

Process:

5. What is important to know about using a compass or reading a map?

Generalize:

6. When would you use the things you learned today?
7. Why is it important to know how to give directions?

Apply:

8. What is the name of our county? Can you think of any times that what county you are in makes a difference? (Ex-listing your specimens by county)
9. What other times would you think it would be useful to know how to use a compass?

Going Further:

1. Make a “treasure map” of some convenient place like your backyard and have someone try to find the treasure (some treat). Alternately, the leader could draw the map and hide the treasure, and the 4-Hers could follow the map to find it.
2. At the next field trip, provide a map and encourage members to look at it. Ask questions like, “Which direction will we go when we start the field trip? What county will we be in?”
3. Children may do a purchased puzzle of the state or of the U.S.
4. Do a simple game to “Mother May I.” All start on one side of the room. The leader gives directions such as “take three steps North. Now take one step West.” Gradually advancing the group across the room. Any incorrect responses must take one step back. First, to get across are the winners. If you are fortunate enough to have a tile floor, go three tiles to the North, etc.
5. Encourage the children to study the map on family trips. “Which way is Grandpa’s house from our house?”

Resources:

Many libraries have books for children on maps, or books that have sections on maps.

State maps available from state highway departments or may be purchased over the counter at gas stations.

More detailed maps are available from the Geologic Survey: Kansas Geological Survey, 1930. Constant Avenue, Lawrence, KS, 66047-3726 and at other locations throughout Kansas.

Roadside Kansas, by Rex Buchanan, lists many interesting geology locations.

Author:

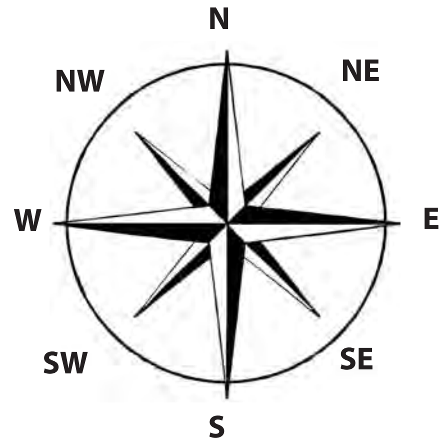
Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by:

Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Answers to Compass Rosette:



Answers to Dino Directions:

1. N
2. S
3. NW
4. NE
5. SW
6. E

Which Way?

Activity Sheet 59, Compass Rosette and Dino Directions

Maps — Geology, Level I

Maps usually have a compass "rosette" on them to show which way is which direction. Put these on the different directions of the compass:

Put an N for North at the top of the compass.
Up is usually North.

Put and S for South at the bottom of the compass.

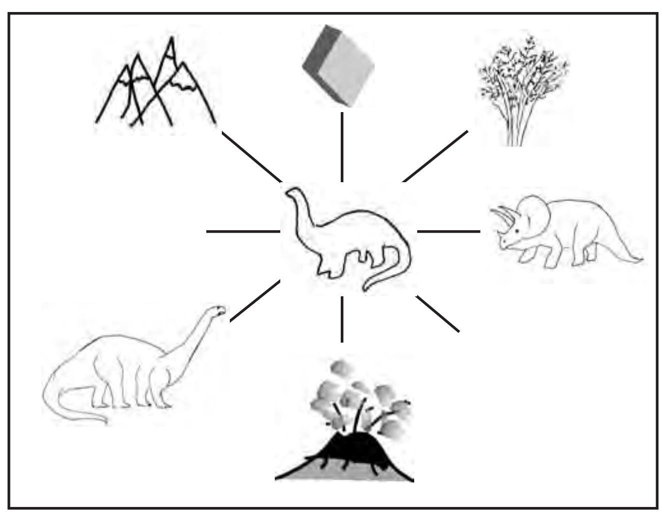
Put an E for East on the right side.

Put a W for West on the left side.

Add more directions to the compass, in between the other directions. Between North and East, add Northeast by writing the letters NE. Add these other directions to the compass: Northwest (NW), Southeast (SE) and Southwest (SW).

Dino Directions

Help find baby Dino find his way. Look at the map below and then tell Dino which way to go. Write in the direction using the letters you used on the compass.



1. Which way is the pretty diamond? ________________

2. Which way is the volcano? ______________________

3. Which way are the mountains? ___________________

4. Which way would Dino go to find some plants to eat?
____

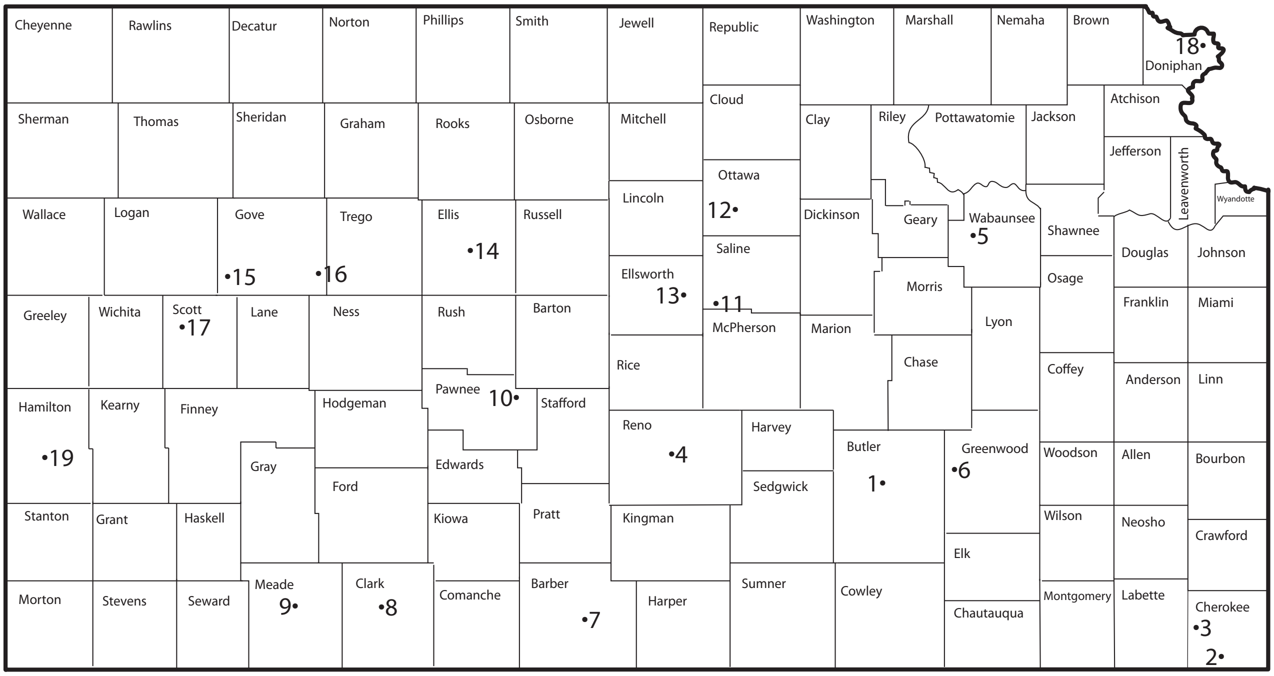
5. Which way would Dino go to find his mother?
____

6. Which way should Dino not go because it has a scary Triceratops? _________________

Which Way?

Activity Sheet 60, State Landmarks

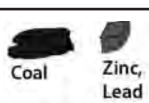
Maps — Geology, Level I



Map adapted from Kansas Geological Survey

1.El Dorado Oil Museum
2. Zinc mines and chat piles
3. Coal strip mined by giant shovel
4. Salt mines
5. Skyline scenic drive (Flint Hills)
6. Flint Hills drive (unmarked)
7. Medicine Lodge, heart of Red Hills Country
8. Big Basin
9. Meade salt sink and Seybert sink
10. Pawnee Rock
11. Coronado Heights
12. Rock City
13. Mushroom Rock
14. Sternberg Museum at Hays
15. Monument Rocks
16. Castle Rock
17. Scott County State Lake and Park
18. Loess Bluffs along the Missouri Rivers “Little Switzerland”
19. Sand dune area, south of Syracuse

Cut out these items and add them to your map.

My House 	Oil 	Capitol 	Mushroom Park 	Coronado Heights 
Tri-State Mining Area 	Sternberg Museum 	Castle Rock 	Sand Dunes 	Flint Hills 

Map of Backyard

Now that you know directions, please draw a map of your backyard on the back of this sheet. Start by turning the paper so that up is North. Then put in your house and at least 2 other things.

Rocks You Eat and Use

Natural Resources — Geology, Level II

What will members learn …

About the Project:

- Geologic products affect every part of our lives.
- Geologic products have some very unexpected uses.

About Themselves:

- Their relationships to geological products.
- How to categorize items.

Materials:

- Products brought to you by members (see Advance Preparation note)
- A few unusual products of your own, including some food products
- Member Handout 35, *Geological Products in Your Home* for each person
- Small prizes (1-3) for most unusual product
- Poster "Your House Came out of a Mine" (optional, see reference)

Activity Time Needed: 10-15 minutes

Activity

Let's look at things you brought from home that are geology related. What a variety! Let's group them into categories. What would be some good ones? (*A. Foods, metals, electronics, building materials, etc.*) Are you surprised that we even eat rocks? The most common one is probably salt, but they are also in many other things, like calcium for strong bones. Some drinks used to have a small amount of clay, kaolin, in them to make them look cloudy. Now they often have a calcium product. What are some others? Let's look at the labels and see what is in them

It's probably not so surprising that we use geology products for building, from the cement for the basement to the bricks for the chimney. Even petroleum products are considered geologic materials. Are you surprised that electronics are geology related? Even the silicone for computer chips is a geology product. Here is a page listing some geology products. Which product do you think is unusual? Why? All your products were interesting and helped us learn about geology. Let's take a vote to see which is the most unusual product that one of you brought.

Advance Preparation:

When you notify your members of the meeting, ask each of them to bring one to four geology related products from home (number depending on the size of your group). Tell them they will receive a small prize if they bring the most unusual one.

Leader's Notes:

Designate a table for them.

Use categories that make sense with what products you have.

Hold up a bottle or can and show the label.

Provide Member Handout 35, *Geological Products in Your Home*.

You could choose the winner yourself instead but this makes them think about them more.

Dialogue for Critical Thinking:

Share:

1. What products surprised you the most?
2. What new uses of geology products did you learn tonight?

Process:

3. What kind of products were alike, and in what way? (Use? Appearance?)
4. Did you think mostly of metals when we first mentioned this lesson?

Generalize:

5. What did you learn about grouping items into categories? (*A. Decided whether to use similar characteristics, uses etc. Items do not always fit neatly into one category or may fit in more than one etc.*)
6. How important is geology in your life?

Apply:

7. What unusual items do you have in your home?
8. What would you say to someone who told you that geology wasn't important?

Going Further:

1. Compare orange drink with a geological product in it to make it look thicker, with a clear one. (Tang to orange Kool-Aid would be one example.) Read the label to find out what is in each.
2. Make a poster or display of geology products and exhibit it.
3. Investigate what geology products are produced in your state. Make a display or presentation.

References:

Your Home Comes Out of Mine (free flyer), one page summary poster from the SME Foundation for Public Information and Education, Inc., 8307 Shaffer PKWY. Littleton CO 80127 Phone (303) 973-9550.

Author:

Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by:

Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Rocks You Eat and Use

Member Handout 35, Geological Products In Your Home

Natural Resources — Geology, Level II

Building:

Many parts made of wood, a plant material rather than geologic, but a lot of components are made of geologic products.

Foundations, slab: concrete (composed of cement, sand and gravel)

Walls:

Concrete — as in concrete block houses

Building stone — limestone, or others

Metal in nails, bolts, plates, wire — Could be iron, copper, or aluminum

Plaster board and plaster — made of gypsum

Paint — assorted metals, petroleum products, limestone and dolomite

Roof: if not wood, it could be slate, metals such as iron or copper, petroleum products, mineral or rock fragments

Fixtures/ Furniture:

Iron, copper, tin, zinc, glass

petroleum products

Heating and Cooling:

Oil, gas, coal

Electricity carried on metal wires

Clothing and Care Products:

Some made of plant and animal fibers.

Others made of these:

Petroleum products (polyester), metals

Detergents, additives and fillers (borax, phosphates, etc.)

Health Care Products:

Medicines — Antacids, laxatives

Fillers in medicines — clays, calcite, etc.

Abrasives, such as found in toothpaste — limestone, dolomite, salt

Food Products and Supplements:

Minerals needed for life — iron, calcium, etc. Salt

Limestone and dolomite fillers (to make products look cloudy or be thicker)

Clays and minerals

Cooking and eating utensils

Entertainment:

Wires, metal parts on TVs etc.

Silicon chips, without which computers would be very primitive.

Cross Sections

Maps — Geology, Level II

What members will learn …

About the Project:

- How a geologist can tell what is under the surface of the earth.
- How core drilling works.
- How to read and use the cross section maps.

About Themselves:

- How to analyze information to make logical deductions.

Materials:

- Cross section maps
- Kansas map showing I-70 cross section (Available from the Kansas Geological Survey.)
- Peanut butter
- Dark jelly (like grape)
- White bread and whole wheat bread
- Sharp knife, and table knives (could be plastic)
- Plastic straws, large if possible, for each member
- Small sharp scissors (optional)
- Napkins or paper plates
- Actual core samples (Possibly from Kansas Gas Service (KGS) Well Log Library in Wichita.)

Activity Time Needed: 30 minutes

Activity

Did you ever wonder how a geologist can tell what is underneath the surface of the earth? One way they find out is by drilling holes into the earth. By seeing what comes out of the hole, an experienced geologist can map underground layers far below the surface of the earth.

Sometimes they use a drill that brings up the layers whole in a round core. This is called a core drill. Auger or rotary drill, on the other hand, grind the rocks and dirt up as they drill, and then bring pieces to the surface. They sometimes also use sophisticated instruments to "see" below the surface.

Cross Section:

Here is a map of Kansas showing where different layers show at the surface. The cross section at the bottom shows what it is like underneath the surface at I-70 highway. I will use this peanut butter sandwich to show how that

Leader's Notes:

Preparation:

Make two peanut butter sandwiches ahead of time. One should be many layers thick, and one should have grape jelly spread on only one quarter of the sandwich, with no jelly showing on the outside edge.

Use the taller peanut butter sandwich you made to show this.

works. See how it is several layers tall. The layers were originally laid down flat, although they may not have been quite as flat as these are. Then, our earth became more active geologically. Parts were buckled and erosion washed away a lot of Kansas.

Bend the sandwich slightly to show a hill for buckling.

I am making a slanting cut to show how more is gone in the Eastern part of Kansas than in Western. What layers are showing at the surface now? (A. *Now different, lower ones show at the surface.*) We can't be sure that the layers that are not there (cut off) were actually like the ones that are left, as that part is gone. Now I am going to cut the sandwich in half. This would be like the cross section.

Cut off a piece at least three layers thick at one side and one layer thick on the other.

Make a perpendicular cut to cut the sandwich in half.

See how all the layers show now and you can tell how deep they are. Look at your maps. The cross section they show was not really ever cut there. It is just to show what it would show if you could. See the letter 'A' and the line on the top map? That is about where Interstate Highway 70 is? That is where they did the cross section and it shows what is under Interstate 70. Have you driven on that highway? Do you remember that Western Kansas looks different than Eastern? At least part of the reason is that different rock layers are showing at each area. Look at the map and find your county. Now look straight down to the cross section. What rock layers are under your county and in what order?

Core Sample:

If you can, make enough sandwiches so that every two or three members have one to experiment with.

Can you think of a place where you have seen a cross section? (*Road cuts, Dam spillways.*) Most of the time geologists can't cut away the dirt to see what they want to know, so they make drill holes to find out. Here is another peanut butter sandwich. I have put grape jelly on one quarter. Can you tell which it is? Each of you take a guess which quarter of the sandwich has the grape jelly. Use a straw and take a pretend core sample on a part of the sandwich. Push the straw straight down with a slight twist. Cut down the side of the straw until you can see the whole plug. Do you see any grape jelly? Keep trying until you find the jelly in the sandwich.

If you don't have scissors, try gently blowing the core out.

A real core sample is usually several inches in diameter. Sometimes they are put in long trays to keep them in order so they can be examined later.

Show core sample and pass it around, if you have one.

Now, you are going to make a sandwich with grape jelly on one quarter. When you have made your sandwich, find someone who hasn't watched you make it, and core sample it to find the grape jelly.

If you don't have enough for each member to make a sandwich, then have them do it in pairs. If their hands are clean, they may eat the sandwich afterwards.

Dialogue for Critical Thinking:

Share:

1. How does a cross section of a sandwich help you understand the earth?
2. How does a core sample substitute for a cross section?

Process:

3. Where can you find good cross sections of earth layers?
4. How do geologists use core samples? Why?

Generalize:

5. Where else might cross sections be used?

Apply:

6. Why do people need to know what is below the earth's surface? (*Consider buildings, highways, natural resources and earthquakes*)
7. When might a core sample be misleading?

Going Further:

1. See if you can get some actual core sections to study. Observe them closely. Can you tell the different kinds of rocks? How does it compare to a profile (cross section) of the area? Can you see any interesting features, like fossils, in it?
2. Map a road cut. Measure each feature carefully so you will have an accurate map. (See Mapping, levels 3 and 4)
3. Find out some of the other methods geologists use in addition to core holes. Compare.
4. Observe a water or oil well being drilled. The materials coming out are ground up. Can you still tell what is under the surface? How?
5. Take your I-70 cross section map with you on a trip. Can you identify any of the layers?
6. Make a chart or prepare a talk on the advantages and disadvantages of a cross section or core sample.

References:

VanCleave, Janice, *Earth Science for Every Kid*, 1991, John Wiley & Sons, Inc.

Author:

Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Top It Off

Maps — Geology, Level III

What members will learn …

About the Project:

- How to read a topographic map.
- Elevation lines are:

  Equal distance apart in elevation.

  The same distance above the ocean anywhere on the line.

  Closest together where land is steepest.

  Form a V pointing up river.

  Form circles for mountains or hills.

  Changes in direction are indicated by hash marks.

About Themselves:

- How models and observation help learning.

Materials:

- Large amount of modeling clay or play dough
- Clear shoe box style storage box with clear lids or plexi glass to lay over top of it
- Clear acrylic sheets like overhead transparencies or report covers cut to size of shoe box
- Grease pencil or permanent marker that will draw on sheets
- Large tray or cookie sheet to catch drips, and a towel
- Water — at least two gallons — and pitchers
- Food color
- Pencils
- Masking tape, ruler, nail
- Topographic map of your area, and other topographic and relief maps as available
- Activity Sheet 61, *Topographic Maps*

Activity Time Needed: 45 minutes or more

Activity

A special kind of map is used in geology to show elevations, which is the height above sea level. Do you know what it is called? A. Topo, or topographic map. Here is one for our area. See all the little lines? Each line shows a certain elevation, and everywhere on that line is the same elevation.

Leader's Notes:

Let them look at the map for a while and give examples of elevation.

If only two groups, have one group do a young (V-shaped) river valley and the other do a typical cone-shaped mountain that can later be modified into a volcano. More groups (reuse play dough?) can do a mesa or cliff, a plain (gradually sloping) or a volcano.

Monitor each group as they work.

You can tell a lot about the shape of the land by looking at a topographic map. We are going to do an experiment to show how topographic maps work. I am going to divide you up in groups and I want you to make a small model of your assigned land form feature that will fit into a shoe box. When we are done, we will pour water on the models to different depths to show how different landforms make different patterns on the topographic maps.

Use a separate sheet of clear plastic for each landform. Start with the mountain. Tape first clear sheet to top of box.

Place the landform model in shoebox. Readjust as needed to fit. Be prepared for a little messiness and spilled water. Use grease pencil and ruler to mark 1-inch levels on side of shoebox, starting from bottom.

Pour water in until it reaches first mark (or about a half inch if models are small). Looking straight down, draw a line where the model meets the water. Repeat for each inch. The lines should eventually become somewhat circular and closer together as you move up the mountain to steeper slopes. When done ask:

What shapes approximately do the lines form? *(A. A circle*)

Repeat or modify for volcano. Use a pencil to punch a hole through to crater so water can get inside.

Add some hash marks.

Where were the lines closer together? (*A. Where steepest*)

How can you tell if the lines are going up or down in the center? Can't? Mappers use hash marks, or short lines, to tell if it changes direction.

Do the river the same way.

Repeat with other features, which should show:

Plain: gradual lines far apart.

Mesa or cliff: closely spaced lines where it is steep.

What shape does this form? (*A. V's*)

Which way do the V's point? (*A. Up river in the direction the river is getting higher. Not all V's show where the water would run together on its way to form a river or stream.*)

Point out symbols, compass rose, scale, etc.

Here is a real topographic map. How does it look different? (*A. Much more on it.*)

Colors: typically, each fifth topographic line is darker or a different color to make it easier to follow and figure out elevation.

Repeat with several locations. Have them find a mountain or hill, and a river or stream.

Find_______(pick a feature on the map, like where you are meeting or a landform)

What elevation is it?

If you climb this mountain, or go to this lake, from________, what would be the easiest way to go? The most challenging?

Now we will do simplified worksheet of land forms.

Do Activity Sheet 61, *Topographic Maps*, following the directions and reinforcing concepts.

Answers:

1. River-C, Mountain-A, Plain-D, Volcano-B
2. North
3. A
4. Up

OPTIONAL or substitute if not doing models:

Trace different contours off of a simple topographic map or from the activity sheet, showing one or two features. Cut each contour out of cardboard, or foam board, painting each layer a different color if desired. Use only every fifth line if area is large. Stack them up in proper order and glue to resemble the area. Study and analyze it as you did the other models.

Dialogue for Critical Thinking:

Share:

1. Was it easy or hard for you to identify features on the topo maps?
2. How did the models help you learn the map features?

Process:

3. When are the contour lines closest together? (*A. Where land is steep*)
4. What is the basic reason for topo maps? (*A. To show elevations of different areas, which can tell you what landforms are at a location.*)

Generalize:

5. How could you use a model in other areas of your life?

Apply:

6. How would you use topographic maps to find a good place for a field trip?
7. Where on a topographic map would it indicate a pretty view?
8. How would a topographical map help you build a highway.? (*Consider cost, view, safety, distance, etc.*)

Going Further:

1. Study a variety of topographic maps. Try to get ones showing different features, such as karst topography or sinkholes.
2. Collect relief model maps and study them. They are often available at National Parks and those have interesting features. Compare them to each other and to topographic maps. What is the highest elevation on each? What would you consider the outstanding feature on each?
3. If you can get some stereoscopes and stereo photos of different types of landforms, these can be a good way for members to comprehend topographic maps.

References:

These books have good analysis of topographic maps whether or not you use a stereoscope (3-D viewer) with them.

Stereogram Book of Contours by Horace MacMahan, Jr.; Hubbard Scientific Company, 2855 Shermer Road, Northbrook, Illinois 60062. (Good book with basics of elevations and generalized topo maps of landforms)

Stereo Atlas sponsored by the Am. Geological Institute; also printed by Hubbard. (Has aerial views, stereo aerial views and a topographic map section of 50 interesting geological features)

Author:

Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Top It Off

Activity Sheet 61, Topographic Maps

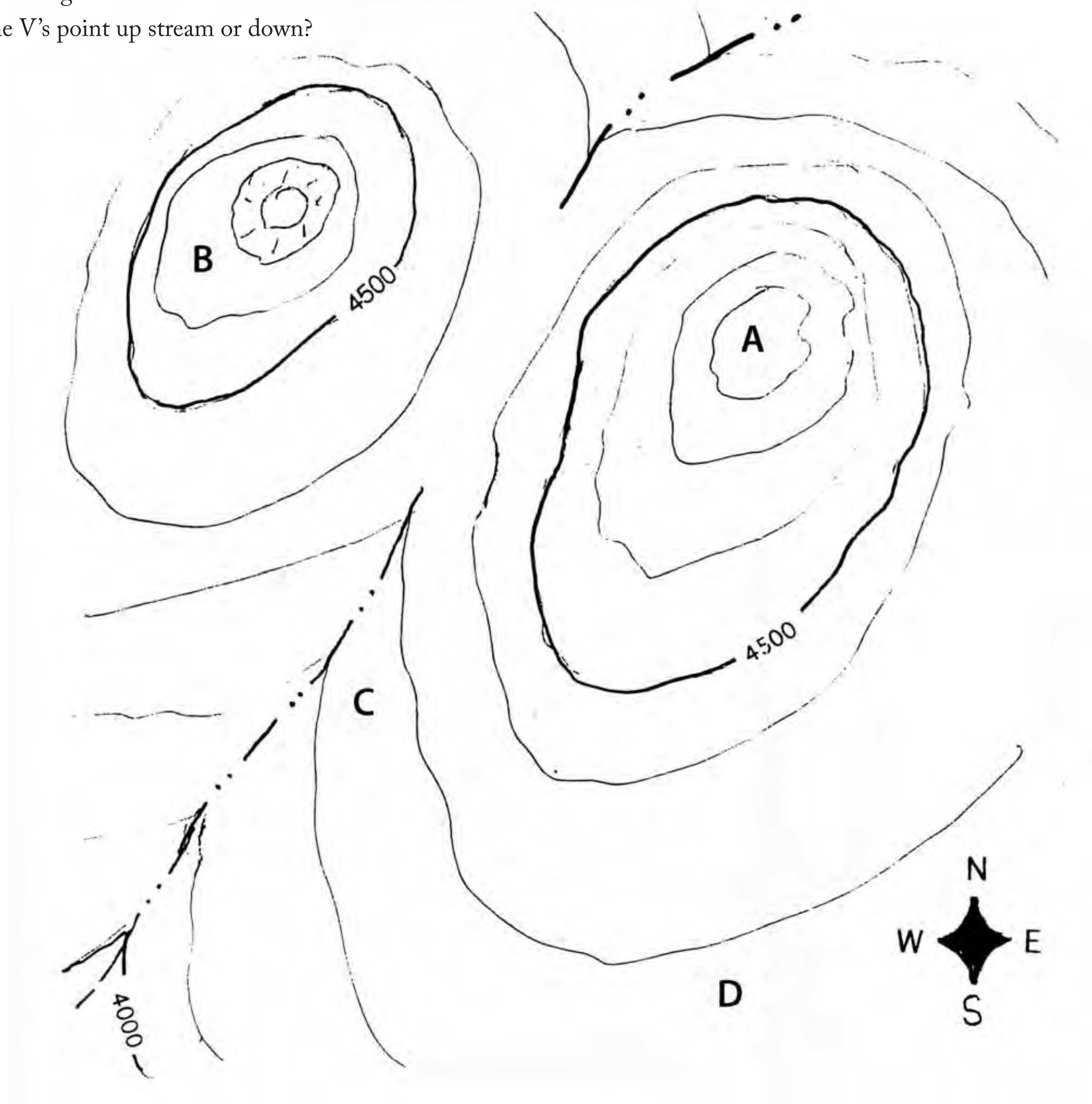
Maps — Geology, Level III

Use the map below to answer these questions:

1. What letter is on each of these land forms:

River:______ Mountain:_______ Plain:_______ Volcano: _______

2. Which side of the mountain (A) is steepest
3. Which is higher: Mountain A or Volcano B?
4. Do the V's point up stream or down?



Section, Township and Range

Maps — Geology, Level III

What members will learn …

About the Project:

- What a plat map is.
- How to read section, township and range from a plat map
- How to locate a land owner

About Themselves:

- You should respect other people's rights and get permission before going on private property

Materials:

- Member Handout 36, *Plat Maps*
- Activity Sheet 62, *Using Sections*
- Real plat maps, preferably of your area, available at your county offices
- Larger map or globe showing longitude and latitude
- State map showing township and range
- Pencils
- Field trip logs (optional)

Activity Time Needed: 30 minutes

Activity

To collect specimens you will need to get permission from landowners of private property. To do this, you need to use a type of map that has a smaller scale than most of the ones you have been using. These are plat maps, which show property owners and local features. Plat maps help you find the legal description, which you can use to confirm that the present owner is still the one listed on the map. Then you can contact the owner and ask permission to collect. Sometimes, good collecting locations are described by this method. You can get these maps from the county offices, and they look like this.

The land description system uses section, township and range to tell the location. When you know these things, you can locate to the nearest square mile where the land is in the state. Many places in Kansas have roads on all four sides of the square mile. Sometimes collecting spots are described even more closely, by telling which quarter of the section to use. By using this neat, orderly system, anyone can figure out a location. Here is a handout and an activity sheet on the section numbering system. It is not hard to learn. Let's do it now.

Leader's Notes:

Hold up a plat map.

Provide Member Handout 36, *Plat Maps*, and Activity Sheet 62, *Using Sections*, plus pencils.

Outline areas with finger as you discuss each.

O.K., now we are going to look at a map of the world and work our way down to a map of our own area. First, let's look at this larger map (or globe). What longitude and latitude are we?

Next is the state map. Locate the latitude and longitude lines. These are the basis for the numbering used in determining the sections. Now here is a map of just our area. What section of the larger map does it show?

Can you find your own house on it? Now figure out the section, township and range for it.

Dialogue for Critical Thinking:

Share:

1. Have you ever heard of section, township or range? When?
2. How difficult was it to find a specific feature and list the legal description?

Process:

3. What is the advantage of listing the section, township, and range of your stops on a field trip?

Generalize:

4. Why is it important to get permission before you do collecting, or even just walk, on someone's property?

Apply:

5. What are some non-geology uses for plat maps? (*A. Any time you need the legal description. You could use this in connection with buying some property, locating property to be re-zoned, etc.*)

Going Further:

1. Use your field trip logs to locate section, township and range of the collecting stops. If they are already given, look up the locations on the map. If not, try to locate the stop on the map and add them to the log.
2. Add section, township and ranges to each stop on the list of your specimens.
3. For the next field trip, actually look up the section, township and range before the trip, and add them to the log. Look up any landowners and contact them for permission.
4. Read about a zoning change in the newspaper; then try to locate that area on a map.

Author:

Pat Gilliland and Alan De Good, members, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey.

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Section, Township and Range

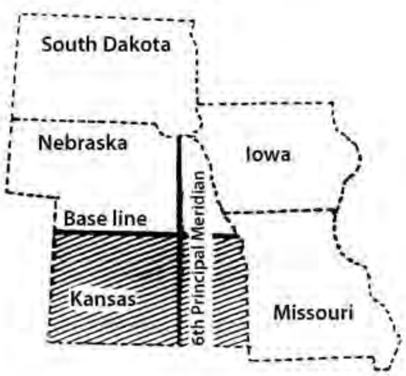
Member Handout 36, Plat Maps

Maps — Geology, Level III

Plat maps are usually available at you local abstractor's office. They are called plat maps because they show the names of the owner on each tract of land within the boundaries of the map. Plat maps have smaller scales than most general highway maps and usually represent geographical areas the size of a county or less.

Plat maps show such features as roads, railroads, houses, schools, churches, etc. They have other details of specific use to rock collectors. For example, the top of the map always represents north. Also, they describe each plot of land according to the legal government land division.

Government townships and sections are the basic units of land division. The townships are designated by positions relative to north-south lines of longitude called base lines. On the map, note the area, including Kansas, governed by the sixth principal meridian and east-west latitude lines called base lines.



Map showing areas governed by the sixth principal meridian and its base line.

The word "range" is used to designate the location of the townships either east or west of the principal meridian, and "township" is used to designate location of township north or south of the base line. Each standard township is 6 miles or 36 square miles in size. Each section is 1 mile square or 640 acres.

Each standard township contains 36 sections. Numbering of the sections within a township starts in the upper right hand corner of the township and goes back and forth across the township with section 36 in the lower right hand corner.

The sketch shows how townships are designated and how sections are numbered within the townships. When you look at your plat map, you will find that townships are coded along the east and west margins of the map; ranges, along the north and south margins; and sections numbered, as indicated, within each township.

If you see the abbreviation "sec.1, T. 1S..R. 2E.," you know this is the northeast section in the first township south of the base line and the second range east of the sixth principal meridian. Note that all townships are south in Kansas because the base line is the north boundary of the state.

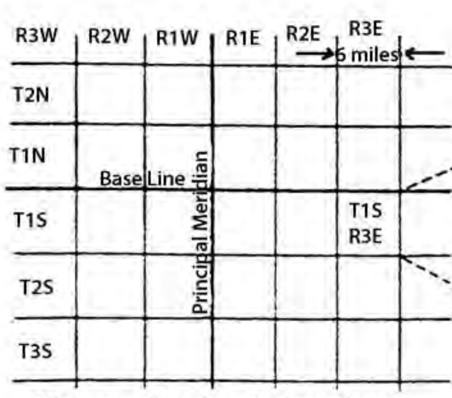
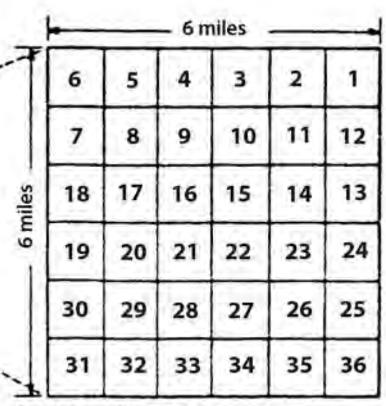


Diagram showing designation of townships and ranges



Sectionalized Township

A sketch showing how townships and ranges are numbered from principal meridians and base lines, and the numbering of sections within a township.

Section, Township and Range

Activity Sheet 62, Using Sections

Maps — Geology, Level III

Locating objects on a map by section:

Step 1: Put North, South, East and West on your township plat map.

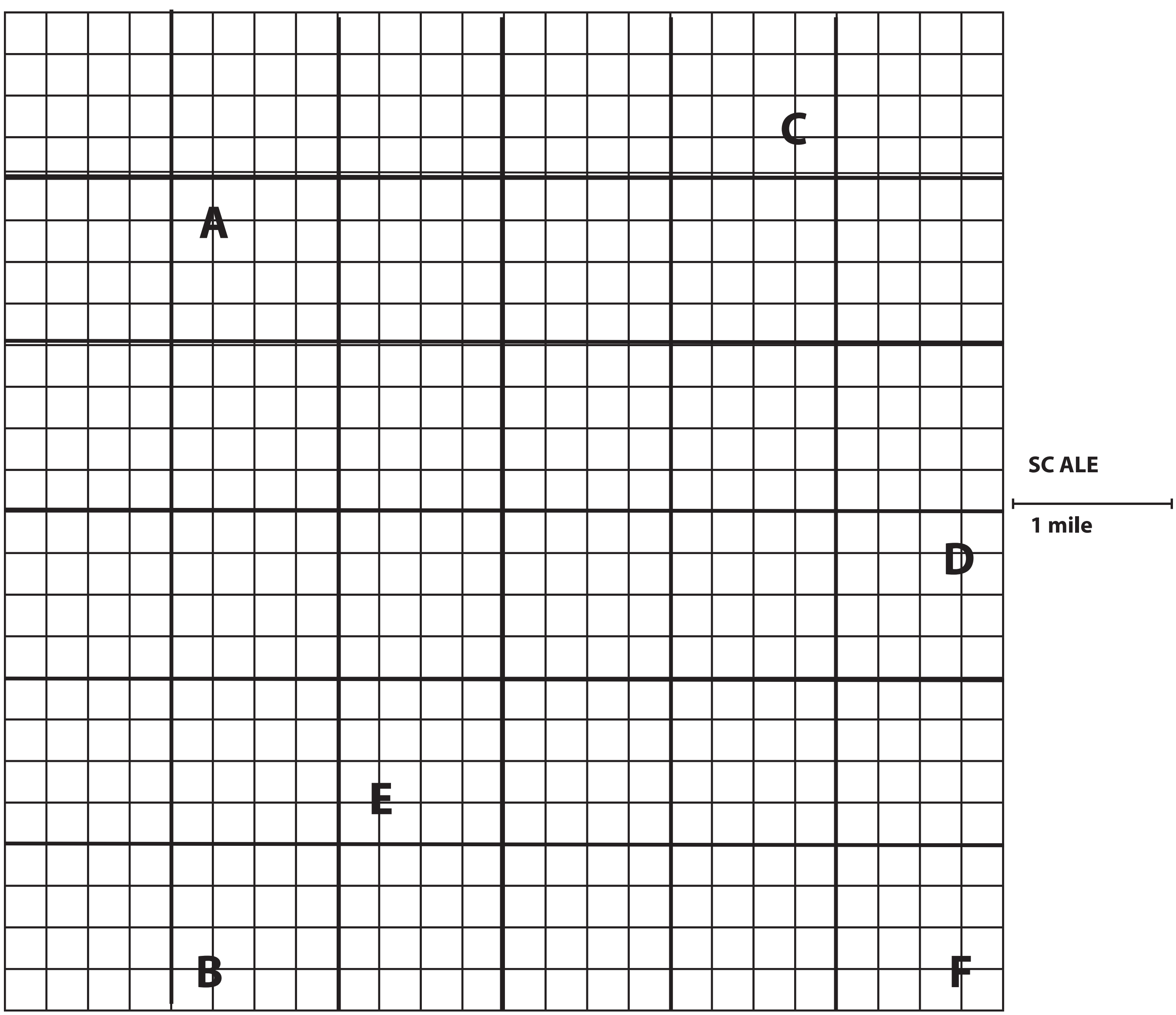
Step 2: Number the sections on your township plat map.

Question 1: What section is the following letter found in? A___, B___, C____, D_____, E____, F____?

Question 2: Starting in the southwest corner of section 1, go 2½ miles south and 1½ miles west. What section are you now?

Question 3: How many miles is it around the township plat? A. 20 miles, B. 24 miles, C. 36 miles

Question 4: How many miles is it around a section? A. 1 mile B. 2 miles C. 4 miles



Kansas 4-H Geology Leader Notebook

Chapter 7 — General, Table of Contents

Field Trip Preparations

General — Geology, Level I

What members will learn …

About the Project:

- How to get ready to go on a field trip.
- How to be safe on a field trip.
- How to collect usable specimens.

About Themselves:

- How to plan and prepare for an event.
- Safety habits.

Materials:

- Paper and Pencil
- Member Handout 37 (two pages), *Geology Field Trip Guidelines*
- One set to show whole group:
  Suitable clothing & shoes
  Containers and labels for specimens
  Identification Aids
  Hammer and/or chisel
  Gloves & safety glasses
  First aid supplies

Activity Time Needed: 30-45 minutes

Activity

We are making plans for a geology field trip. I will divide you into small groups. Use the sheet of paper and pencil to list all of the things you will need to take on the field trip to collect some possible samples for your collection boxes. Circle the three most important items you will need. When you are finished with your lists, we will talk about what we will need and why. Are there any items we have forgotten?

Now we are going to list on the back of our sheets safety tips that we need to remember while we are on our field trip. Mark what you feel are the three most important safety tips.

Let's look at this suggested list of things to take on a field trip and also the safety tips to see how many items you listed.

Next, let's talk about what type of clothes you should wear on a field trip. What type of shoes would be bst? Why? Will you need long pants, a jacket, or gloves?

Leader's Notes:

Before going on first field trip, give an introductory session to project members and parents on what to expect. Some new members may not have any idea of how to dress or what to bring.

Distribute Member Handout 37 (two pages), *Geology Field Trip Guidelines*. Go over it and compare it with the members list. Discuss the differences.

Show suitable items to take, or have a demonstration on proper items.

Mention that rock hammers are not absolutely necessary, that they are used mainly to produce a fresh unweathered surface for identification, climbing banks, steadying things, and only occasionally for getting samples of rocks.

Individual first aid supplies can take care of minor injuries, but leaders should have larger kits available if they are sponsoring a large group.

Give members the *Collecting Tips* portion of the Member Handout.

What tools do you think you will need? Rock hammers can be used to lift or break rocks. When lifting a rock, always lift the side away from you until you know what is under it. There may be snakes or other critters under the rock. When breaking a rock, always wear safety glasses or wrap the rock with cloth before hitting it with your hammer

We will talk about what to look for at each site and what size of specimen you will need. How do you plan to protect and label your specimens until you get home?

Let's talk about this list of *Collecting Tips*. Are these the things you thought about? Why is it important to keep the specimens from each stop separate? How can we emphasize marking locations and mark or label each sample?

Dialogue for Critical Thinking:

Share:

1. What field trip materials did you think of? Why?
2. What new collecting tips did you know?

Process:

3. Why should you use a rock hammer instead of a carpenter's hammer?
4. What is the best way to record where you found a specimen? Why?

Generalize:

5. What other times is it important to wear safety glasses?
6. What other times is planning and preparation important?

Apply:

7. Why is planning a field trip important?
8. What safety habits would apply to field trips other than geology? Why?

Going Further:

1. Have an older project member or Junior Leader present part or all of this lesson. Consider developing a demonstration in a bag for the older members to present to the entire group.
2. Play a game to demonstrate importance of lifting rocks away from you with a hammer so wildlife can escape without harming you. Hide a small toy snake and/or scorpion under one of three or more rocks. Members take turns lifting rocks correctly with hammer until they find the snake. Then that person hides the snake for the next person.
3. Make an inexpensive rock hammer for yourself and maybe extras for others. Find a railroad spike and have someone weld a short length of pipe to it at a 90-degree angle near the middle of the spike for a handle. A welding chip hammer may also be used.

References:

Jones, H.E., *Exploring the World Through Geology*, 1971, Cooperative Extension Service, Kansas State University, Manhattan, Kansas, 32 pgs.

Pabian, R.K., *Minerals and Gemstones of Nebraska, A Handbook for Students and Collectors,* 1993, Educational Circular No. 2, Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, Nebraska, 80 pgs.

Authors:

Pat and James Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by:

Will Gilliland, Environmental Scientist, Division of Water Resources, Kansas Department of Agriculture

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Field Trip Preparations

Member Handout 37, Geology Field Trip Guidelines

General — Geology, Level I

Materials Needed:

- Suitable clothing and shoes
- Pencil and paper
- Containers and labels (sacks, small bottles, plastic bags, etc.)
- Soft material to wrap delicate samples (rags, facial tissues, newspaper, etc.)
- Field trip guide or maps
- Identification aids (books, drawings, charts, etc.)
- Hammer and/or chisel
- Gloves & safety glasses
- Water and food
- First aid supplies, sun screen & insect repellent
- Full tank of gas and spare tire (if using cars)

Rules and Safety Tips

1. Be on time and stay with the group or you might get left behind.
2. When getting out of cars along roads, exit on the passenger side.
3. Be careful when coming out from behind parked cars.
4. Cross roads with adults and be careful at all times when near roads.
5. Stay away from open shafts, pits, mines, equipment and wire.
6. Don't swing or throw rock hammers.
7. Use some type of eye protection if you hammer on a rock. (This includes the people near you.)
8. Take extra care around steep slopes, stream banks, sink holes, quarry walls and piles of material. The footing may not be good and they all offer places for snakes and other animals to be unexpectedly found.
9. Watch out for people below you on out-crops; rocks that you dislodge may injure someone!
10. Do not throw, roll or push other material down hills, cliffs or material piles.
11. Don't try to lift BIG rocks.
12. When looking under rocks, use a hammer to lift the side away from you, and pull it toward you. This allows snakes and other critters a chance to escape.
13. Take plenty of drinking water.
14. Bring a change of clothing, including comfortable, sturdy shoes. (Preferably high-tops)
15. Leave wildlife alone. Let them enjoy their own freedom and space. When returning from a field trip check for ticks and other unwelcome guests.

Field Trip Preparations

Member Handout 37, Geology Field Trip Guidelines, cont.

General — Geology, Level I

Collecting Tips

1. Collect with purpose, don't try to bring home every rock, mineral, or fossil that you find.
2. Always label specimens promptly with the stop number and location.
3. Collect Specimens that are as close as possible to the size that you will be using in your exhibit.
4. If possible, collect samples that are not connected to another rock. These may already be in good shape to exhibit without your having to try to remove the sample from the rock.
5. If it is necessary to remove a specimen from the rock, do so with care. Remember a careless blow with a hammer can ruin the best of specimens. If the rock is small enough, take it home and take your time in removing the specimen. However, if the specimen must be removed from a large rock, use a coal chisel to remove rock from a trough around the specimen (not right next to the specimen, but a little distance away), then use the chisel to undercut the specimen and pop it free. Most specimens obtained in this way will need additional trimming or removal of the excess rock to get it ready for display.
6. When specimens are collected, they should be wrapped in newspaper or other material and placed in some container to provide maximum protection. No one likes to get home and find a bunch of pieces to remind them of how hard they worked to collect the samples.
7. If you collect carbon-film fossils, consider using clear plastic spray to stabilize the fossil. This may need to be applied to the fossil before it is completely dry. However, try it on a sample that is not a prime specimen first, before spraying that one in a million find. Use several thin coats as needed instead of one thick, runny, coat.
8. If you feel that a specimen needs to be cleaned up, try brushing or washing first. This will be okay for most specimens.
9. If you feel that a specimen needs to be removed from other material, check appropriate references for the proper procedure.

Preparing Specimens For Display

General — Geology, Levels I-II

What will members learn …

About the Project:

- How to properly label and prepare different types of specimens.

About Themselves:

- Value of patience and preparation.

Materials:

- Water in suitable container for washing specimens
- Towels
- A little mild detergent like dish washing soap
- Strainers, or screen
- Small pieces of paper and pencils
- Soft brushes, like old toothbrushes
- Hard brushes, like a wire brush
- Examples of different kinds of rocks, including:
  One soft, like chalk (expendable)
  One dissolvable in water, like shale (expendable)
  One very hard, like Barite
  One delicate carbon imprint, if you will be collecting those within a year or so, or other shale or delicate piece to spray
  One in a soft matrix
  One limestone fossil
- Specimens to be cleaned for display (tell members ahead of time to bring some of their own)
- Small scraping tools, like dental picks or screwdriver (not too sharp)
- Vinegar in a container large enough to soak specimens
- Clear acrylic spray; obtained where spray paint is sold
- Old newspapers
- Magnifying glass, if using small specimens

Activity Time Needed: 30 minutes, depending on the amount of fossils to be cleaned

Activity

Today, we are going to prepare the specimens we have collected for display in your geology boxes or wherever else you want to display them. You will get better ribbons on them and they will show their features off better if they are prepared right. Most specimens don't need very much preparation. Do each of you have some specimens you think look pretty good without cleaning them up?

Yes, those do look good. Now, one or two might look even better if we worked on them a little bit. Now can you show me one that will look very good without help? OK. But I'll bet some of those will look pretty good when you are finished cleaning them. As we are talking, I want each of you to be thinking of specimens you have collected, and deciding which of the methods I show you are the best for the things that you have.

Leader's Notes:

If they use their own specimens, it will increase their application of what they have learned, but if it gets too distracting, have them put their specimens away until you are ready to wash them.

The method you use to prepare your specimens depends on the characteristics or features of the specimen. If the specimen is looking pretty good, and just has a little dust on it, you will not have to do much. You can wash it or brush to remove the loose dirt. First I will show you how to brush it. Here is a **soft brush**, actually an old toothbrush. You can just gently brush all sides of the rock with it until the rock is clean. This should work for most pieces. If a piece is very fragile, and might break, then don't do this. Be careful not to drop the piece.

Here is a **hard brush**. It is useful for very hard pieces like this Barite. See how it brushes the loose stuff off of the barite? Let's try the hard brush on this soft piece of chalk. Oops! It is scratching badly. Don't use a hard brush on any pieces that are not very hard. Do you have any pieces that need a hard brush?

Demonstrate whichever steps you want them to use. When they are washing their own, the water may need to be changed frequently. You may prefer to have them wash at home.

Another very useful method is to **wash** the specimen. That method works well for most things. We have set up a washing area here and you can do your own later.

First, you put your specimens in this strainer and lower it into the water. Swish them around with your hand until the mud washes off. I have put a few drops of soap in the water to make it work better. When you think the specimens are clean, lift them out of the water in the strainer and hold them above the water pan for a while to drip. Then you can spread them on the towel to dry. Do not mix your specimens in with someone else's, and remember to keep specimens from different locations separate and keep a sign with them. Let them dry completely before you pack them up again. What kind of specimens should you not wash? Let's try washing this piece of shale. Look, it all crumbled away in the water. What else would you not want to wash? What would happen if you washed a piece of salt? You also shouldn't leave pyrite or marcisite damp very long. Any very fragile pieces also shouldn't be washed or they may break. Do you have any pieces that shouldn't be washed?

Omit this if you like; it is used less frequently.

Once in a while, you will have a fossil that has a little extra limestone around it. **Vinegar** is a weak acid and dissolves limestone. It might also dissolve the fossil, so don't try it on your best one first. I am going to put this in here and leave it until the end of the meeting to see what it does. You may each try one also. Remember, not your best one! It sometimes takes a long time for this method to work, like a day or two.

The next method I am going to show you is carefully **scraping** away extra rock to show more of the specimen. This works best in soft rock like chalk. Put the pieces you are working on, on a table, and use some small tool that is a little sharp. It depends on what you have, and how hard the area around it, called matrix, is. For soft rock, you could even use a table knife. Dental tools, a needle, a screwdriver or ceramic tools work well on most rock for small areas. See how I am carefully scratching off just a little at a time? You need to be careful when you work, and if you are doing it at home, you might want to do it while you are listening to music. As more of the part you are saving shows, be careful not to scratch it, especially if it is soft. Some people paint something on the part they have already uncovered to make it harder. You should try to wait for it to dry before you work on it again. There are also products you can buy, called hardeners.

Homemade hardeners can be made by mixing glue with water.

Now here are some specimens that require special treatment. Do you know what theses are? Yes, they are leaf prints of fossils, and they are very delicate. These are in shale, which breaks easily, and if you have carbon leaf imprints they could also flake off. It is best to **spray** these with a clear spray.

Krylon is a popular brand name. It is a good idea to take a spray can to your collecting area.

I will show you. First, you lay it carefully on a large piece of newspaper. Several pieces can be grouped together. Then you shake the spray can hard for a little while. Now, I am spraying them evenly and making sure to cover every part. Now you have to let the pieces dry a little while. It is a good idea to give them another coat of spray, and some people even spray the back to help it dry evenly. Be sure to store them carefully, and let them dry slowly and completely. Shale is less likely to break if it dries slowly. Do you have any pieces that need spraying? If you do, please have your parents do the spraying, as it is very messy if you touch it and a bit tricky and smelly.

Older members could spray their own.

Let's look at the pieces in vinegar. Do you see a change yet? When we are through soaking the pieces, you will want to wash the vinegar off with water.

Now, which of your specimens do you want to work on first, and what will you do to them? You may need to take turns, if one area gets crowded. I'll bet your all going to have great looking specimens, with a little work and patience on your part.

Dialogue for Critical Thinking:

Share:

1. What methods had you used before?
2. Which method did you like best? Why?

Process:

3. Which process produces clean attractive specimens?
4. What method was the easiest? Messiest?
5. What are advantages and disadvantages of each method?

Generalize:

6. Which preparation method required the most patience? Why?

Apply:

7. What other things do you do that require lots of preparation and patience?

Going Further:

1. Investigate other methods that are especially appropriate for things collected in your area.
2. Make an educational display for the fair showing different cleaning methods and examples of things you have cleaned by each method.
3. Arrange a behind-the-scenes tour of a museum and have them show you how they prepare their specimens. Which of their methods could you use on your specimens?

Source for Commercial Stabilizers and Adhesives (not an endorsement)
Paleo-Bond
Uncommon Colnglomerates, Inc.
287 East 6th Street
St Paul, MN 55101
Phone: 1-800-323-4545

References:

Brocardo, G., translated by Woodward, L., ed. Smith, D.A., *Minerals & Gemstones of the World*.

Devon, David & Charles, *Naturetrek Guide*, 1994, pgs. 36-43.

Cvancara, A.M., *Sleuthing Fossils*, John Wiley & Sons, Inc., New Yprl, 1990, pgs. 134-138.

Dixon, D., & Bernor, R.L., ed., *The Pratical Geologist*, Simon & Schuster Inc., New York, 1992, pgs. 135-137.

Lambert, M., *Fossils*, Arco Publishing, Inc., New York, 1979, pgs. 52-58.

LaPlante, J.C., *The Weekend Fossil Hunter*, Drake Publishing Inc., New York, 1977, pgs 65-78.

Lichter, G., *Fossil Collector's Handbook*, Sterling Publishing Co., Inc., New York, 1993, pgs 26-75.

Parker, S., & Berner, R.L., ed., *The Practical Paleontologist*, Simon & Schuster Inc., New York, 1990, pgs 64-81.

Ransom, J.E.., *Gems and Minerals of America*, Harper & Row, Publishers, New York, 1974, pgs, 99-113.

Sanborn, W.B., *Handbook of Crystal and Mineral Collecting*, Gem Guide Books Co., Baldwin Park, 1966, pgs 52-57.

Authors:

Will and Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey.

James P. Adams, Associate Professor, 4-H Youth Developement, Kansas State University

Show It: Geology Display Box

General — Geology, Level II

What members will learn …

About the Project:

- Proper display methods.
- How categories work to divide rocks, minerals and fossils and other sub-divisions.
- Correct names and spellings for specimens.
- How geology boxes are evaluated.

About Themselves:

- Self-confidence in learning to identify specimens and achieving goals.
- Categorizing helps organization.
- Importance of neatness and correctness.
- Evaluation is an important part of the learning and growing process.
- I am responsible for the decisions and effort I make that affects the finished product and my rewards.

Materials:

- Member Handout 38 (two pages), *Making a Geology Display Box*
- Member Handout 39, *Geology Display Case*
- Member Handout 40, MG18, *Scorecard for Judging Geology Exhibits*
- Member Handout 41, MG20, *Rock, Mineral and Fossil Labels for Geology*
- Activity Sheet 63, *Geology Display Box Checklist*
- Specimen card prepared correctly; and one prepared sloppily
- Local and State exhibiting rules
- Any demonstration materials you may need showing how to prepare a geology display box
- Completed display box (have members bring one first-year box and one or two more advanced boxes)
- Names and addresses of anyone in your area who makes boxes for sale

Activity Time Needed: 40 minutes

Activity

You've learned a lot this year, and collected a lot of good specimens. Most of you have gone on several field trips and have a lot of nice specimens to display. Now let's learn how to exhibit them so the judge and others can see what you have done.

Leader's Notes:

If your county has a collection for younger members, bring a suitable box and review the introductory requirements.

Recognize that not all members will choose to exhibit their specimens at all.

You may want to have one of the members present the demonstration on making the box.

Go over your county's requirements thoroughly as this is a prime spot for misunderstandings.

If your county doesn't have this category, skip this section.

Go through the handouts, integrating appropriate fair rules and your own experiences. Show the boxes and how to do each step. Be sure to emphasize that their plexiglass should fit in the box **from the top** so it will not fall out when the box is moved.

Distribute Member Handout 40, MG18, *Scorecard for Judging Geology Exhibits*.

Show the correctly and incorrectly completed cards, and pass them around.

If you just want to display your specimens for your own enjoyment, that is fine. Many people use a plastic box to sort their specimens into compartments and store them. If, however you want to compete at the fair, you will need to meet the requirements.

For most categories, you will need to display your specimens in a wooden display box. Some counties have a class for younger, newer, members that doesn't require a box. If you are eligible for that class, you should consider it. Remember, that class does not go to the state fair, even if you win a purple ribbon because you must be 10 years old before January of the current 4-H year to exhibit at the Kansas State Fair.

The same box can be used for at least two years' worth of specimens. Who will need a handout giving directions for building the box? Here is how you set the box up when you get the box itself assembled. I will hand out this sheet with some ideas on setting up the box, and we will go over the steps necessary to set it up. You need to group specimens by rock, mineral or fossil. This makes an orderly, attractive box, but also allows you to learn as you assemble your box. This is a general way to do it. Many members have thought of ways to personalize their boxes for a unique display that they prefer based on previous years of experience.

Now we will look at the Judges Score Sheet. You have to make a lot of decisions when you set up your box, and now you can see how those decisions can add up to make a box that shows well. What is the largest category on the judging sheet? Why is that important? Each of the other categories count for points also. You can make your box look better by making a neat display that will catch the judge's eye and look appealing to people who view your box. Masking tape helps remove lint from boxes and lint free towels help clean the plexiglass. Here are two cards with specimens on them. Which of these cards would you rate better if you were a judge? Under which section would these points come off?

Now, each person can be a judge for a few minutes. Choose one of the boxes and use the score sheet to rate it for each section. Then add up the totals to see how that box rated.

Dialogue for Critical Thinking:

Share:

1. What do you think is the most important feature of a geology display box? Why?
2. What is the most difficult aspect of displaying a specimen? Why?

Process:

3. What is the most important item when judging a geology exhibit? Why?
4. What are the major categories for classifying geology specimens?

Generalize:

5. Why is it important to set goals?
6. How can another person's (judge) evaluation help you learn?

Apply:

7. Where else might you use the skills of neatness and organizing?
8. If you have a display geology box, what do you plan to change for next year? Why?

Going Further:

1. After members have their boxes finished (and hopefully before the fair) have each member exchange "peer" judging with two others so that each person has some ideas of what to improve in their box.
2. Display your geology box at club meetings, project fairs, gem and mineral shows, schools, or downtown window display to promote the project.
3. Geologists often put a number on each specimen. They use a little white paint on an inconspicuous spot. When that is dry they write the specimen number on that spot. What are the advantages and disadvantages of that procedure? You could do that for your specimens also.
4. Go to a Gem and Mineral Society show. You may be able to enter your box if they have a youth category. How is it different from 4-H fairs?
5. Investigate other means of display. What do museums do that you could adapt? Ask someone who has been collecting a long time what methods they use.

References:

Exploring the World Through Geology, Cooperative Extension Service, Kansas State University, Manhattan KS. 1971

Authors:

Pat and Will Gilliland, 4-H Geology Curriculum Team

Reviewed by:

Alan DeGood, Geologist

Steve A. Fisher, Extension Specialist, 4-H Youth Development (retired)

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Show It: Geology Display Box

Member Handout 38, Making a Geology Display Box

General — Geology, Level II

Collecting rocks is fun, and showing off rocks you've collected is also fun. When you make them into a display, it helps you organize them and learn their names. It also shows other people what interesting things can be found in our state and is more attractive and convenient to look at than a pile of rocks.

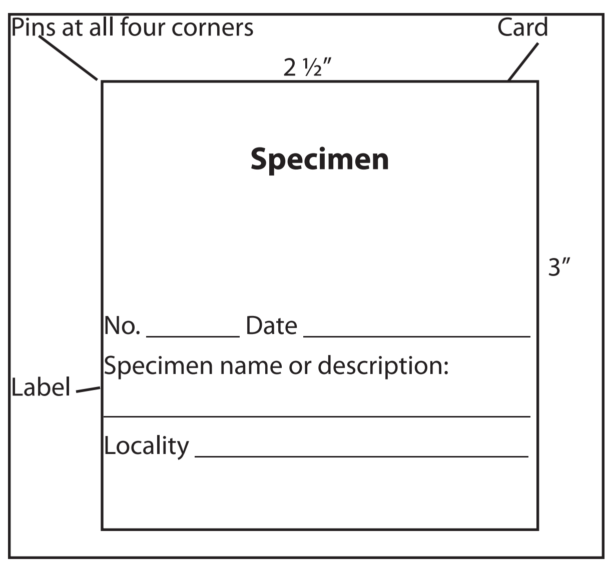
If you are not planning to show your display for competition, you could display your collection by any of a variety of methods. One way is to put each one in one section of an egg carton. Another is to get a plastic box with dividers in it (like for fishing tackle or sewing supplies). You could also glue your samples to a board or poster. Be sure you have each sample labeled with where you found it and what it is.

If you are going to be exhibiting at the state fair and most classes of the county fair, however, there are strict rules that you will need to follow to qualify. There are several variations of rules that do not meet the requirements. You might want to consider the ones you have seen used. Here is a basic guide to producing a top-notch geology display box.

Select your specimens carefully. Reread the rules in the fair book to make sure you have met the requirements. Most classes require you to have 15 new specimens collected in the current year in Kansas. Another member of your family or the group could have actually found the specimen as long as you were at that stop. You want specimens that are approximately 2 inches or less in size. If you have one or two really great larger specimens, that is OK also. If you have several small fossils, see if you can make a grouping with an odd number (three, five or seven) of them on the card (like putting seven fusulinids on one card). Make sure your identifications are correct. If you have a specimen you can't get a positive I.D. on, leave it out if you can.

The box used for geology is a wooden box 18 inches by 24 inches with a plexiglass top; the same as an entomology box. You can get directions for making it from your 4-H leader or the extension office, or from your geology leader. Put something in the bottom of the box, like ceiling tile or cork, that pins can penetrate; and cover it with some attractive fabric like felt that will not detract from your specimens, nor show dirt (medium color). Each box can hold up to approximately 30 specimens.

Each specimen must be labeled with the following correctly spelled information: date collected, name of specimen and location (county) where it was found. The label also calls for a specimen number. When you return from a field trip, each specimen should be given a number. For example, one of the specimens you collected on the first stop of your first field trips would be No. 1. The next year, you start numbering where you left off. You should also show whether it is a rock, mineral, or fossil by putting a capitol R, M or F in the upper right hand corner of your label. For fossils, genus and species names should be underlined, or typed in italics, if you are using any of those designations. If possible, have your labels typed. If someone else types the labels, you should be the one to write out the information and check the spellings. Then they just need to type them. Labels may be obtained from your county extension office, or you could format your own on the computer, etc. It is a handy idea to print them off on gummed labels.



Instead of mounting your specimens directly in the box, you may want to mount them on a small piece of cardboard so that it is easy to remove them and take them out. Half of an unlined 3-inch-by-5-inch recipe card is a good size for most specimens. The regular label also fits across the 2-inch dimension of it with only

Show It: Geology Display Box

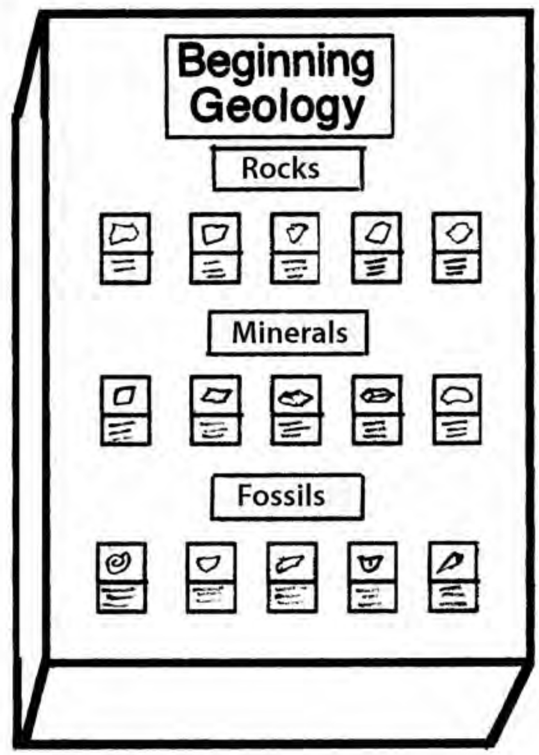
Member Handout 38, Making a Geology Display Box, cont.

General — Geology, Level II

minor trimming. Glue your specimen firmly to it about ⅓ of the way down the card (leaving room for the label) without any extra glue showing. A glue gun is handy for larger specimens. Elmer's Glue types also work but be sure to allow it to fully dry in a flat position, or your specimens may slide from position. Glue the proof-read label on the bottom 1/3 of the card. You may need to neatly trim the label to match the card.

Your box needs a title that tells in what phase of geology you are enrolled (Example: BEGINNING GEOLOGY). Make smaller labels for the categories. You will need labels for at least rocks, minerals and fossils, and maybe more for later years. Arrange your box neatly and logically, grouping the cards with specimens under each category. As you do this, look at each category and see if you can tell how they are alike. Put larger, heavier specimens toward the bottom of the box. Straighten the rows, using a ruler or straight edge for a guide. Then pin the cards and labels down, pushing the pins in all the way. Sequin pins, available at some fabric or hobby stores, are good to use as they are not as long as regular pins. It usually takes a pin in each corner to hold the card flat.

Fig. 1: Example of completed display box.

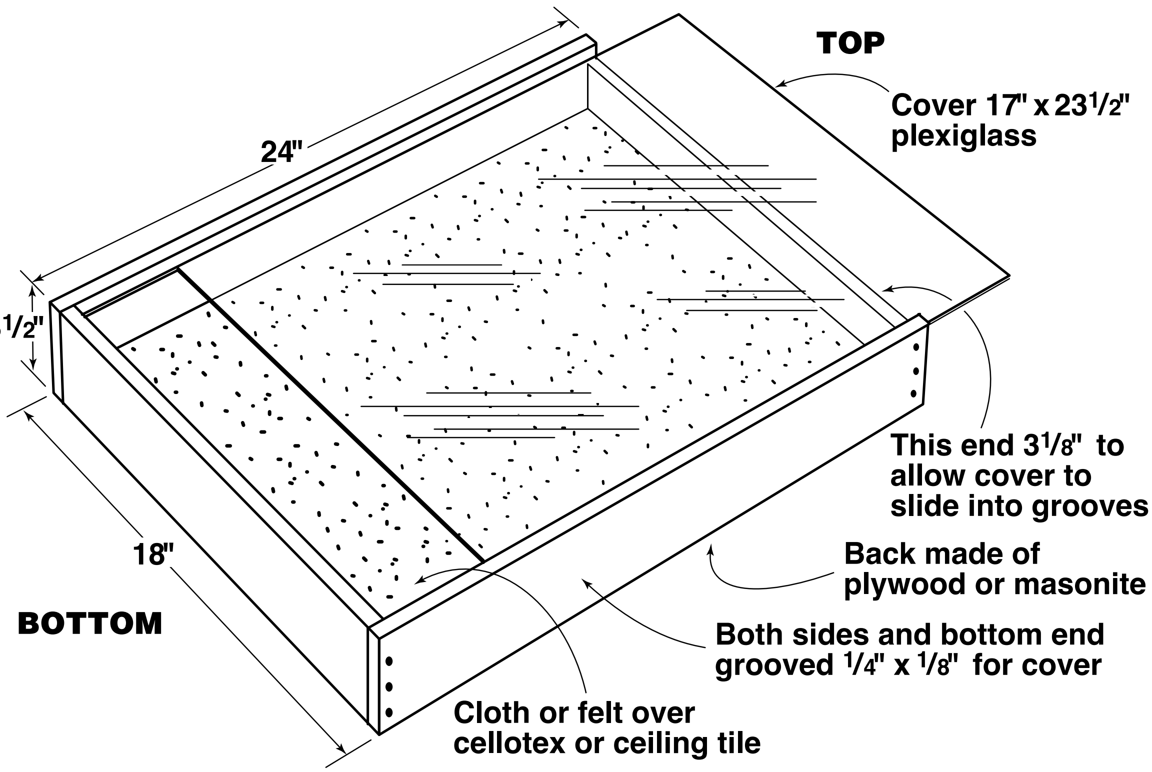


Now your box is finished. Look at it carefully, pretending you are the judge. Did you follow all the requirements? Is your box neat and attractive? Are your identifications correct? Use a checklist, if you have one. It is a good plan to review it also. Correct any errors that are found. Then pack it carefully and enter it in the fair. No matter what award you get, you will know that you have done a good job, and have completed a project you can be proud of.

Show It: Geology Display Box

Member Handout 39, Geology Display Case

General — Geology, Level II



Geology Display Case

18 X 24 inches

Materials List:

1. Bottom ¼” X 18” X 24” plywood or ⅛” x 24” tempered masonite
2. Two side pieces of pine ¾” x 3 ½” x 24” groove to accept cover ¼” x ⅛”
3. One end piece of pine ¾” x 3 ½” x 16 ½” groove to accept cover ¼” x ⅛”
4. One end piece of pine ¾” x 3 ⅛” x 16 ½”
5. One cellotex or ceiling tile ½” x 16 ½”“ x 22 ½.” Cover bottom so pins will stick.
6. One piece of cloth or felt to cover bottom, about 18” x 24”
7. One plexiglass for cover ⅛” or more x 17” x 23 ½”

At the State Fair the top of the box should be the short end (18”) from which the cover is to be removed for inspection. Otherwise there is a chance that the cover will fall out when the boxes are placed upright in the display racks. Any lettering or labeling in the exhibit should be right side up for reading with the cover removal end up.

For exhibiting at the State Fair, the specimens must be displayed in cases 3½” x 18” x 24” in size similar to the case shown above. It is not necessary to have the cover inserted in grooves as shown in the diagram, but the cover must be removable. The reasons for asking for display cases of this size and construction are simple. The covers allow the judges to examine the specimens. The display racks hold the cases with the long side (24”) up and down, and cases too long or too short may not fit in the racks.

Adapted from the 1975 Exploring The World Through Geology Leaders Notes.

Show It: Geology Display Box

Member Handout 40, MG18, Scorecard for Judging Geology Exhibits

General — Geology, Level II

County	Contestant's Name	Class No.	Placing (ribbon color)

Scoring Guide — Points

Specimens	Correct Identification ____________ (2 points off each incorrect — limit 35 points)	35 ______
	Condition (identifying characteristics easily seen) (1 point off each undesirable specimen — limit 15)	15 ______
Labels	____________ (1 point off each incorrect or incomplete label — limit 20 points)	20 ______
Minimum Requirements	Has at least minimum number of specimens for Class (2 points off for each specimen less than required — limit 15 points)	15 ______
Showmanship	(neatness, arrangement, placement, background, lettering, etc.)	15 ______
		Total 100

Notes This space should be used by judge to record correct identification of incorrectly named specimens; and for comments on condition of specimens, labeling, minimum requirements, showmanship, etc.

Specimen number	Points off	Reasons

Show It: Geology Display Box

Member Handout 41, MG20, Rock, Mineral, and Fossil Labels for Geology

General — Geology, Level II

No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________
No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________	No. _______ Date ________________ Specimen name or description __________________ Locality________________________

Show It: Geology Display Box

Activity Sheet 63, Geology Display Box Checklist

General — Geology, Level II

__1. I have read the requirements in the fair rule book for geology exhibits, know entry times, and have read the rules for the class I am exhibiting in.

__2. I have attached the box labels as specified in the rule book and have set up my box so that the plexiglass slides in from the top, not the bottom.

__3. I have chose specimens for my box that are good examples of their kind, and show that I have learned about a variety of things.

__4. I have grouped my specimens into rocks, minerals and fossils, and have labeled the groups.

__5. I have counted that I have the right total number of specimens, and no more than 2 extras; and that I have the required number of new ones from this 4-H year, and the required number in each category.

__6. I have checked that I have no duplicate specimens or numbers in my box.

__7. I have eliminated specimens that are controversial such as ones showing characteristics of several groups, ones whose names can't be agreed upon, or ones that are so unusual not even a judge can verify them.

__8. I have typed (preferred) or neatly written my labels and have proof-read them (or someone has typed them for me and I have proof-read them).

__9.I have double checked all spellings and identifications.

__10. I have underlined or put in italics the genus and species, and only the genus and species.

__11. I have listed the phylum for each fossil

__12. If required for my class, I have indicated whether rocks are igneous, metamorphic or sedimentary.

__13. I have lined up my specimens neatly using a ruler or other straight edge.

__14. If this is not the first time I am exhibiting this box, I have made changes suggested by previous judges.

__15. I have cleaned my box, and given it one final check over.

Do You Want To Be a Geologist?

General — Geology, Level II

What Members Will Learn …

About the Project:

- Geology is the study of the earth.
- Geology careers are many and varied.
- Geology careers are interesting and exciting.

About Themselves:

- Geology career choices.
- Decision-making skills.
- How to ask a good question.

Materials:

- Activity Sheet 64, *Geology Careers Match-up*
- Pencils for each person

Activity Time Needed: 15 -20 minutes.

May combine with another lesson or make longer by doing one of the activities under the Going Further section.

Activity

What do you want to be when you grow up? Well, today we are going to find out about career possibilities in geology. Geology is the study of the earth, but there are many specialties within that. Who can name some geology careers? What do those people do?

Many geologists now combine their interest in the earth with their interest in the environment. They might help to clean up some pollution, using what they know about geology to help them, for example.:

What do you think geologists need to learn in school to make them good geologists? They need to learn lots of things about the earth and science in general, but they also need to learn about computers and math. To tell others about their ideas, they will need good writing and speaking skills from classes like English and Speech.

This activity sheet has descriptions of some of these careers with pictures. Draw lines matching the careers with the pictures. We'll use it to get ideas for a game and to put in your geology notebook.

Now, We are going to play "What am I?" One person who is "It" will think of one of these jobs. Everyone else will ask Yes or No questions until they guess the job. Then that person will be "It" for the next round until

Leader's Notes:

May want to generate the list on a flip chart or wallboard.

Hand out Activity Sheet 64, *Geology Careers Match-up*.

Encourage them by asking "What about the people who study volcanoes?" etc., if they don't start out strong.This should only take a short time.

Go over right answers when done: (in order of pictures, top to bottom): Marine Geologist, Seismologist, Volcanist, Mineralogist, Petroleum Geologist, Geochemist, Engineering Geologist, Paleontologist.

Remind them to ask only yes-no questions, and give an example of broad questions like "Do you work outside?"

Allow them to give some answers.

everybody has been "It." If somebody guesses right twice, they may choose somebody to be "It" for them.

What kind of questions should you ask first, broad ones or narrow ones?

Dialogue for Critical Thinking:

Share:

1. What was the hardest job to guess? Why?
2. Did any of the jobs sound exciting to you?

Process:

3. What kind of questions in the guessing game made it easiest to guess the careers?
4. What do all the careers have in common?.

Generalize:

5. What things about being a geologist do you think you might like? Dislike?
6. What things do you do that would make you a good geologist? Do you like to investigate things? Work outside?

Apply:

7. For what other decisions besides choosing a career would it be wise to consider lots of different choices?
8. What other geology careers do you know of, and what do they do? [*A. Hydrologist (Water), Teacher, Planetary Geologist, Geophysicist, Mathematical Geologist, Environmental Geologist (as with remediation) etc.*]
9. Which geology career do you think you would like best? Why?

Going Further:

1. Play Pictionary, Charades or Lemonade with geology occupations.
2. Have a geologist in to speak to the group about what he or she does and about geology careers in general.
3. Make an educational poster about a geology career and display it at your group's meeting. Is there a category at the fair for that also?
4. Make a collage about geology careers.
5. Make a word search of terms associated with geology careers.
6. Order geology career materials from the Level 4 Careers unit references, or look up geology careers in the encyclopedia.

REFERENCES:

Teacher's Packet of Geologic Materials, U.S. Geological Survey, 907 National Center, Reston, Virginia 22092 :

Careers in Geology. American Geological Institute: 4220 King Street, Alexandria, Virginia 22302. American Association of Petroleum Geologists: 1444 South Boulder 74119-3604, P.O. Box 979 74101-0979, Tulsa, OK

Written by:

Pat Gilliland, 4-H Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey

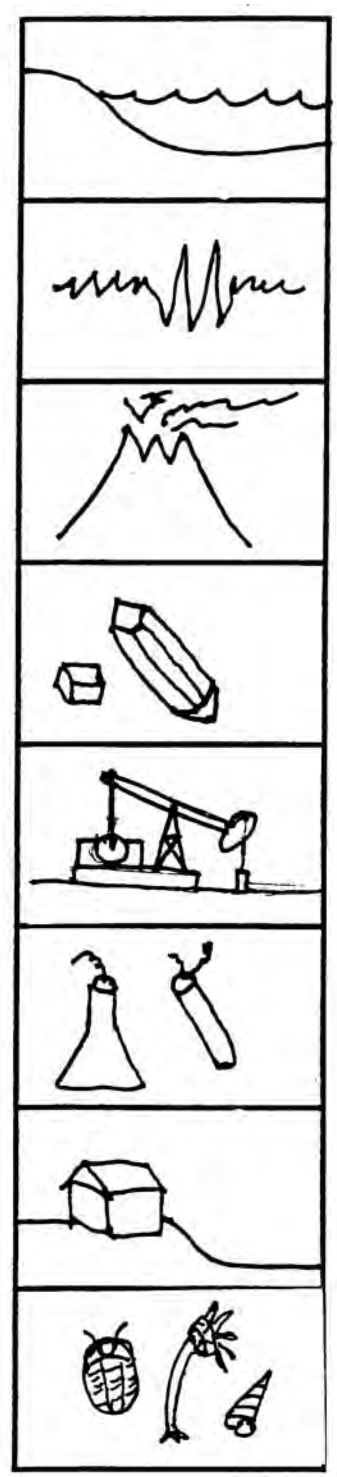
James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Do You Want To Be A Geologist?

Activity Sheet 64, Geology Careers Match-Up

General — Geology, Levels III

Draw a line from the career name and description to the picture, matching up all the pictures and names.



Engineering Geologist
Advise engineers on building dams, houses, etc. so their construction will have a good foundation.

Geochemist
Studies the chemical materials in the rocks.

Marine Geologist
Studies the ocean floor and the actions of the ocean on the shore.

Mineralogists
Study, classify, and describe minerals.

Paleontologists
Use fossils to describe the development of life through time.

Petroleum Geologists
Locate locations to drill for oil and other petroleum products.

Seismologists
Earthquake specialists.

Volcanologists
Study volcanic activity.

Log It

General — Geology, Levels III

What members will learn ...

About the project:

- How to make a professional style road log.
- Imporant geological features of your area.

About Themselves:

- How to keep accurate records.
- How to analyze features for importance.
- How to follow directions.

Materials:

- Pencil
- Paper – A steno notebook or spiral notebook works well
- Member Handout 42, *Example Road Log*
- Copies of map showing area of your field trip (optional)

Activity Time Needed: 15 minutes each, before and after field trip; plus field trip time

Activity:

Geologists often make a road log of a field trip. It tells where to go and what is interesting along the way. Even years later, someone else can enjoy the same things with just this log to guide them. Here is an example of a pretend road log.

Let's look at the road log and tell me what some of the features are that might be helpful if you were following it.

Here is how to make your own road log. Practice on your next field trip, and then compare your logs at the next meeting to see if everybody thought the same things were important.

First, you will need to keep track of the mileage. This is much easier if the vehicle you are driving in has a trip odometer. Simply reset it to zero at the start of the trip. If not, you will have to read the odometer that tells your mileage at the beginning and at each feature and subtract the smaller number from the larger to get the miles traveled. Write the number of miles traveled since the start of the trip at the left side of your paper in the margin. At each feature, you want to write down the mileage and why that feature is interesting. You may even want to do some research on the geology of the area to include something in your log that you couldn't learn just by being there.

Leader's Notes:

Do this lesson in connection with a field trip you would take anyway.

Provide Member Handout 42, *Example Road Log.*

You might want to supply copies of maps of the field trip area.

Here are some ideas of things to include in your road log:

1. Turns and driving instructions
2. Your collecting stops: What can be found there and landmarks to find the right area.
3. Major road intersections and landmarks so that someone who loses their place can start up again.
4. Geologic features, even if you are not stopping at them. Ex., a house built of a locally quarried stone.
5. Major rivers and something about them.
6. Major formations, especially the ones at which you collect.
7. A geologic column, if desired
8. A map of the area. You could copy a highway map on a copier, cut out the area of your trip, and draw in stops and the route.

Dialogue for Critical Thinking:

Share:

1. Have any of you ever used a road log before?
2. Compare your road log to someone else's. What did they do differently? Think about the difference. Which do you think would be a better way to do it? Remember not to argue, just try to think of the best way.

Process:

3. What is the difference between a road log and a field trip guide?
4. Why is it important to keep a road log?

Generalize:

5. What will happen if you don't follow directions carefully when using a road log?
6. What features of your log would prevent people from getting lost?

Apply:

7. When else is it important to follow directions carefully?
8. Why is it important to keep accurate records?

Going Further:

1. In cooperation with your leader, make a road log ahead of time of a field trip your group plans to take. Make it as accurate and informative as you can. Give copies to your group.
2. Get road logs that someone else has made and follow one. Enjoy your trip, but also analyze the log. How did the person making that log do things differently than your log? Which way do you think works best? Why? Was the log easy to follow? Why or why not?
3. After studying the lesson on section, township and range, find that information for each of your collecting stops and add it to your road log. Why does that make it better?

References:

Kansas Geology by Rex Buchanan (1984) contains a road log along Interstate highway I-70 across Kansas.

Road logs of geology field trips may be obtained through the State 4-H Geology Project Web page (*www.kansas4-H.org*).

Written by:

Pat Gilliland, Kansas Geology Curriculum Team

Reviewed by:

Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Log It

Member Handout 42, Example Road Log

General — Geology, Levels III

Rock County Field Trip

Mileage	Description
0	Start trip at Rock County extension office at Third and Main Street in Diamond, Kansas. Turn South (right) on Main.
1.5	Turn left (East) on County Road 34.
2.6	You are driving over Little Muddy Creek. It's dark color and name come from all the soil its water has picked up as it runs over cultivated fields on its way to the river.
4.0	Collecting stop. This area has nice quartz-lined geodes. Look for round rocks that seem light weight for their size. Look in the road cuts on both sides of the road (watch for traffic). You are collecting from the Diamond Limestone, named for Diamond, Kansas. Elevation: 2510 feet.
4.5	Turn right on gravel road.
5.7	Cross Muddy River again. Notice how much larger it is here. That is because it has joined with the Big Muddy River.
6.8	Notice the large quarry on your left. It supplies limestone gravel for roads in this county.
7.3	Collecting stop for fossils. You will find invertebrate fossil in this area from the Permian Age 220 million years, or more, ago. You will be collecting from the Bartley Shale, the gray shale layer beneath the thick limestone layer. Fossils you may find include Derbyia, Neospirifer, Crinoid, and maybe trilobites. The elevation here is 2420 feet. We are 90 feet lower than our last stop and in older layers than at our last stop.

Here are some ideas of things to include in your own road log:

1. Turns and driving instructions.
2. Your collecting stops — What can be found there and landmarks to find the right area.
3. Major road intersections and landmarks so that someone who loses his place can start up again.
4. Major geologic features, even if you are not stopping at them. Ex. — a house built of a locally quarried stone.
5. Major rivers and something about them.
6. Major formations, especially the ones at which you collect.
7. A geologic column, if desired.
8. A map of the area. You could copying a highway map, cut out the area of your trip, and draw in stops and the route.

Geology as a Career

General — Geology, Level IV

What Members Will Learn. . .

About the Project:

- Geology careers are varied and interesting.
- Geology careers require preparation.

About Themselves:

- Their unique skills and interests.
- How to gather information to make decisions.
- Their needs and wants in a career.
- The value of education in career preparation.

Materials:

- Career materials as needed for research (available in libraries, etc.) Occupational Handbook is recommended for general careers. American Geologic Institute (AGI) has geology career materials.
- Pencils, pen, paper, envelopes and stamps
- Activity Sheet 65, *Geology Career Interview*
- Activity Sheet 66, *Geology Careers Chart*

Activity Time Needed: Extremely Varied

Activity

Geology careers are many and varied, from atmospheric scientist to volcanologist, from finding oil wells to teaching. If you want to get a general overview of the possibilities, you can review the Level 2 lesson that tells about the different career possibilities. Not all those jobs are available in all areas of the country, but you will be surprised at the variety in just our state.

You may not have decided on a career yet, and that is fine. Even if you end up going into some other area, your life can be richer for knowing about geology and its careers. Also, the same general principles apply in evaluating all career possibilities, and most employers look for good workers who are well prepared. With your 4-H background, you will have a number of skills that can make you a good employee. You know that working hard gives you good results. You know that record keeping is important, even if not always fun. You have a lot of information on a number of projects and have had a lot of hands-on experience that you can use in a job. You have developed leadership skills in working with others.

Leader's Notes

This lesson is designed to be used directly by the members. Leaders should work closely with members and provide support where needed.

Analyze Yourself

It is important to choose a career that suits you, not your parents or your leader. Think about what you like to do, and what your strengths are. If it is hard for you to do this, you can ask others what they feel are your strengths. You also can ask you guidance counselor at school for career programs (some are even on computer). They will ask you to consider things like: Do you like to work outside or in? Do you like to work with people or things? How much school are you planning to take? How much money would you like to make? Most of us would like an easy job with great pay, but there aren't many of those around. What skills have you developed in 4-H? What was your favorite 4-H project and why?

Decide on Level of Involvement

How involved do you want to get in checking out a career right now? You can do one thing, and then proceed onto the next if it seems "right." Here are some common types of career involvement:

Job Research

Look up careers in books and pamphlets and find out what geologists do in those careers, what the pay is, etc. The Occupational Handbook is a good resource as are the pamphlets from the American Geological Institute. This is a good way to get some facts to start your investigation.

Interview

Talk to a geologist and ask questions. You can ask questions not in the books, and usually you will get to see where the geologist works as well, and maybe get to tour the company. This takes only a short time.

Shadowing

Follow a geologist around as though you are a shadow. This can be as short as a few hours or a day or two. You get to see what they REALLY do. Even so, it might not be a typical day.

Mentoring

A geologist works with you, answering your questions, helping you with your educational project and identification of specimens, giving you ideas that you might find interesting, taking you places, and providing you with resources and opportunities. This may be combined with other involvement.

Get a Job in the Company

This is a great way to earn some money while evaluating a job. It also might lead to a better job there later. Usually entry level jobs are monotonous, and you may have to spend most of your time doing things like filing or answering the phone, instead of learning about geology.

Internships

You work at a place (often for free or low pay) as a learning experience. Usually, someone is responsible for you, and sees to it that you are provided with interesting opportunities to learn about geology and about the career. Considerable time is involved, but rewards are greater. You should be able to do some hands-on geology things and get to really know the careers of the people working there.

Get Set

Go to your library or send for materials. If your chosen level of involvement involves a geologist, here are some tips for finding and choosing one:

Finding a Geologist

Maybe this is easy and you already know who you want to work with. If so, skip this section. If not, look at these ideas, and talk to your leader for ideas.

Universities and colleges — Often have at least one geologist, full or part time, on staff.

Phone Book — Look under Geologist or Geological Services in the yellow pages.

Commercial Companies — Many companies employ at least one geologist. Consider oil exploration companies, engineering companies, etc.

Government Agencies — Departments of Transportation, Health and Environment, Water Resources, Natural Resources, etc. all employ geologists. Each water management district has at least one geologist on staff. Most states have regulatory agencies for oil and gas drilling and mining. In Kansas, it is the Kansas Corporation Commission. Most states have a Geological Survey, usually located at one of the state's major universities. In Kansas, it is associated with the University of Kansas.

Contact the geologist and introduce yourself. Tell them you have been taking the geology project in 4-H and are interested in finding out more about geology as a career. Explain what you would like to do and ask if they are available for that. If so, arrange a convenient time and as where you should meet. If not, ask if they could refer you to someone else. Your leader can also help you with this phase.

At the Career Site:

Think about the career opportunity ahead of time. What do you most want to find out? Use the activity sheet *Geology Career Interview* to record a conversation with someone in a geology related job. If you never quite get around to doing what it is that you really want to learn about, it would be all right to politely ask for that. For example, "Sometime, I'd really like to see how you drill the holes that give you that information." Geologists are not mind readers, and clear communication is essential.

Normal common sense and courtesy will pay off for you. Be polite and considerate. Arrive on time and dress neatly and appropriately. You may not need to be as dressy as the office personnel, but neither should you wear casual shorts to most offices, or to heavy construction sites. It is not polite to ask directly what someone earns, but you might ask what a geologist starting out in this profession might make.

At the end of the interview, or whatever project you are doing, thank the geologist, and, if you wish to do more, ask if you may do that. Write a thank you note promptly, mentioning specifically at least one thing you really enjoyed or found interesting.

If you are doing an internship, keep a daily, or weekly log or journal documenting the time you spend there, what you did, and what you learned.

Provide Activity Sheet 66, *Geology Careers Chart*.

Evaluating the Career

You can use the worksheets to help you decide if geology is the right career for you. Rate each area of each career as it fits you on the activity sheet *Geology Careers Chart*. By adding up the scores in the small shaded boxes for each career on the *Geology Careers Chart* you can get a number to help you decide. You could also make up your own similar matrix with what you think is important.

Think about what you have learned. Was there anything that surprised you? Especially think about how the job fits you. Do the job requirements match with your abilities? Would you enjoy that kind of work? Are you prepared to get the required job preparation? A college degree is required to become a professional geologist. How are your grades in school? If you don't feel you have enough money for college; scholarships, grants, and loans are available. Statistics show that college graduates earn about twice as much as high school grads- usually over a million dollars during their working years- so a little effort now can pay off big later. If you don't feel that you can swing a college degree, don't despair. You could become a technician. They have less training than a geologist and do some of the less complicated geology tasks. There are other related careers that involve geology, like working on an oil drilling rig. Geology careers are many and varied. If this one wasn't quite right, consider all of the possibilities.

Choosing a career can be exciting, but difficult. You can usually go to two years of college before you really have to make a final decision on a career. Talk to your parents, leaders, and guidance counselor at school. Geology has many good possibilities for interesting and exciting careers.

Dialogue for Critical Thinking:

Share

1. Which job experiences have you already done?
2. What did you like most about your career experience? Why?

Process

3. What makes geology jobs important?
4. What process helped you learn most about a possible job?

Generalize

5. What makes geology especially appealing to you?
6. What did you learn about making important decisions that you could use when making other decisions?
7. How do you compare advantages and disadvantages when studying jobs?

Apply

8. Do you think there is only one job that is right for you, or could there be several?
9. Do you think it is worth going to four years of college to increase your chances of earning twice as much?
10. How would your job choice affect the other areas of your life?

Going Further

1. Go to professional meetings. They often have good speakers on a variety of topics and you would get to meet other geologists. Some groups are specialists such as engineering or petroleum geology, and some are more general. See addresses in reference section or ask your geologist.
2. Find out what people look for when hiring a geologist. Your work in 4-H should be a plus, especially if you have done an internship.
3. Contact the Earth Science Field Corps on being a long term Volunteer. They are currently working on mapping activities, revising geologic maps in your area. Scholarships and college credit are available after many hours of service. See address below.
4. Some states license geologists. What are the advantages and disadvantages? Check the requirements for Kansas.

References:

"Finding Work as a Petroleum Geologist: Hits for the Job Seeker" American Association of Petroleum Geologists; Box 979, Tulsa, OK 74101

"Careers in Geology" and "Careers in Geoscience Information;" American Geological Institute; 4220 King Street, Alexandria, Virginia 23302

"Career Choices in the Natural Gas Industry," American Gas Association, 1515 Wilson Boulevard, Arlington, Virginia 23302

"Engineering Geology," "Marine Geology," "U.S. Geological Survey: Earth Science in the Public Service," Publications of the U.S. Geological Survey; Western Distribution Branch. U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225

"Careers in Oceanography," "Careers in Geophysics," American Geophysical Union, 200 Florida Avenue, N.W., Washington D.C. 20009

"Careers in Exploration Geophysics," Society of Exploration Geophysicists, Box 3098, Tulsa, OK 74101

"Earth Science Field Corps" (contains application form), Earth Science Corps, MS 513, U.S. Geological Survey, Reston, Virginia 22092, Phone:800-254-8040, Fax: (703) 648-6265, Internet:escorps@usgs.gov.

Author:

Pat Gilliland, Kansas 4-H Geology Curriculum Team

Reviewed by:

Lawrence H. Skelton, Retired Manager of the Kansas Geological Survey office in Wichita

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Geology as a Career

Activity Sheet 65, Geology Career Interview Form

General — Geology, Level IV

Here are some ideas of things to find out when you interview someone about a geology job, or participate in a job shadowing or internship program. There is room to write your own questions at the bottom.

Date ________________________ Name of person I talked to ____

Occupation ____

1. What are the primary tasks of this job?

2. Does this job require you to work most with ideas, data, people or things?

3. What do you like most about your job?

4. What do you not like about this job?

5. Compare the amount of paper-work to time spent out in the field.

6. What kind of training and education is required for this job?

7. What is the approximate beginning salary for this job? Do pay increases come regularly?

8. What are the physical requirements and the personality traits needed for this job?

9. Is there much stability in this job? Do needs for it vary seasonally or from year to year?

10. What are your questions?

Geology as a Career

Activity Sheet 66, Geology Careers Chart

General — Geology, Level IV

Fill in the spaces below for as many careers as you would like to investigate. You may rate each on a scale of 1 (lowest) to 5 (best) and put that number in the small box. When you are done, add up the score for each occupation. You may add in twice any trait that you feel is especially important.

Areas	Career No. 1	Career No. 2	Career No. 3
Primary Tasks List what this job basically does			
Salary What is the salary range for this occupation? Are there extra benefits?			
Preparation What education and training are required? Licensing?			
Working Conditions Indoor/Outdoor Physical demands and activities Environment Travel			
Job Outlook Stable or fluctuating? Future?			
Work with: People? Things? Data? Ideas?			
Other List additional things you think are important			