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.

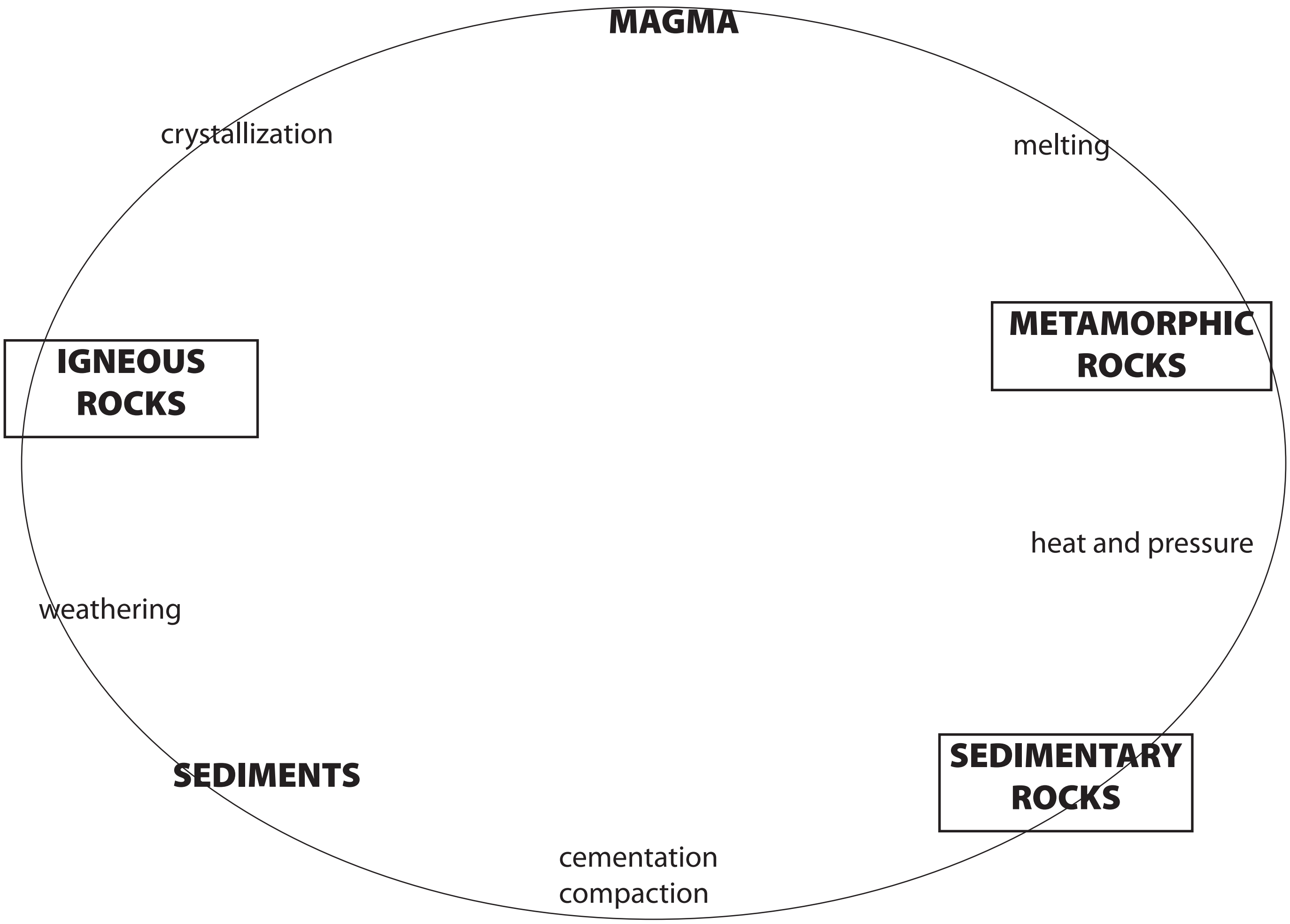
Reviewed by: Rex Buchanan, Geologist with the Kansas Geological Survey

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.

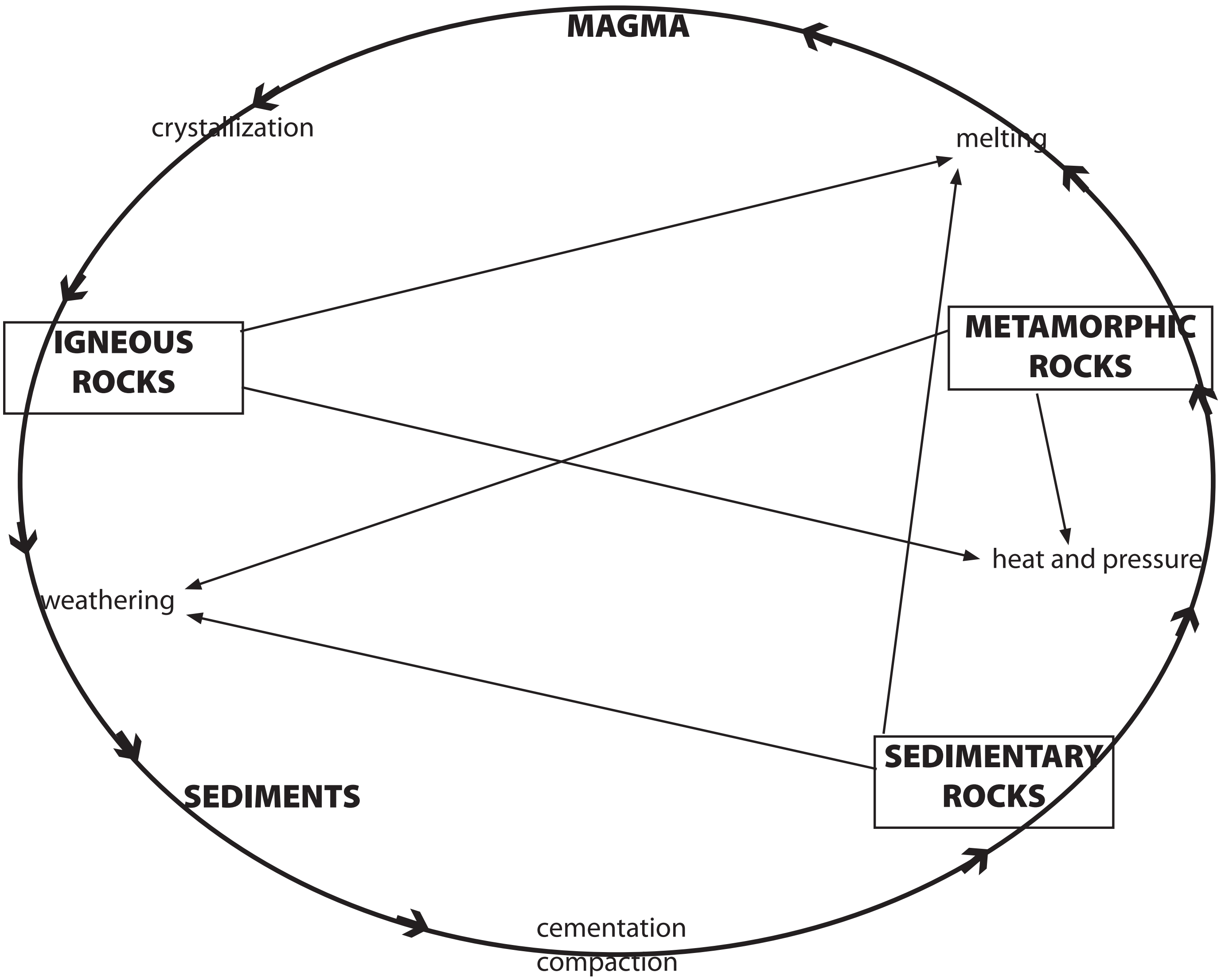
Rock Changes Fill in the boxes to show changes that can occur.

Material	Sedimentary	Metamorphic
Clay		
	Sandstone	
Calcium		

How Rocks Change

Activity Sheet 22, Rock Cycle Leader's Key

Rocks — Geology, Level I

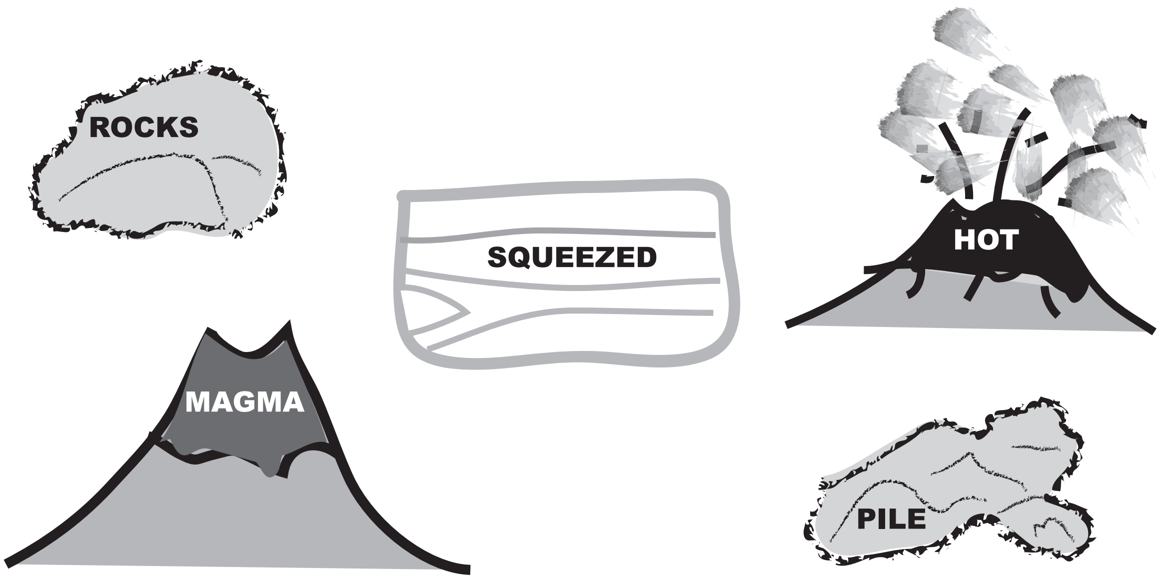


Rocks are moving and changing, but very slowly. With colored pencils, shade each type of rock and draw in arrows to show what makes one type of rock change into another.
Key: Igneous — red; Sedimentary — blue; Metamorphic — green.

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 ______________________________.

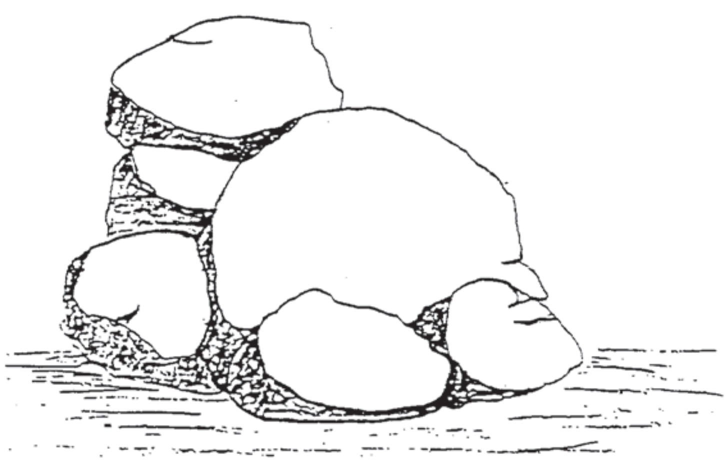
Sometimes igneous and sedimentary rocks are deep inside the Earth. The heat and pressure there can change the rocks into new rocks. The new rocks are metamorphic rocks. Pile books on six slices of bread in a stack and watch how pressure can change things.

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



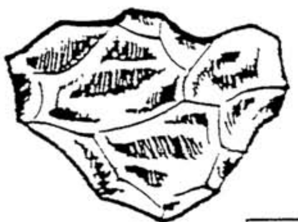
Rocks can be used in construction. Draw what you would build from a pile of rocks. What type of rocks (igneous, sedimentary, metamorphic) are in your rock pile?

How Rocks Change

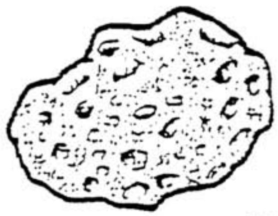
Activity Sheet 25, Rocks Are Different

Rocks — Geology, Level II

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



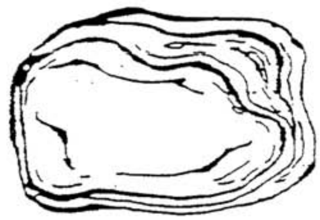
Obsidian



Pumice

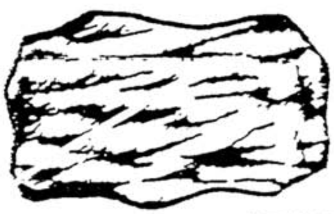
Granite

Limestone

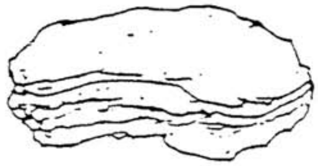


Shale

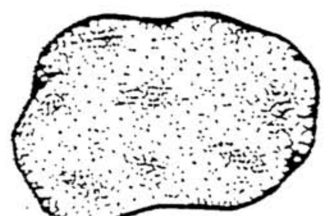
Gneiss



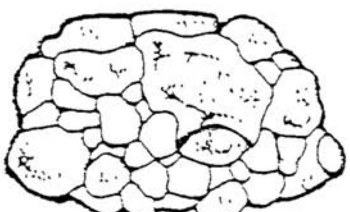
Basalt



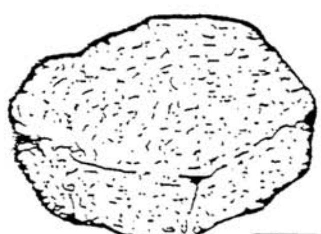
Slate



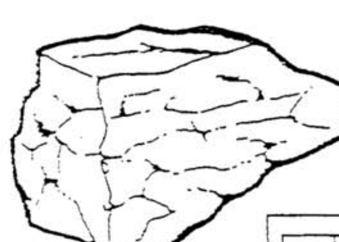
Sandstone



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.

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.

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

Answers to *Formation of Sedimentary Rocks* activity sheet:

A. Dissolved chemicals and organic sediments
B. Gravel
C. Sand
D. Mud or clay

A. Limestone
B. Conglomerate
C. Sandstone
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?

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

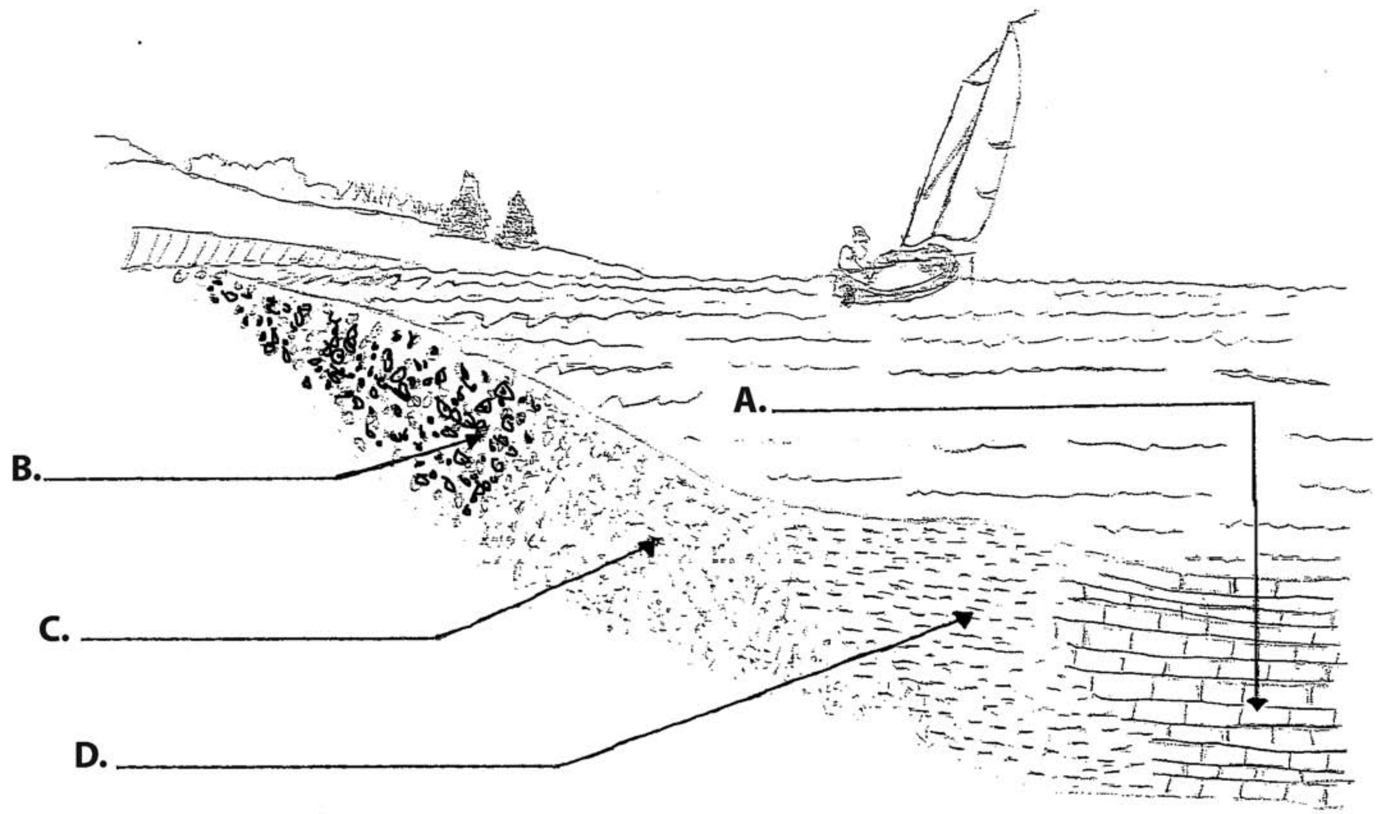
James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Time may not permit the use of Activity Sheet 29, *Sidewalk*.

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.

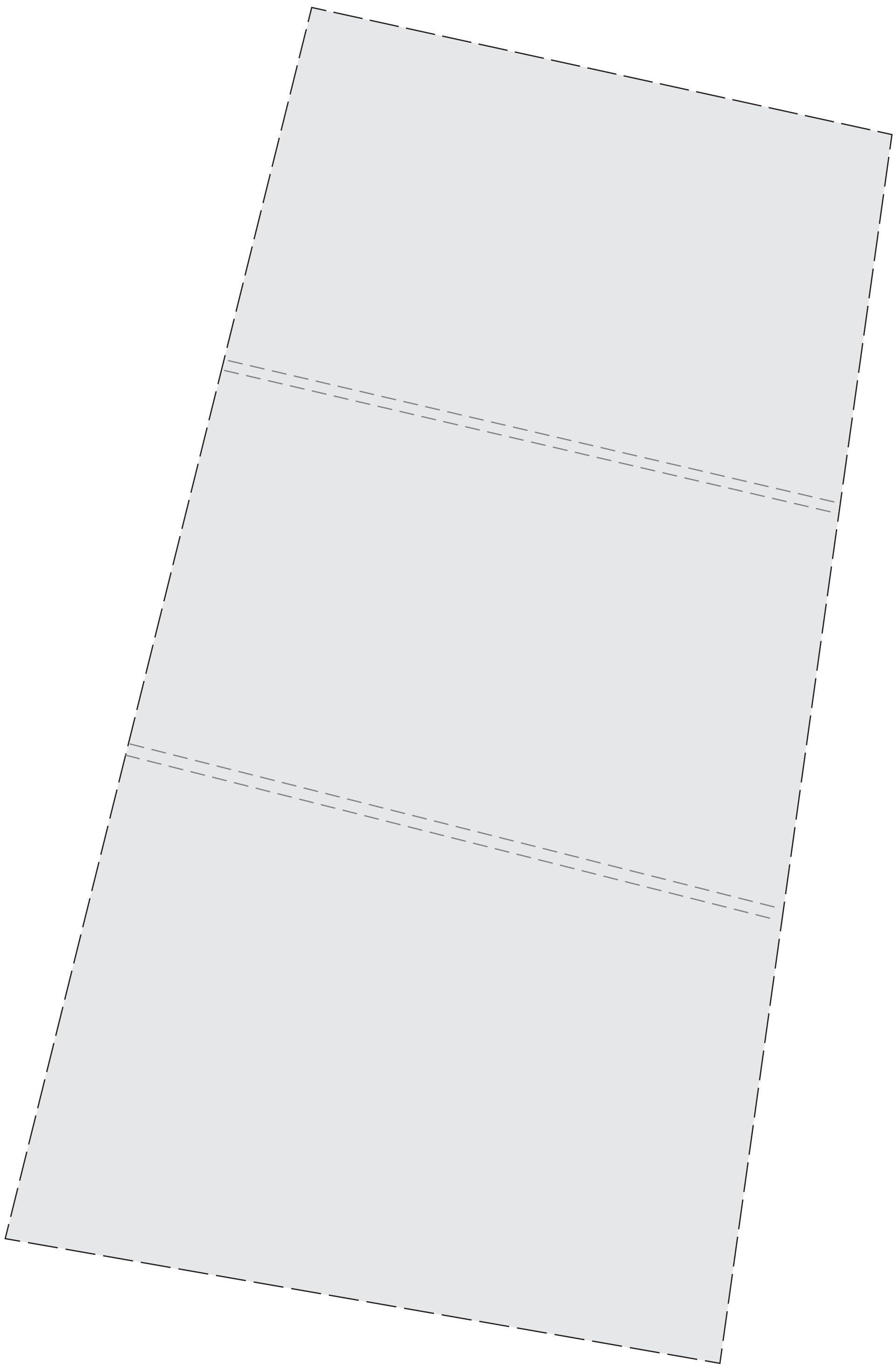
S	C	O	Q	U	I	N	A	S	U	T	R	R	S	I
E	L	F	V	I	N	O	R	G	A	N	I	C	M	Q
D	S	E	D	I	M	E	N	T	A	R	Y	E	P	U
I	N	H	T	Q	Y	V	O	U	K	W	B	H	L	K
M	L	X	A	A	V	E	N	O	T	S	D	N	A	S
E	Y	V	U	L	R	M	F	D	P	R	N	D	Z	Q
N	P	V	E	O	E	E	S	K	L	A	H	C	N	U
T	Z	Z	C	L	A	Y	M	J	T	E	P	I	E	A
A	K	K	B	G	M	L	A	O	C	S	O	N	T	R
R	E	N	O	T	S	E	M	I	L	G	I	A	I	T
Y	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.

Display rock salt, rock gypsum, and chert.

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.

Display a sample of limestone in which shells may be seen.

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 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.

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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 fingernail, 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.

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

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.

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

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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.

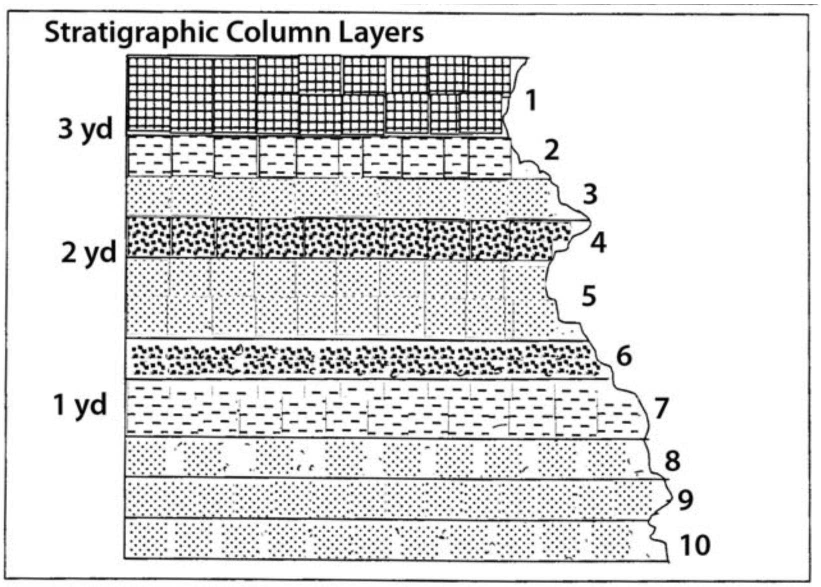
Apply Question #8:

*Use the geological age of surface rocks in your area.

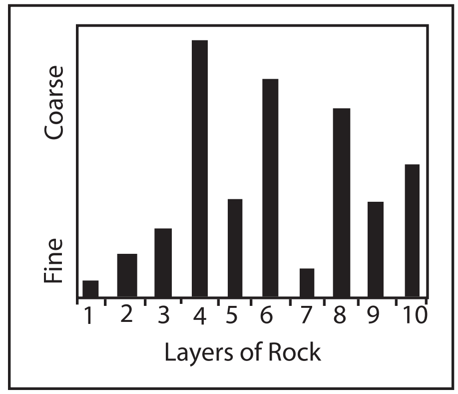
Stratigraphic Cross Section

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__

______

______

______

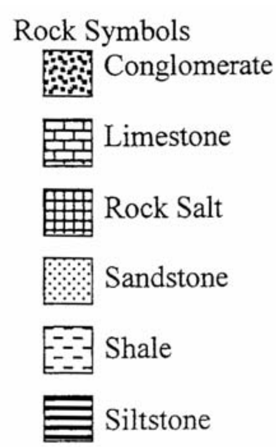
______

______

______

______

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)

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.

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 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.

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Barnes, John H. *Rocks and Minerals of Pennsylvania.* Educational Series 1. Pennsylvania Geological Survey: Harrisburg. 1991. 30 pages.

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

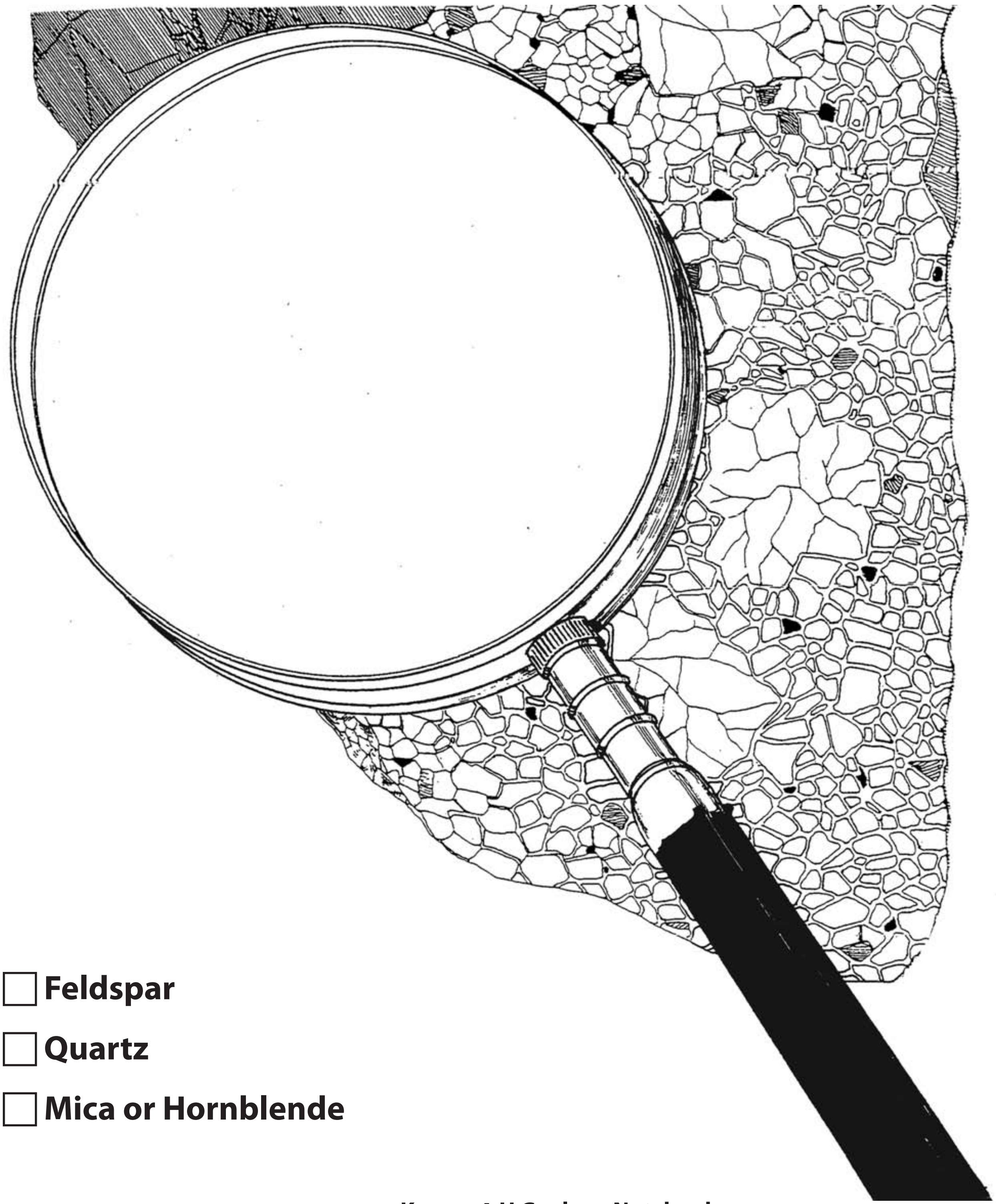
Reviewed by: Dr. James Underwood, retired Geology professor, Kansas State University

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

Rocks from Fire

Activity Sheet 32
Granite Mosaic

Rocks — Geology, Level I

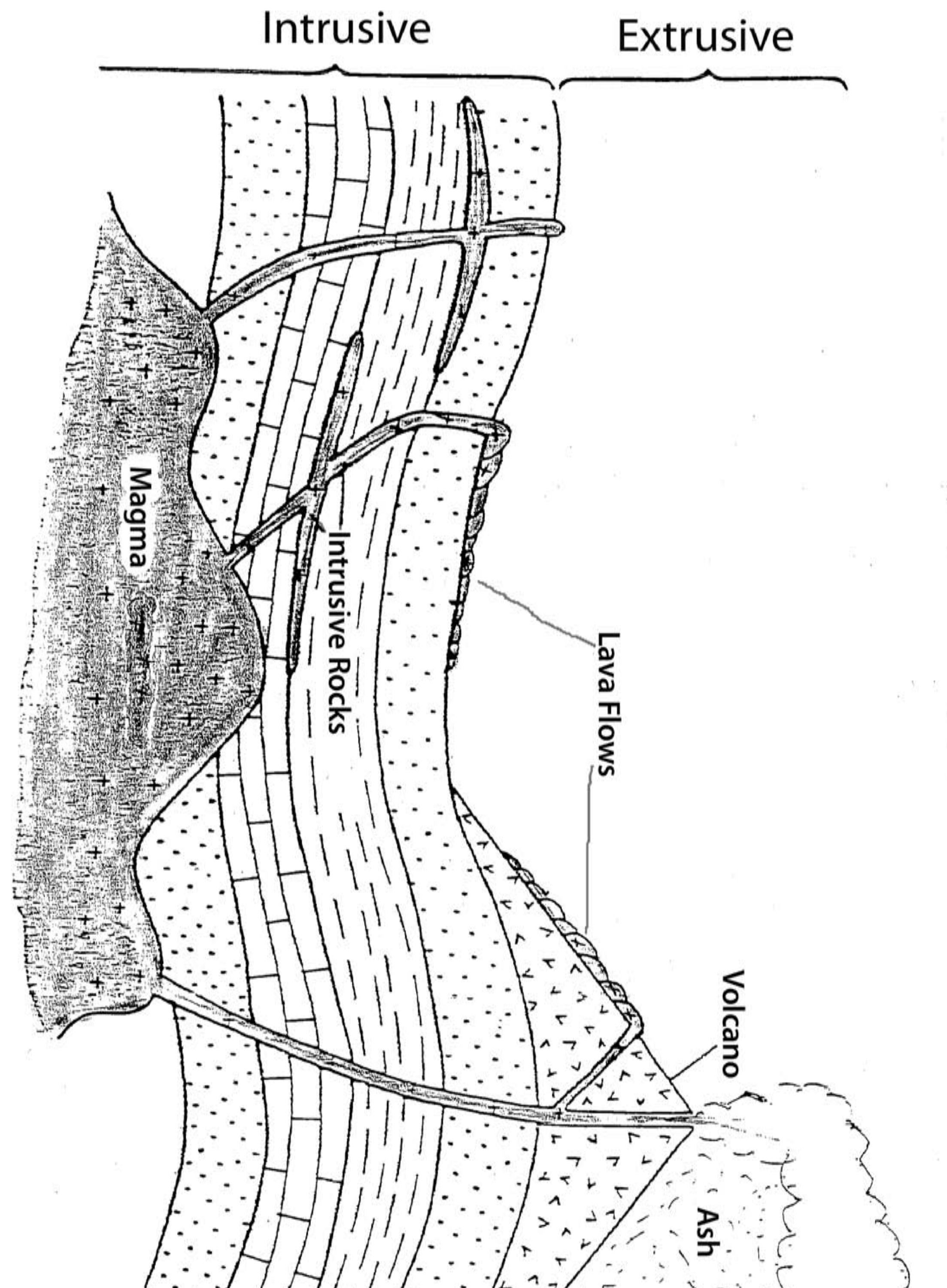


- [ ] **Feldspar**
- [ ] **Quartz**
- [ ] **Mica or Hornblende**

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.

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

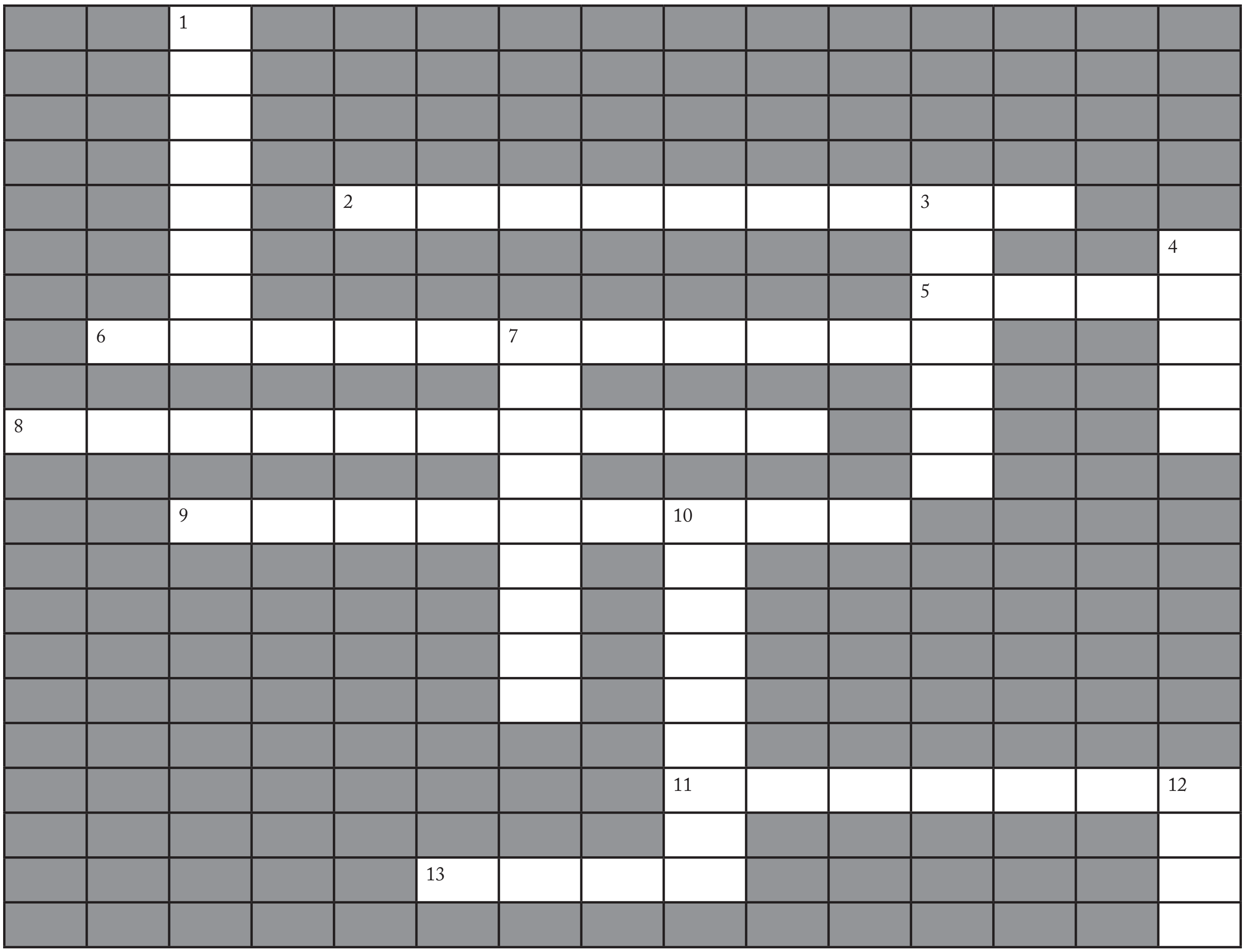
Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

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						
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						T		R						
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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:

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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

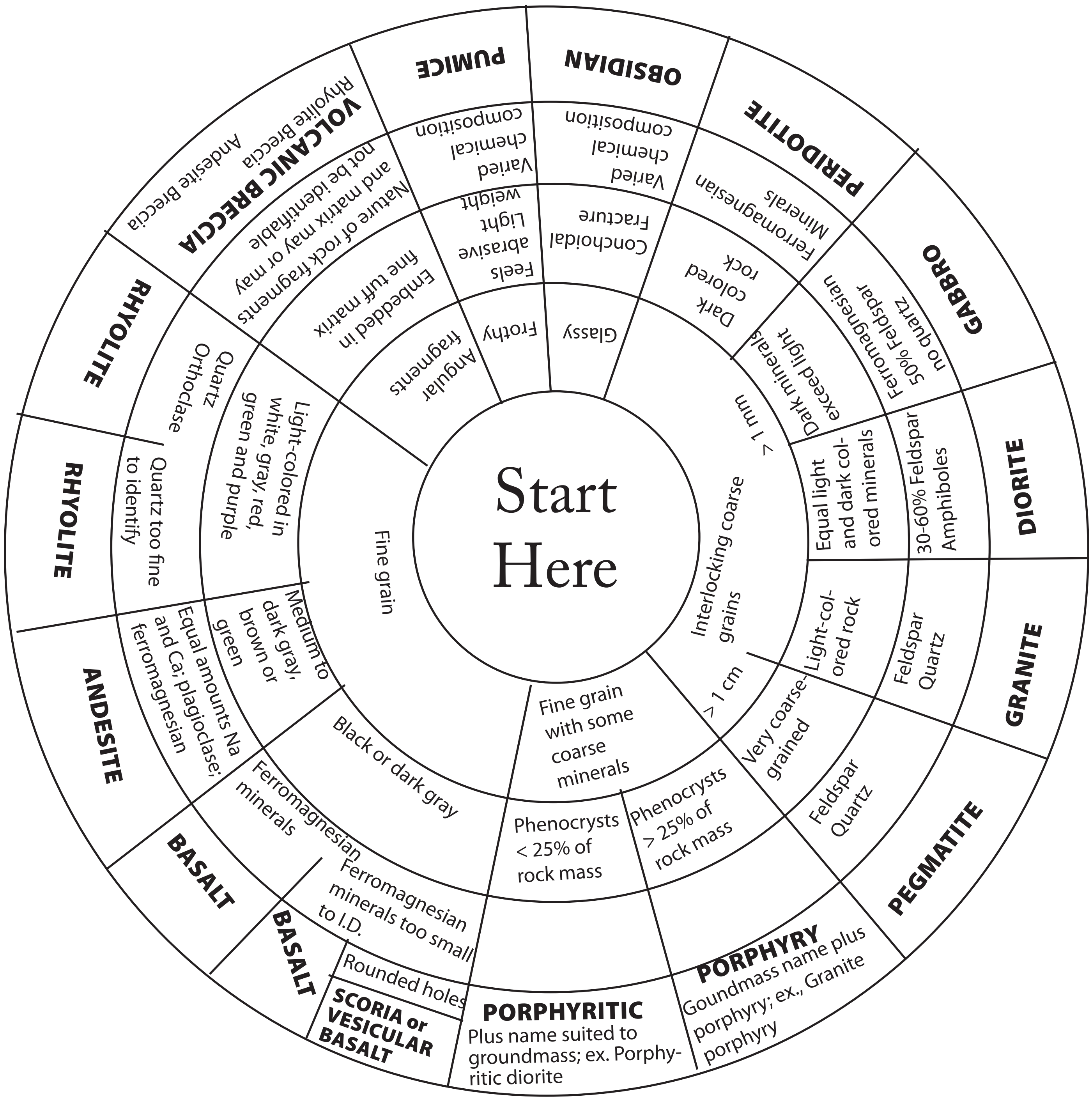
Andesite
- Shades of gray and green are common
- Plagioclase exceeds orthoclase
- Pyroxene or hornblende may be present
- Fine-grained, may have phenocrysts of feldspar and dark minerals

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.

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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 rich	Mafic
Low temperature (last to crystalize)	Amphibole 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.

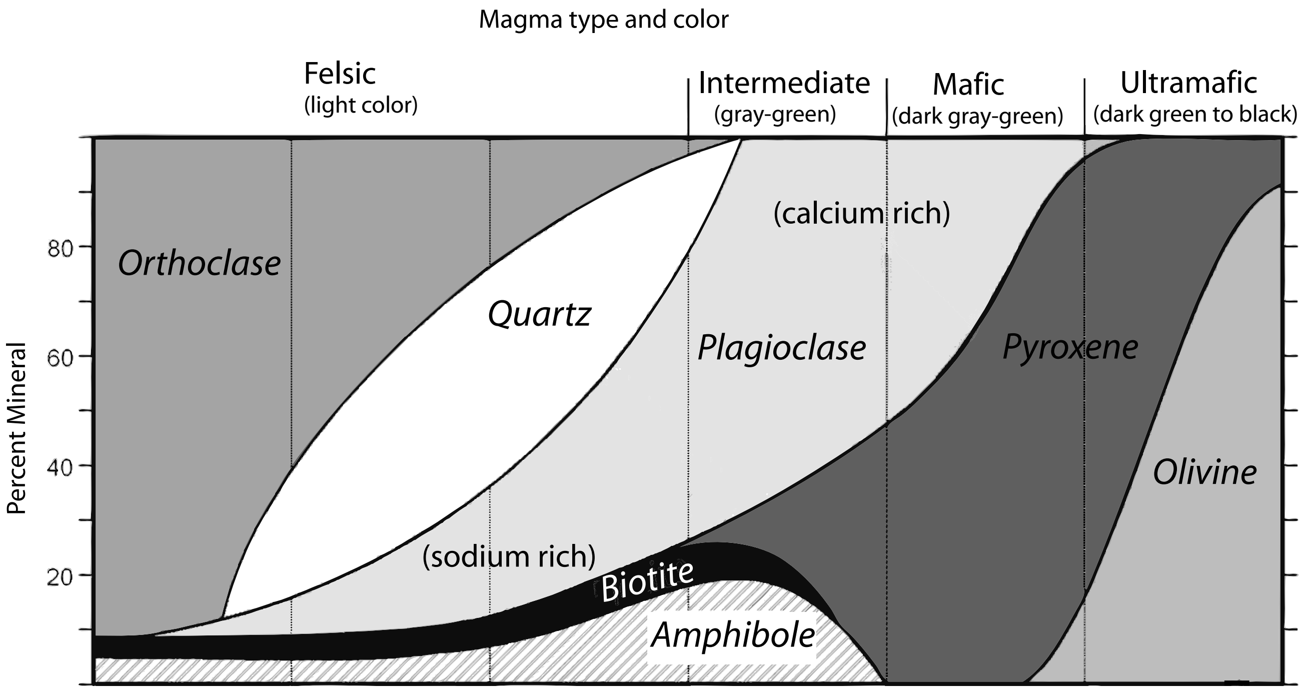
Silicate: A substance that contains silica as part of its chemical formula.

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

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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
  - argillite
  - phyllite
  - schist
  - gneiss
  - quartzite
  - hornfels
  - marble
  - mica schist
  - 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

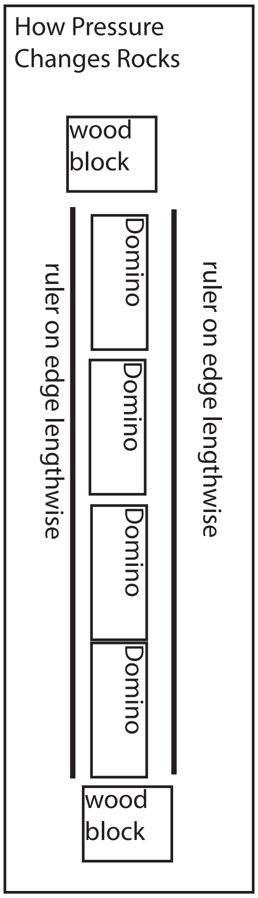
2 rulers

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?

Have following chart on newsprint pad.

Length of dominoes

before	after	drawing of results

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.

Length of clay or play dough

before	after	drawing of results

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.

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*.

Dialogue for Critical Thinking:

Number the metamorphic rock samples. Distribute Activity Sheet 40, *Metamorphic Rock Identification*.

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.

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

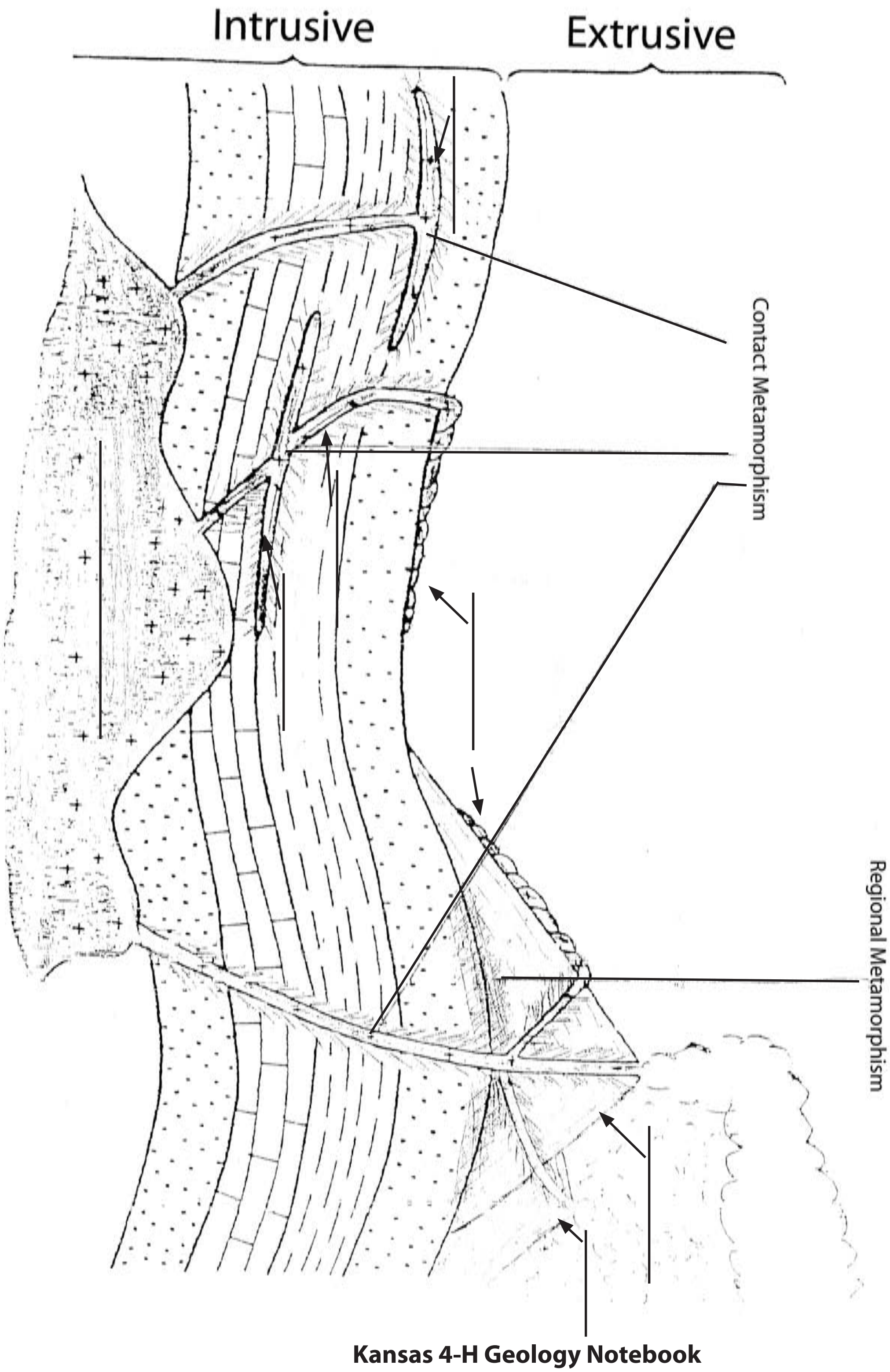
Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

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

Changed Rocks

Activity Sheet 38, Metamorphic Activity

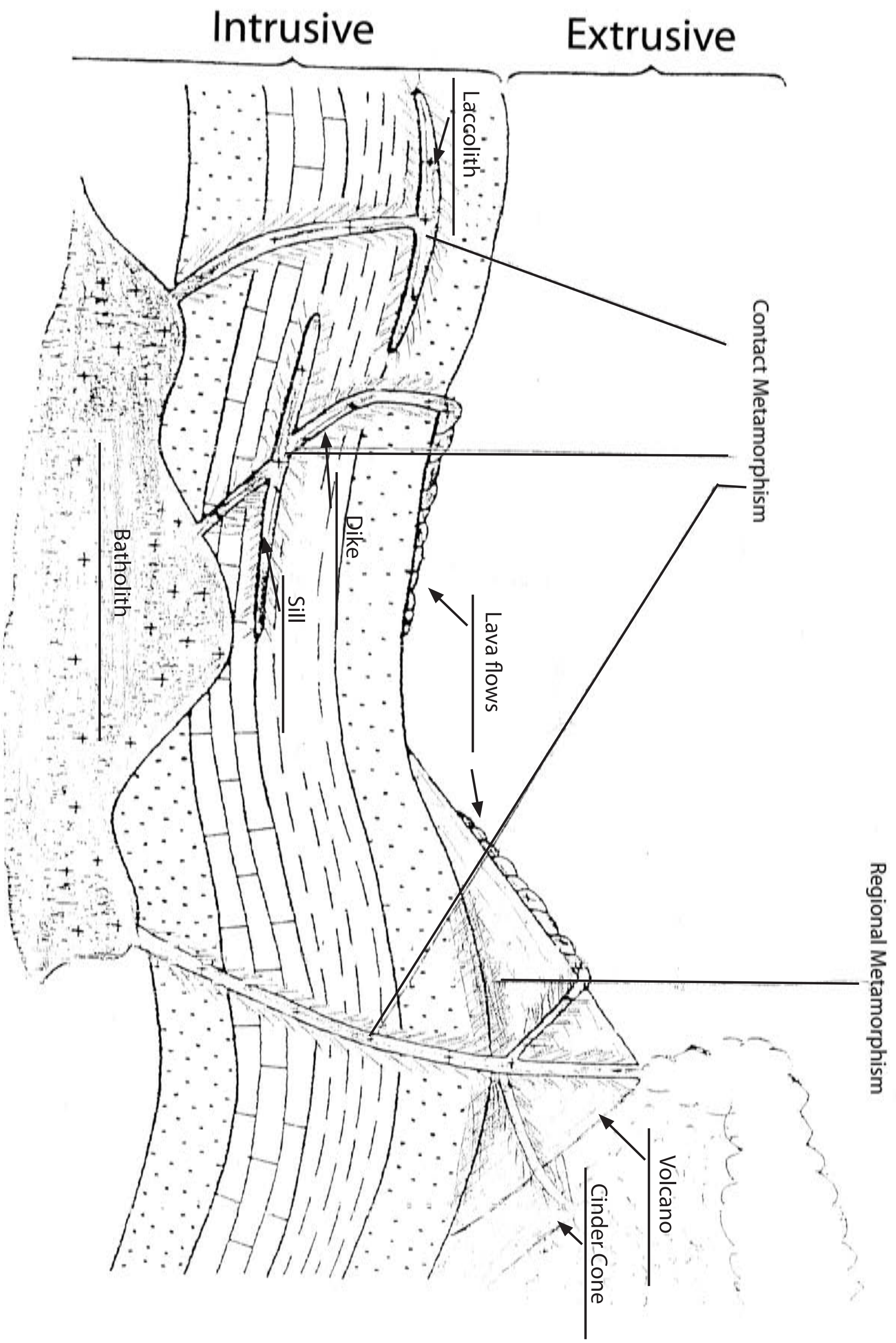
Rocks — Geology, Level II



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
- newsprint pad
- dilute HCl
- nail
- magnifying lens
- quartzite
- hornfels
- metamorphic rocks
- slate
- schist
- gneiss
- marble
- phyllite
- 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 Rocks*

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.

Form two groups:

- A foliated group
- A non-foliated group

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.

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.**

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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

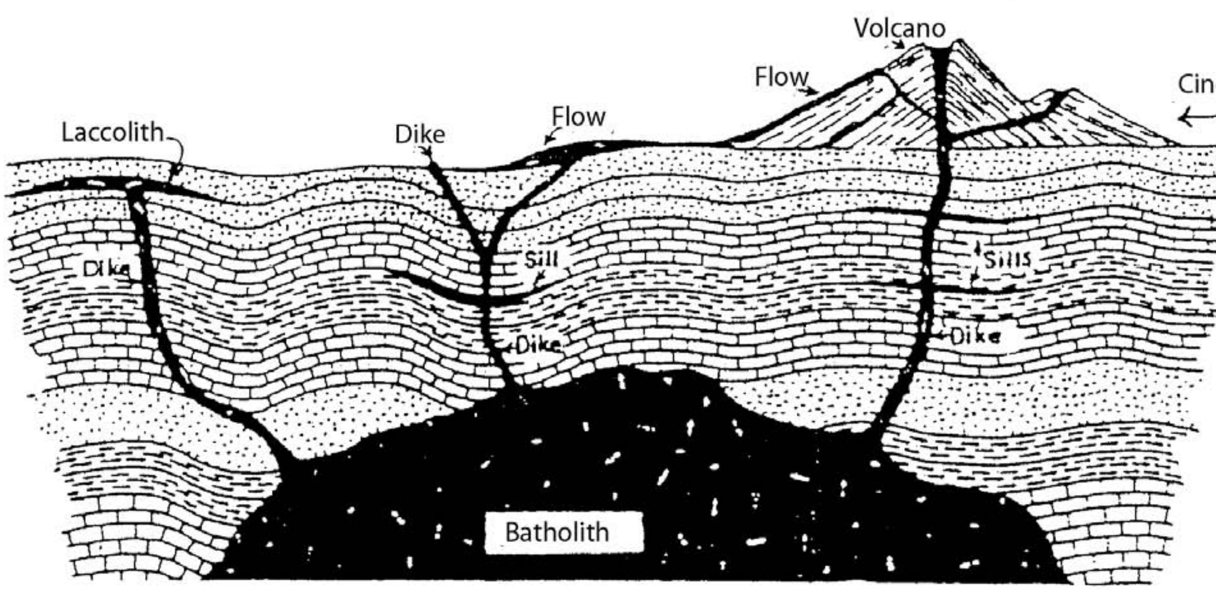
Igneous Rocks are those that have been formed by the cooling and hardening of molten rock material. The word molten means melted and signifies a hot liquid. This liquid is called magma - a Greek word meaning dough.

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