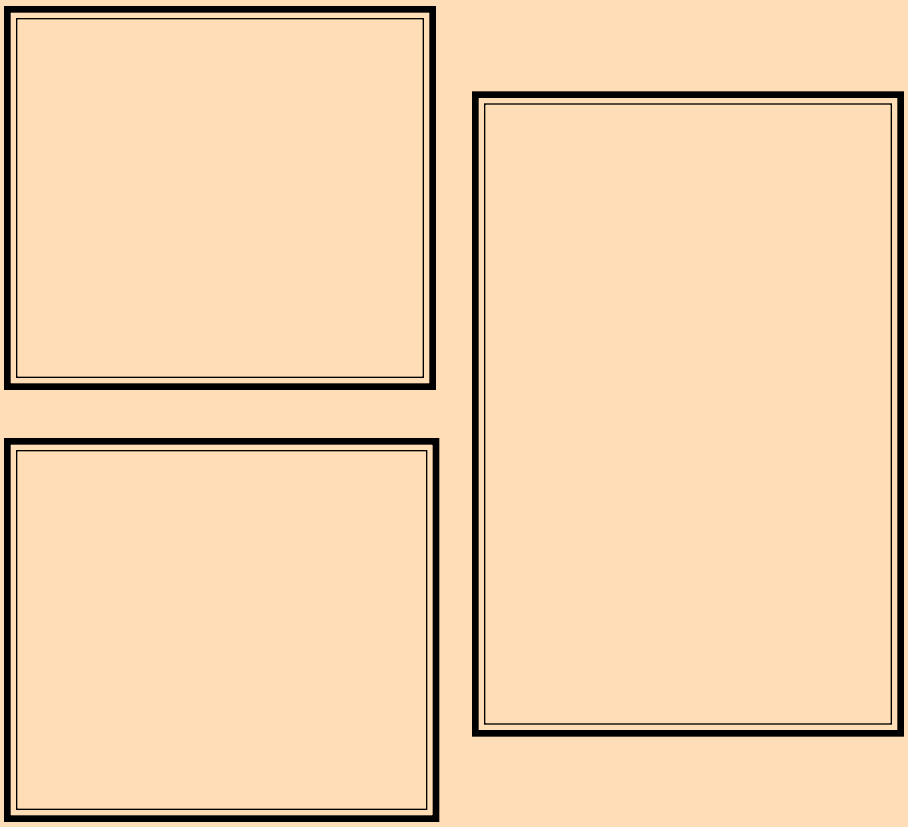
EROSION AND WEATHERING

from the

Basics of Geology Series



Teacher's Guide

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Erosion & Weathering
from Basics of Geology

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THE BASICS OF GEOLOGY SERIES
A Unit of Study
Grades 5-9

A NOTE TO THE TEACHER

During a human lifetime, the land appears to be stable and permanent. However, in the media we are constantly reminded of the dynamic natural processes that are affecting the land: volcanoes erupting in Indonesia, earthquakes trembling in Japan, and hurricanes striking the United States mainland. By studying the basics of geology, it is anticipated that one will have a better understanding of and respect for these and the other forces that are found within and around our beautiful planet, Earth.

GENERAL DESCRIPTION OF THE PROGRAM

THE BASICS OF GEOLOGY SERIES is intended for use in grades five through nine (5-9). Each video and accompanying lesson activities may also be appropriate for older students.

The full-motion videos and accompanying student activities have been prepared to help students to become more familiar and aware of their home, planet Earth.

THE BASICS OF GEOLOGY SERIES is designed to be used in two ways–as a complete self-contained *Unit of Study* or as *stand-alone* video lessons.

The Unit of Study consists of four videos, three lessons, four sets of blackline master activities, and this accompanying Teacher's Guide containing Suggested Instructional Procedures for each of the three lessons, Answer Keys, scripts, Geologic Time Line of the Earth Activity, and a Unit Test.

Each stand-alone lesson consists of one or two videos, one set of blackline master activities, and a Teacher's Guide. An envelope containing the blackline master activities for the appropriate lesson is enclosed.

This unit of study has been divided into three lessons:

1. FORMATIONS OF CONTINENTS AND MOUNTAINS: Introduction to Geology and Mountains, Volcanoes, and Earthquakes (two videos)
2. EROSION AND WEATHERING (one video)
3. ALL ABOUT ROCKS AND MINERALS (one video)

It is highly recommended that your students each have his or her own portfolio for the blackline master activity sheets, his or her own writings, and other information he or she finds interesting or important to keep for his or her study of **THE BASICS OF GEOLOGY SERIES**.

UNIT GOALS

After viewing the four videos and participating in the respective follow-up activities in this Unit of Study, students will be able to:

- Define that time is an important component of every geological process, and demonstrate understanding of the scope of the time line of geologic development.

- Identify the natural processes that help change the earth.

- Identify the internal structure of the planet earth.

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• Describe the constructive and destructive forces that shape the land.

• Describe the importance of minerals.

• Describe the processes which act to transform one rock into another.

• Describe the formation and composition of soil.

• Identify how fossils provide evidence about how life and the environment have changed on the earth over time.

These Unit Goals comply directly with the **National Science Education Standards** for grades 5-9 in Earth and Space Science:

Formations of Continents and Mountains
• The solid earth is layered with a lithosphere: hot, convecting mantle; and a dense,metallic core.
• Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate movements.
• Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
• The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past.
• The outward transfer of earth's internal heat drives convection in the mantle that propels the plates comprising earth's surface across the face of the globe.

Erosion and Weathering
• Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria.
• Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
• Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.
• The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past.

All About Rocks and Minerals
• Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.
• Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.
• Fossils provide important evidence of how life and environmental conditions have changed.
• Geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations.

Specific Student Objectives are given for each video lesson in the Suggested Instructional Procedures section.

MATERIALS IN THE UNIT

Videos
This Unit of Study contains four videos. The program highlighted in bold type is the subject of this guide. The video titles and themes are as follows:

1. FORMATIONS OF CONTINENTS AND MOUNTAINS: INTRODUCTION TO GEOLOGY
The science of geology studies the dynamics of the earth's past and its present structures, and seeks to predict its changes in the future. The internal structure of the earth is composed of several zones of solid, liquid, and soft rock. For the almost five billion years, the earth has transformed itself from a fiery ball to a sphere whose surface is covered by land and water. The internal dynamics within the earth affect its surface. Plate tectonics is a theory that explains the movement of the earth's plates.

2. FORMATIONS OF CONTINENTS AND MOUNTAINS: MOUNTAINS, VOLCANOES, AND EARTHQUAKES
The forces of heat and pressure play a major role in causing the land to rise. When molten rock within the earth breaks through the crust, a volcano is formed. Volcanic activity is often found along the broken sections of the earth's crust. These sections move very slowly, pressing against one another in some places, and pulling apart in other places. The spreading apart of oceanic plates is called sea floor spreading and the collision of two plates is called subduction . When layers of land within a plate are under extreme pressure to move, the stress causes the layers to fold and rise into mountains. Mountain formation can also occur when the land is forced to break. The vibrations from the release of this pressure is called an earthquake.

3. <u>EROSION AND WEATHERING</u>
The forces of nature not only build up the land, but they break it down as well. *Physical weathering* is the breaking down of rock by the action of water, wind, plants, and animals. *Chemical weathering* deteriorates rocks by the reaction of different chemicals on the surface of the rocks. Examples of chemical weathering are: the formation of rust due to oxidation, the lichen plant's ability to secrete acid into rock, and the formation of caves due to the presence of carbonic acid. When plants and animals help break down rock, they often add organic matter to it. The combination of disintegrated rock, organic matter, and a community of plants and animals make up *soil* . If soil is poorly maintained, it and other weathered rock could be easily washed, blown, or carried away. This process is known as *erosion* . Running water is the most dominant cause for changing the landscape. Glaciation, mass wasting, and wind are also agents of erosion. Acid rain, along with human activities such as mining, farming, and dune buggying, also contributes to the erosion of the earth.

4. ROCKS AND MINERALS
There are over 2,000 types of minerals in the world, but only twenty minerals are common. Of all the mineral characteristics, the crystal structure is perhaps the most important clue to mineral identification. A rock is composed of different combinations of minerals. Most geologists refer to the rock cycle to explain rock types. Minerals, temperature, and forces all play a part in the making of a rock. For example, as the sediment of sand and smaller particles are gradually buried and later cemented together by dissolved minerals, they become sedimentary rock. Fossils are often found in sedimentary rock and provide evidence of how life and environmental conditions have changed on the earth over time. Since the arrival of early humans, rocks and minerals have played a vital role in the development of the human race. Today, a staggering amount of the earth's natural resources is consumed. As people become better-educated about our earth, the more aware we become about the health of our home, planet Earth.

Video Quizzes
Each of the videos Formations of Continents and Mountains: Mountains, Volcanoes, and Earthquakes; Erosion and Weathering; and Rocks and Minerals includes a Video Quiz, which immediately follows the closing credits after the video presentation. A short period of time is provided for each question; you may wish to pause the videotape to allow more time between questions.

Teacher's Guide
This Teacher's Guide has been prepared to aid you in utilizing materials contained within the Unit of Study. In addition to this introductory material, the guide contains the following:
• Culminating activities for the unit, including The Geologic Time Line of the Earth and a Unit Test, designed to assess student comprehension of the Unit Goals.
• Suggested Instructional Procedures for each lesson.
• Follow-up activities and projects for each lesson.
• An Answer Key for the activity sheets for each lesson.
• The script of the recorded narration for each lesson.

Blackline Master Activities
Included in this Unit of Study are three envelopes containing blackline master activities for each video lesson. These blackline masters are provided as follow-up activities for each lesson.

A fourth envelope of the blackline master activities is provided which contains the Culminating Activities for the Unit of Study, which include The Geologic Time Line of the Earth and a Unit Test.

These blackline masters are provided as the follow-up activities for each lesson.

They will help you determine focal points for class discussions based on the objectives for the lesson. The activity sheets have a three-fold purpose:
• To reinforce the information presented in the video.
• To provide an opportunity for the students to apply what they have learned from the video.
• To be used as diagnostic tools for assessing areas in which individual students need help.

INSTRUCTIONAL NOTES

It is suggested that you preview each video and read the related Suggested Instructional Procedures before involving your students in the lesson activities. In this way, you will become familiar with the materials and be better prepared to adapt the program to the needs of your class.

If used as a Unit of Study, you may find it helpful to follow the videos and lesson activities in the order in which they are presented in the Teacher's Guide.

It is also suggested that the video presentation take place before the entire class and under your direction. The lesson activities grow out of the context of the videos, therefore the presentations should be a common experience for all students. Arrange later viewing of the videos in small or in large groups to aid in the completion of some of the activities.

As you review the instructional program outlined in this Teacher's Guide, you may find it necessary to make some changes, deletions, or additions to fit the specific needs of your students. We encourage you to do so, for only by tailoring this program to your students will they obtain the instructional benefits afforded by the materials.

If you are using THE BASICS OF GEOLOGY SERIES as a Unit of Study, a Unit Test Answer Key, designed to assess student comprehension of the Unit Goals, is included on page 7 of the Teacher's

Guide. You may find it necessary to alter some of the questions to make them developmentally appropriate for your students. This Unit Test is an optional activity. If you are using a grading system based on percentages, you may want to give additional credit for the short-answer questions. Please duplicate as many copies of the unit test as you need.

The following unit activities are not included in the envelopes containing blackline masters which accompany this video lesson.

UNIT OF STUDY CULMINATING ACTIVITIES

1. Unit Blackline Masters 1-8, The Geologic Time Line of the Earth. Directions and activity sheets are found at the end of this unit. The geological events are dated and should be placed in chronological order. Suggestion: This long-term project could be assigned during the same time period the other lesson activities are assigned. The following information and the blackline master activity are supplied for the use in creating a thirty-nine foot time line of the earth's 4.6 billion years, along with the demarcation of the earth's eons, eras, and tectonic events.

Materials Needed for Time Line

- 39' x 1' roll of white butcher paper per student or team
- Pen and pencil
- Rulers
- Scissors
- Glue sticks or paste
- Colored markers, pencils, or crayons: red, brown, grey, green, and yellow
- Large space to work

Time Line Preparation and Execution

1. To help students become familiar with time lines, have them make time lines of their own lives.

2. In the beginning and end of the activity, it is best to set up a space where the time lines can be laid out so the students can get familiar with the earth's extensive history.

3. Talk to the students about time and how it is measured. Next, have the students read page one: "Introduction." Using this worksheet, familiarize the students of the earth's past and its division of time.

4. Pass out butcher paper, materials, and pages two through eight. Explain to the students that most time lines of the earth are rarely to scale or are so small, it is hard to grasp the earth's long history. Therefore, THE GEOLOGIC TIME LINE OF THE EARTH activity will help them achieve a better understanding and sense of geologic time.

5. Help the students to read page two, **Directions**. A teacher-made example of this activity would be helpful to show what the final project will look like. Have students follow the directions from this sheet.

6. As students lay down the dates at each increment, encourage them to say the date aloud. Constantly remind them that each time increment equals ten million years. Check for errors in counting. The exact length of the time line may need adjustment. Correct any errors during the process since the focus of this activity is an accurate time line of the geological history of the earth.

7. Assessment of this project could be based on neatness, cooperation, accuracy, the ability to complete project on time, and the knowledge and skill to read the time line.

8. Display time lines around the school, administration offices, government buildings, and business offices where appropriate.

2. Unit Blackline Master 9, Unit Vocabulary. This list of vocabulary words is crucial to the comprehension of this Unit of Study.

3. Bulletin Boards: As the Unit of Study progresses, it is recommended you assign various groups of students to make bulletin board displays centered around specific topics contained in each of the four videos.

4. A Mural of the Earth's Surface: A mural is an excellent way to show the variety of formations found on the Earth's surface. Collect magazine pictures of the various geological structures and environments found on the earth. Arrange these smaller visuals on large butcher paper to create a larger picture that looks like a landscape. For example, in the background group sky scenes, on the horizon display mountain and volcano pictures, in the foreground arrange lowland and water pictures. The bigger the mural the better. Make sure all areas of the mural are covered either with pictures or with the appropriate colored paper so that the total area of the mural looks complete. Take a picture or videotape your mural with your class.

5. Television Interview/Report: Prepare a television news report about a fictional or past geological event such as a volcanic eruption, hurricane, or earthquake. Include factual information and opinions. Shoot the interview or report with a video camera. Take into consideration during the shooting that lighting and sound are appropriate, that the people on camera are appropriately dressed, and that your background enhances and does not distract from the presentation.

It is suggested that written, oral, or computer multimedia reports be assigned during the course of the Unit of Study. You may wish to give your students opportunities to select topics prior to or during the individual lessons.

Suggested Topics:

Rocks and Minerals
Igneous Rocks
Volcanic Activity
Weathering and Soil
Sedimentary Rocks
Geologic Time
Glaciers and Glaciation
Shorelines
The Earth's Interior
Plate Tectonics
The Ocean Floor
Mountain Building
Metamorphic Rocks
Mass Wasting
Deserts and Winds
Earthquakes

6. Blackline Masters 10-12, Unit Test. This assessment tool may be used as a pre-test to gauge student comprehension prior to the presentation of the Unit of Study and/or as a post-test to evaluate student comprehension after completion of the Unit. Answers appear in the Unit Answer Key on the following page.

INTERNET RESOURCES

1. Check out the **American Geological Institute**'s homepage at

http://jei.umd.edu/agi/agi.html

This site contains helpful links to many aspects of geology, from online databases to government affairs to education.
American Geological Institute
4220 King Street
Alexandria, Virginia 22302-1502

2. The **Geological Society of America** has a homepage at

http://www.geosociety.org

which contains links to a variety of publications and educational information.
Geological Society of America
3300 Penrose Place
Boulder, Colorado 80301
(303) 447-2020
(303) 447-1133 fax

3. Visit **The Paleontological Society Homepage** at

http://www.uic.edu/orgs/paleo/homepage.html

for information on all things paleontological.
Geological Sciences
University of Illinois at Chicago
845 West Taylor Street
Chicago, Illinois 60607

UNIT TEST ANSWER KEY

Unit Blackline Masters 10-12, Unit Test

Part One: Fill-In-The-Blank

1. geology
2. continents
3. soft or liquid rock
4. plates
5. plate tectonics
6. One of the following: oxidation, lichen secretion of acid, formation of caves due to carbonic acid.
7. mass wasting
8. sea floor spreading
9. physical weathering

Part Two: True or False.

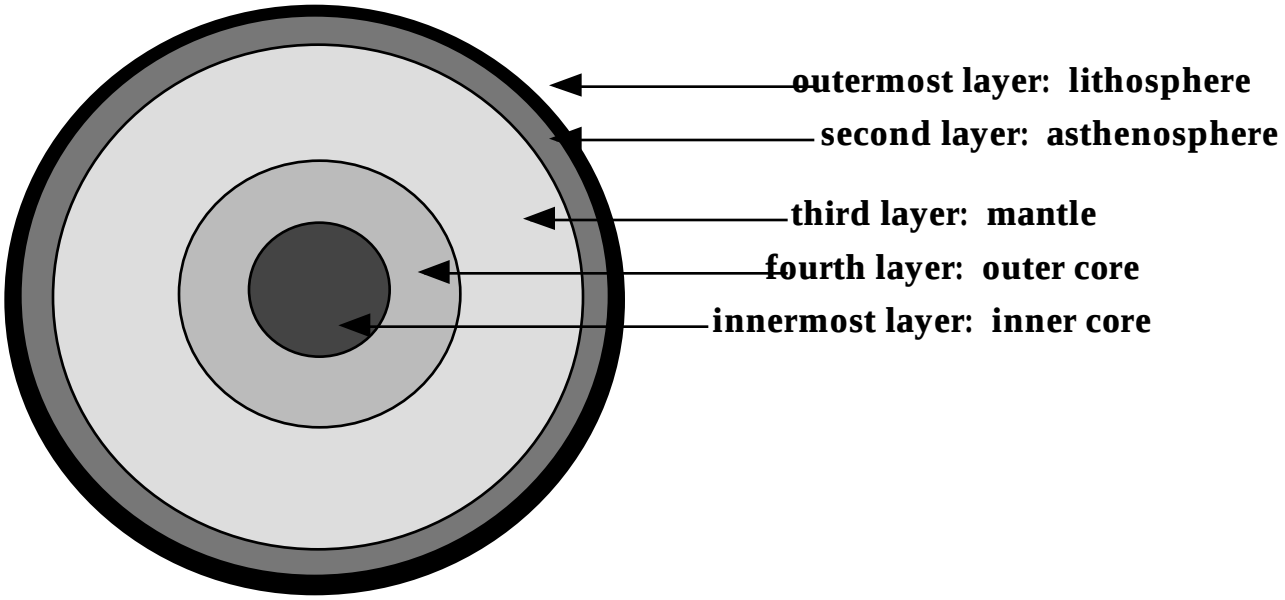
1. T	6. T
2. F	7. F
3. F	8. F
4. F	9. T
5. T	10. T

Part Three: Multiple Choice

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

Part Four: Long Questions

1.



2. The three processes which cause the earth to wear down are physical weathering, chemical weathering, and erosion. Physical weathering is the actual breakdown of rock by the action of natural forces such as water, wind, plants, and animals. Examples would be water turning to ice in the cracks of rocks which causes them to breakdown, the growth of plant roots through rocks, the wearing down of rocks due to animal foraging, and the breakdown of rock due to wind. Chemical weathering causes changes in the rocks from the reactions of different chemicals on the surface of rocks. Examples are oxidation, such as rust, that deteriorates any surface on which it acts, the acidic secretions of lichen plants growing in rock, and the effects of carbonic acid, which can cause caves and caverns to form over time. Erosion is the washing, blowing, or carrying away of weathered rock material. Forces of erosion are wind, water, ice, and gravity. Running water is a good example of erosion, as are glaciers and mass wasting.

3. Subduction is the result of a collision of two land plates; one plate is pushed under the other, causing the land to build up on the edge of the continent. Because of this plate movement, the land is slowly squeezed and crumpled over millions of years until, finally, mountain ranges are formed.

4. Minerals are important in many ways. First, many minerals are useful. Salt is used to flavor food, graphite is used in pencils, and gemstones and precious metals are used to make jewelry and other pleasing items. Minerals also combine as the basic building blocks of all common rocks.

5. The three types of rock are igneous, sedimentary, and metamorphic. Igneous rocks are formed by the molten material, or magma, deep below the earth's crust. Sedimentary rocks is formed by weathering and erosion forces, which break down and transport rock fragments. When a pile of fragments accumulates, the particles near the base become compacted by the weight of the overlying layers and become cemented together by dissolved minerals (called lithification). Metamorphic rock is created when either sedimentary or igneous rock undergoes transformation involving heat and/or pressure. The "rock cycle" is the cycle by which igneous rock is broken down and becomes sedimentary rock; igneous or sedimentary rock can turn into metamorphic rock through heating or pressure. Metamorphic rock can become sedimentary rock through erosion and/or weathering or igneous rock through heating.

EROSION AND WEATHERING

Grades 5-9

Running Time: 25:20

GENERAL DESCRIPTION OF THE PROGRAM

Erosion and Weathering is designed to provide intermediate grade students (5-9) with an in-depth look at how physical weathering, chemical weathering, and erosion are constantly modifying the earth. Soil formation is also included.

This program is an unusual audio visual experience in that it is made up of an original musical score and spectacular live-action footage of national parks, glaciers, white water rafting, massive rock slides, and hurricanes taken at a number of locations from mountain tops to desert regions.

Another unique feature of this program is that it is an earth science program that can also be used in the context of integrated learning. Reading and writing experiences, art activities, and projects designed to develop visual and audio comprehension are all a part of this fascinating presentation.

MATERIALS IN THE UNIT

Video

EROSION AND WEATHERING

This video focuses on the never-ending process of the disintegration, soil formation, and movement of rock. Immediately following the closing credits is a Video Quiz, the questions to which appear on **Blackline Master 2, Quiz**, and the answer to which appear in the Answer Key on page 15 of this Guide.

Blackline Masters

Included in this program are fifteen Blackline Masters for duplication and distribution. They consist of vocabulary worksheets, take-home activities, classroom activities, information sheets, and a quiz.

These blackline masters are provided as the follow-up activities for the lesson. They will help you determine focal points for class discussions based on the objectives for the lesson. The blackline masters have a three-fold purpose:

- To reinforce the video.
- To provide an opportunity for the students to apply what they have learned from the video.
- To be used as diagnostic tools for assessing areas in which individual students need help.

Teacher's Guide

This Teacher's Guide has been prepared to aid the teacher in utilizing materials contained within this program. In addition to this introductory material, the guide contains the following:

- Suggested instructional procedures for each lesson
- Answer Keys for activity sheets
- Follow-up activities and projects for each lesson

INSTRUCTIONAL NOTES

It is suggested that you preview each video and read the related Suggested Instructional Procedures before involving your students in the lesson activities. In this way, you will become familiar with the materials and be better prepared to adapt the program to the needs of your class.

You will probably find it helpful to follow the videos and lesson activities in the order in which they are presented in this Teacher's Guide, but this is not necessary.

It is also suggested that the video presentation take place before the entire class and under your direction. The lesson activities grow out of the content of the videos; therefore, the presentations should be a common experience for all students.

As you review the instructional program outlined in this Teacher's Guide, you may find it necessary to make some changes, deletions, or additions to fit the specific needs of your students. We encourage you to do so, for only by tailoring this program to your students will they obtain the instructional benefits afforded by the materials.

INTERNET RESOURCE

1. The **U.S. Geological Survey**, a bureau of the U.S. Department of the Interior, has a wonderful website, whose homepage is

http://www.usgs.gov

This site is crammed full of information, including fact sheets, educational links and information, the latest in geological news, and its own search engine. There are also ways for kids to contact geologists directly.

SUGGESTED INSTRUCTIONAL PROCEDURES

Teacher Preparation

- Preview the video **EROSION AND WEATHERING.**
- Duplicate Blackline Masters 1 through 15.
- Read the descriptions of the blackline masters.

Video Summary

Weathering and erosion belong to a two-step process. The first, **weathering,** is the **breaking up** of rock at or near the surface of the earth. The next step, **erosion**, is the **transportation** of material by agents such as water, wind, ice, and/or gravity. These are separate processes, yet both are involved in the making of rock slides, valleys, caverns, canyons, balanced rocks, and arches.

Weathering may occur in two ways. **Physical weathering** is the disintegration of rock. This process retains the same characteristics of the original material. **Chemical weathering** is the process whereby the rock's internal structure is altered by removing and/or adding elements. Water is the the most important factor in this process.

Soil formation is dependent upon the combination of weathered rock particles, organic matter, and a community of plants and animals.

Next, transporting weathered rock or soil is the process of **erosion**. The effects of erosion are apparent

in the majestic rock sculptures on and below the earth's surface. These works are formed by the agents of water, gravity, ice, and wind. Groundwater creates caverns, gravity triggers rock slides, ice as glaciers moves slowly and transports stone, wind lifts fine sand to form dunes, and rivers form valleys and canyons.

Vocabulary

The following words are mentioned in the video. They are listed on **Blackline Master 3, Vocabulary**, which may be distributed to students.

carbonic acid: carbon dioxide dissolved in water

canyon: a steep-walled gorge carved by a river or stream

cavern: a group of large connected chambers located beneath the earth's surface that is large enough for a person to enter

chemical weathering: the alteration of a rock's internal structure by removing and/or adding elements which produce new minerals

dune: a ridge or hill of sand deposited by the wind

erosion: the transportation of weathered material by natural agencies

glacier: a large mass of ice formed from the recrystallization of snow which shows evidence of present or past movement.

humus: organic matter in soil produced by the decomposition of plants and animals

hurricane: a cyclonic storm having winds in excess of seventy-four miles per hour

mass wasting: a large bulk of material moving downslope caused by gravity

oxidation: the process of oxygen combining with another mineral; example: iron to form rust

physical weathering: the breaking down of rock by natural forces, such as water, wind, plants, and animals, into smaller fragments which still retain the characteristics of the original material

soil: matter composed of a combination of mineral and organic matter along with a community of plants and animals

tornado: a small cyclonic storm with very high winds

valley: a low-lying stretch of land formed by a stream or river, bordered on both sides by higher lands

Student Preparation
Materials needed:

Pen and pencil and materials for activities as follows:
Blackline Master 4, Weather or Not the School Grounds or Playground: school map is requested but not necessary
Blackline Master 6, Ghostly Silhouettes: crayons, pastels or water colors; glue, scissors, 18" x 12" black and white construction paper
Blackline Master 9, Make Your Own Sugar Stalactites: water, jar, spoon, string, measuring cup, sugar, pan, hot plate

Student Objectives
After viewing the videotape, **EROSION AND WEATHERING**, and participating in follow-up activities, students will be able to:

- Define the differences between weathering and erosion.
- List some of the mobile agents of erosion: water, wind, ice, and gravity.
- Identify weathering and erosion of rocks.
- Identify that land is constantly changing, above and below the earth's surface.
- Describe that smaller rocks come from the breakage and weathering of bedrock or larger rocks.
- Identify that soil is made up of weathered rock, organic matter, and a community of plants and animals.
- Define physical weathering, chemical weathering, and erosion.
- Identify that if soil is poor or if the climate is severe, soil could easily be eroded.
- Describe how wind, water, ice, and gravity alter the surface of the earth.
- Identify that the destructive forces of erosion and weathering are slow processes that change the surface of the earth.

These Objectives comply directly with the **National Science Education Standards** for grades 5-9 in Earth and Space Science:

Erosion and Weathering
- Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria.
- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
- Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.
- The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past.

Video Presentation
- Distribute copies of **Blackline Master 1, Know, Need, and Learn**. Cooperative groups may be used for this activity. Students brainstorm their concepts of the processes weathering and erosion and write them under the heading "What I Know." This part of the activity is designed to help the students identify what they already know and to stimulate interest in understanding weathering and erosion. Next, have the students write what they need to know in the "What I Need to Know" column. This will help the students focus on what you want them to know.

Ask the students how many of them have visited or seen pictures of the Grand Canyon. How did the canyon develop? How long did it take? Ask them if they can name other examples of the forces of nature shaping rocks. What do they think affects these processes?

• Present the video. The viewing time is 25:20.

After viewing the video, and as the students learn terms and definitions throughout the lesson, have them record their findings on the "What I Know" side of **Blackline Master 1, Know, Need, Learn**. It is important for the instructor to motivate the students to maintain a record keeping system. This sheet may be duplicated and distributed as often as necessary based upon the students' needs.

A Video Quiz immediately follows the closing credits of **Erosion and Weathering**. The questions in the Video Quiz appear on **Blackline Master 2, Quiz**, and may be used as a pre-test to gauge student comprehension before and after the video presentation. Answers to the Video Quiz appear in the Answer Key on page 14 of this guide.

FOLLOW-UP ACTIVITIES

Blackline Masters
Blackline masters are provided as the follow-up activities for this lesson. They will help you determine focal points for class discussions based on the objectives for the lesson. The activity sheets designed for this lesson on erosion and weathering have a three-fold purpose:

• To reinforce the video lesson.
• To provide an opportunity for the students to apply what they have learned from the video.
• To be used as diagnostic tools for assessing areas in which individual students need help.

1. Administer the Video Quiz immediately following the closing credits of the video. **Blackline Master 2, Quiz** lists the questions which appear in the Video Quiz and may be used as a pre-test to gauge student comprehension before and after the video presentation.

2. Distribute **Blackline Master 3, Vocabulary**. This list of pertinent vocabulary words will provide handy reference throughout the presentation of this lesson.

3. Distribute **Blackline Master 4, Weather or Not the School Grounds or Playground**. Specific examples of chemical and physical weathering are given to the students to use in their research to locate and identify weathering evidence around the school grounds.

4. Distribute **Blackline Master 5, The Investigation of Running Water**. This activity serves to identify soil erosion due to water around the school grounds. This activity is best done immediately after a rainfall or a snow melt.

5. Distribute **Blackline Master 6, Ghostly Silhouettes**. Students will create an artistic representation of eroded land forms from Arches National Park, Utah.

6. Distribute **Blackline Master 7, "My Sled-Trip on Muir Glacier" by John Muir**. This is an excerpt from John Muir's essay "My Sled-Trip on Muir Glacier." It exemplifies a genre of literature based on nature observations. This selection may be bound and be reused for other reading activities. **Blackline Master 8, John Muir's Sled-Trip on Muir Glacier** is a questionnaire based on the excerpt.

7. Distribute **Blackline Master 9, Make Your Own Sugar Stalactites**. This activity further explains the process of how caves are formed and offers a recipe to make rock candy. Note: to make rock candy takes several weeks and requires adult supervision.

8. Distribute **Blackline Master 10, Cave Decorations**. Students identify and color the formations found in a cavern that are also seen in the video. After the students have completed this sheet, play back the video to the cavern scene, turn down the audio, and have the students identify those formations on which you "pause."

9. Distribute **Blackline Master 11, A Crossword Cavern**. Students use the vocabulary words defined in the two lessons of **Erosion and Weathering** to complete the puzzle.

Projects

1. Create a class experiment on the effects of oxidation. Place an iron nail in each of the following filled glasses: a glass of distilled water, a glass of rain water, a glass of lemon juice and water, and a glass of cola. Hypothesize which nails will rust slowly, quickly, or not at all. Record daily the changes seen on the nails. Check your results.

2. Check with the city planner to locate any flood planes near the school or students' homes. Color this area in on a city map. Also on this map locate any wells, lakes, ponds, streams, swamps, or marshes in your city. Discuss the information that you mapped out.

3. Study how arches are formed. Following is a brief description of how the arches from Arches National Park, Utah, are formed:
These arches are composed of small particles of quartz sand held together by a natural cement called calcium. Rainwater, which is slightly acidic, dissolves this natural cement. The sand, therefore, is easily washed away as its calcium cement is chemically weathered. Also, water and ice break up flakes and chunks of rock along with gravity's force, causing further thinning of the rock wall. As more rock is eroded, pressures pent up within the formation release even more rock. The combined result of these processes forms an arch. Interestingly, the wind's abrasive powers with sand is limited to only a few feet above the ground.

4. Make a class mural recording the earth's ice ages. This could also be represented by a time line of the earth's history. Indicate the flora and fauna that was present during each ice age represented. Include how much of the earth's water was used at that time.

ANSWER KEY

Blackline Master 1, Know, Need, Learn
Based on the students' background and needs.

Blackline Master 2, Quiz

1. Weathering
2. In most cases, slowly.
3. One of the following is acceptable:
   a. when water collects in cracks, it freezes, expands the crack, and repeats this sequence often to the point when the rock breaks down
   b. roots of plants that penetrate rock and break it down

4. One of the following is acceptable:
   a. the oxidation of rock, as in rust
   b. the acid secreted from lichen breaking down rock
   c. when carbonic acid breaks rock down such as with caves
5. Disintegrated rock, humus or organic matter, and a community of plants and animals
6. Erosion
7. Impact and pressure; also the small stones and rocks within the wave that saw, grind, and cut away the shoreline
8. True
9. False
10. False

Blackline Master 4, Weather or Not the School Grounds or Playground
Answers will vary.

Blackline Master 5, The Investigation of Running Water
Answers will vary.

Blackline Master 8, John Muir's Sled-Trip on Muir Glacier
1. Eleven days
2. Half past ten o'clock
3. Wolves, goats, bird, ravens, hummingbird
4. The roar of water cascading down the mountain slopes, water rushing, wolves howling, a bird calling, falling stones, screaming ravens
5. Answers may vary but should contain some of the following: crossing over crevasses, one of his shoes was worn out, inflamed eyes, wet feet every night, fatigue, falling into a crevasse filled with water, spending a night shivering in his sleeping bag
6. The sun's rays
7. Water
8. The lower part of the glacier
9. Moraines of washed pebbles, like those on glacier margins, are formed by snow avalanches deposited in crevasses, then weathered out and projected on the ice as shallow, raised moraines
10. Answers will vary.

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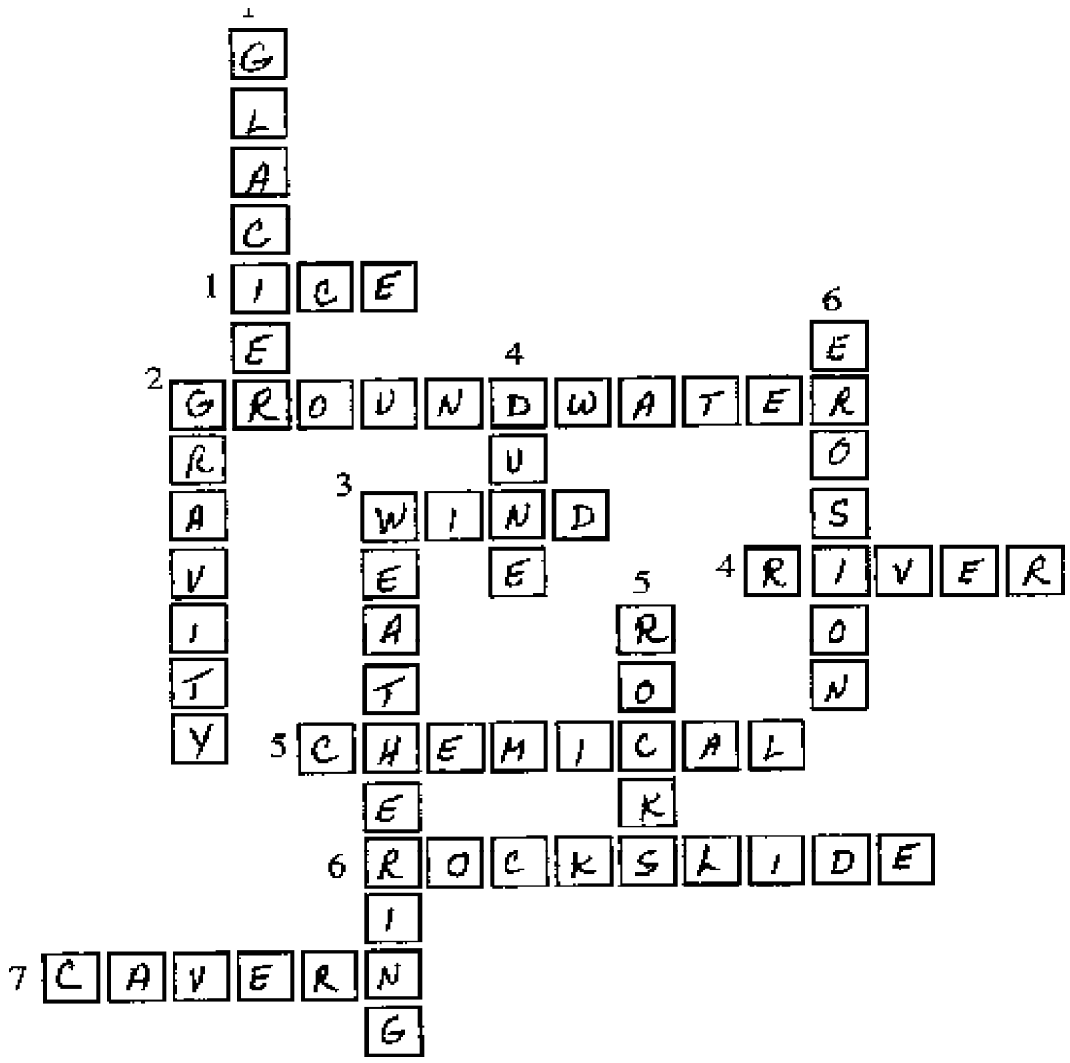
Blackline Master 11, A Crossword Cavern



OTHER APPLICABLE UNITED LEARNING TITLES

Glaciers: Nature's Conveyor Belt
Catalog #2304

Drops of Water, Grains of Sand
Catalog #2674

Script of Video Narration
Erosion and Weathering

These ghostly silhouettes of strange shape and form are all that now remain of once huge land formations.

Dwindled away over thousands of years, they serve as a constant reminder that the forces of nature are always at work, not only building up the land, but wearing it down as well.

Water, wind, ice, and even plants and animals all play their part in turning the mightiest of mountains into the tiniest grains of sand.

How does the surface of the earth wear down?

There are several major processes which cause the earth to wear down.

They are **physical weathering, chemical weathering** and **erosion.**

Each process contributes its own part in disintegrating the face of the earth.

Physical weathering is the actual breaking down of rock by the action of natural forces, such as water, wind, plants and animals.

But how do these forces wear down rock?

Here we see trees growing out of what appears to be a solid granite rock. Actually, their roots are penetrating tiny cracks in the rock. As the trees continue to grow, their roots will further extend and enlarge the cracks, eventually fragmenting the rock, just as these roots have done to this rock.

Probably the most common cause of physical weathering is due to the constant freezing and thawing of water in and around the rocks themselves.

Let's take a look at a simple experiment, which shows how liquid water expands when it turns to solid ice.

We fill this plastic measuring cup with water up to the top mark. We want to make sure that we use a plastic container and not a glass container. We'll now take our cup of water and place it in the freezer. Here, it will sit undisturbed for several hours. Later, when we view the cup, we find that the water has turned to ice, and that it has expanded almost ten percent. We note that it has increased in size both upward and outward and has actually cracked the plastic cup.

But how does freezing water effect rocks?

Water frequently collects on rocks and gets into their small openings. When temperatures drop below freezing, the water in these cracks turns to ice and expands. This exerts a tremendous amount of pressure on the openings in these rocks.

As temperatures rise and the ice melts back into its liquid form, it creeps deeper into the fractures. When the water freezes again, it further expands the openings in the rock. This cycle will go on day after day, year after year, until finally, a once huge mountainside could disintegrate to a pile of small rock fragments.

The second kind of weathering is called **chemical weathering.**

Chemical weathering causes changes in the rocks from the reaction of different chemicals on the surface of the rocks.

One common example of chemical weathering is called **oxidation.** If we were to leave an iron nail in a cup of water for a few weeks, a chemical change takes place. The nail gradually becomes coated with a dark red substance we call rust. Rust is oxidized iron.

Here we see the difference between a shiny new nail and an oxidized nail. This rusting, or oxidation, deteriorates any surface on which it reacts and will eventually cause it to break down and fall apart.

The mineral iron is present in many different kinds of rocks and oxidation can break down these rocks if they are exposed to water for long periods of time.

But are there other ways in which rocks can chemically weather?

These rocks are covered with a plant called **lichen.** They illustrate another example of how the chemical weathering process takes place. The lichen actually secrete a mild acid which can dissolve or eat away the surface of the rock.

Carbonic acid, a mild corrosive agent, can form when water and carbon dioxide combine naturally in the air or below the earth.

Underground caverns, like this, are one of the most spectacular examples of the effects of weathering caused by carbonic acid. This cavern started out as small openings below the earth's surface where water seeped in. The water combined with carbon dioxide from decaying plant material in the soil, to form carbonic acid. As this acid dissolved the rock around it, the pockets gradually grew in size.

The force of gravity, combined with underground streams, carried the dissolved rock fragments away, until finally, a huge cavern was formed. This, along with the continuous seeping water, caused the cavern formations to grow ever stranger as time passed.

Weathering is just one part of the natural breaking down process that has been occurring for millions of years.

Once rock has disintegrated into many smaller pieces, plants such as mosses take root within the rock fragments. Eventually, as the plants die, the dead plants' roots and leaves offer food for bacteria, fungi, and other microorganisms. Soon more plants and microorganisms begin to live in the soil. Next, animals such as worms, rodents, and other creatures begin to live in the soil. Often animals contribute to the soil by breaking up the soil and by adding organic matter to it. Inevitably, the plants and animals die, and later decay into the soil. The decayed remains of the living things become nutrient rich organic matter called humus. Importantly, **humus** aids in the soil's capacity to hold water and air. The water in the soil provides a solution that help plants obtain the nutrients they need for growth. The air in the soil is a source of oxygen and carbon dioxide which is necessary for the life of the microorganisms and plants. The combination of disintegrated rock, organic matter, and a community of plants and animals make up soil.

With good, nutrient-rich, fertile soil, plant life is easily supported, which in turn supports animal and human life. For the earth to produce good soil naturally, it could take over 500 years.

If soil is poorly maintained or if the climate is harsh, it could easily be washed, blown or carried away along with other weathered rock material.

This process is known as **erosion.** Water, wind, ice, and gravity serve as the great natural forces that transport the weathered material and further wear down the surface of the earth.

What is erosion's most powerful agent?

Water is the most significant force of erosion. Water erosion can happen in one of three ways. One, by lifting the loose rocks; two, by grinding the rocks; or three, by dissolving the rocks. Flowing water in the form of creeks, streams, and rivers can take vast amounts of rock fragments and transport them great distances.

A white water raft trip easily illustrates the tremendous power and force of the mighty Colorado River. Starting high in the Rocky Mountains, it carves a path through hundreds of miles, or kilometers, of the western United States.

But nowhere does it leave more evidence of its erosional power than here at the Grand Canyon National Park, considered one of the seven wonders of the natural world.

Over millions of years, the flow of the river and the continued effects of weathering has displaced huge amounts of rock fragments and debris, leaving behind this magnificent canyon, that's over two hundred miles or 300 kilometers long, ten miles or 16 kilometers wide, and over one mile or almost two kilometers deep.

It is important to realize that these erosional forces are still constantly at work digging ever deeper into the earth's surface each day.

Most flowing water eventually works its way to the oceans of the world. Oceans produce their own form of destructive force and power.

Waves beating against a coastal area can cause extensive erosion as evidenced by these sheer cliffs along the California coast.

Here at Big Sur, we can see some of nature's finest work. Although it is not easily noticed, the shoreline is constantly changing by the moving ocean waters. Waves erode rock by wave impact and pressure. Also important are the small stones and rocks within the wave that saw, grind, and cut away the shoreline.

Earlier, we saw how water, in the form of ice, could split huge boulders. But the effects of freezing water on the earth's surface can be even more dramatic than this.

Geologists believe that several times during the history of our planet, the earth experienced what are called **ice ages.**

These ice ages were periods when the earth's temperature became so cold that vast amounts of the earth's water froze. Huge sheets or mountains of ice, called **glaciers**, began to form. As the earth's temperatures continued to drop, the glaciers grew to enormous proportions.

With passing time, most of these glaciers melted, sometimes leaving behind majestic ice-carved valleys.

Yosemite Valley, in Yosemite National Park in California, is one excellent example of an ice-carved valley.

Although the huge glaciers that carved this spectacular valley have long since melted, large glaciers still exist today in some extremely cold portions of the earth.

As the seasons change, falling rain and melting ice seep into the ground and loosen the earth. Combined with the invisible force of gravity, this land can sometimes slide and separate, demonstrating one of the most sudden and powerful forms of erosion.

We call this **mass wasting.** In extreme cases, entire mountainsides can erode away in massive landslides or rock slides.

Wind is another force that can cause erosion. In some cases, tiny grains of sand can be picked up by the wind. As they are blown against rock formations, they can slowly round off and polish jagged weathered edges.

In others cases, wind can reshape large sections of the earth's surface. Sand dunes and desert floors provide very visible examples of wind erosion.

In extreme cases, like tornadoes or hurricanes, winds can reach speeds of over 100 miles or 160 kilometers per hour and cause extensive damage along with the torrents of rain and debris they carry with them.

Finally, let us not forget the erosional impact that people have on the earth's surface. For example, the waste gases from cars and industry transform rain into acid rain which has the power to corrode various substances and to dissolve concrete. Human activities, such as mining, farming, irrigation, and even dune buggying also impact the environment and increase erosion. Yet today, with increased awarenes and through the cooperative efforts of citizens, government, and industry, many of the earth's environments are carefully being restored and protected.

Nevertheless, as we continue to develop new land and further tap our natural resources, we must always ask ourselves, "What effects will our actions ultimately have on our planet?" Only time will tell.

We've seen how many of nature's forces can act upon the earth, constantly changing its surface through physical weathering, chemical weathering, and erosion.

These processes frequently act together as they break down and reshape our land–sometimes producing strange and beautiful forms.

From delicately sculpted arches, to majestic canyons and magnificent coast lines, weathering and erosion play a major role in creating the many faces of our wondrous planet Earth.

Video Quiz.
Please answer the following questions:

1. What is the name of the destructive force that breaks down rock?

2. Does erosion and weathering change the earth's surface quickly or slowly?

3. Give an example of physical weathering.

4. Give an example of chemical weathering.

5. What makes up soil?

6. What is it called when rock is washed, blown, or carried away?

7. How do waves erode rock?

Please answer the following true or false:

8. Mass wasting changes the surface of the earth quickly.

9. During the ice age, glaciers rarely eroded away any of the earth's surface.

10. Wind is another force that causes weathering.

EROSION AND WEATHERING
from the
The Basics of Geology Series

Cat. No. 2232

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EROSION AND WEATHERING

Know, Need, Learn

Directions: Use this sheet as you study Erosion and Weathering, to record what you already know, what you need to know, and what you learned about geology.

WHAT I KNOW

WHAT I NEED TO KNOW

WHAT I LEARNED

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EROSION AND WEATHERING
Quiz

Directions: Answer the following questions which appear in the Video Quiz at the end of Erosion and Weathering.

1. What is the name of the destructive force that breaks down rock?

2. Does erosion and weathering change the earth's surface quickly or slowly?

3. Give an example of physical weathering.

4. Give an example of chemical weathering.

5. What makes up soil?

6. What is it called when rock is washed, blown, or carried away?

7. How do waves erode rock?

True or False
Directions: Mark each of the following statements "T" if it is true, or "F" if it is false.

8. ____ Mass wasting changes the surface of the earth quickly.

9. ____ During the Ice Age, glaciers rarely eroded away any of the earth's surface.

10. ____ Wind is another force that causes weathering.

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EROSION AND WEATHERING
Vocabulary

The following vocabulary words are important to the study of erosion and weathering.

carbonic acid: carbon dioxide dissolved in water

canyon: a steep-walled gorge carved by a river or stream

cavern: a group of large connected chambers located beneath the earth's surface that is large enough for a person to enter

chemical weathering: the alteration of a rock's internal structure by removing and/or adding elements which produce new minerals

dune: a ridge or hill of sand deposited by the wind

erosion: the transportation of weathered material by natural agencies

glacier: a large mass of ice formed from the recrystallization of snow which shows evidence of present or past movement.

humus: organic matter in soil produced by the decomposition of plants and animals

hurricane: a cyclonic storm having winds in excess of seventy-four miles per hour

mass wasting: a large bulk of material moving downslope caused by gravity

oxidation: the process of oxygen combining with another mineral; example: iron to form rust

physical weathering: the breaking down of rock by natural forces, such as water, wind, plants, and animals, into smaller fragments which still retain the characteristics of the original material

soil: matter composed of a combination of mineral and organic matter along with a community of plants and animals

tornado: a small cyclonic storm with very high winds

valley: a low-lying stretch of land formed by a stream or river, bordered on both sides by higher lands

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EROSION AND WEATHERING
Weather or Not the School Grounds or Playground

The process that breaks down rocks is called **weathering**.

There are two types of weathering:

1. **Physical weathering** is when a rock is broken into smaller and smaller pieces. This process could be a result of the following:
   a. Alternating water's freezing and thawing action.
   b. Plant roots wedging the rock apart.
   c. Burrowing animals moving soil and rocks.
   d. The breaking up of rock due to human activity.

2. **Chemical weathering** is when the rocks change due to different chemical reactions. This process could be a result of one of the following:
   a. When water and iron oxidize and become rust.
   b. When a mild acid from rain water deteriorates the rock, paint, or building's surface.

Explore your school's grounds and playground looking for the effects of weathering. Record (1) what is weathered; (2) what type of weathering was involved: physical or chemical. Use the above information to help with your identification.

WHAT IS WEATHERED	WHAT TYPE OF WEATHERING

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EROSION AND WEATHERING
The Investigation of Running Water

Directions: During or after a rainfall or a snow melt, locate the water's paths around your school grounds and playground. Note any effects it might have produced.

1. Is there any evidence of soil erosion? Where?

2. Was any soil, pebbles, trash, or plant life transported by the water? Please be specific.

3. How much soil or debris did the water deposit in areas that before were cleared of such materials?

4. Next, record the water's paths on a map of the school grounds. If no map is available, use the back of this sheet for the map. If present, record any slopes and plant life around your school grounds.

5. To where and into what did the water eventually disappear? Why?

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EROSION AND WEATHERING

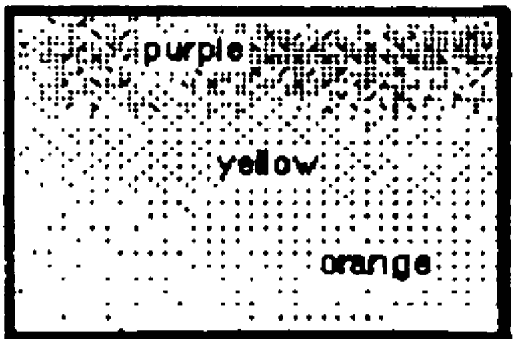
Ghostly Silhouettes

Make your own ghostly silhouettes by following these directions:

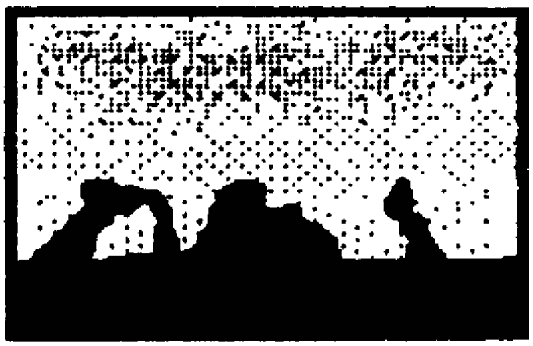
Materials: black construction paper 18" x 12"
white construction paper 18" x 12"
scissors
glue
pencil
crayons, pastels, or water colors

Background: Position your white construction paper horizontally on your desk. First, make the twilight sky. With long horizontal strokes, lay a medium to light purple sky at the top third portion of the paper. Color the middle third of the paper with yellow horizontal strokes. Carefully blend some of the yellow into the light purple strokes. Color the bottom third of the paper with light strokes of orange, blending some into the yellow.

Foreground: Sheet 6a displays eroded landforms of Arches National Park, Utah. Cut out the forms or design your own rock formations. Next, lightly draw a horizon line lengthwise, three inches from the edge of the black construction paper. Arrange your landforms on the horizon line. Lightly trace the shapes of the forms onto the black paper. Erase the horizon line that touches any of your landforms. Carefully cut on the lines that shape your landforms and the horizon. Erase any pencil marks. Glue this cut-out at the base of your background. Display your work for all to see.



background



foreground over background

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6a

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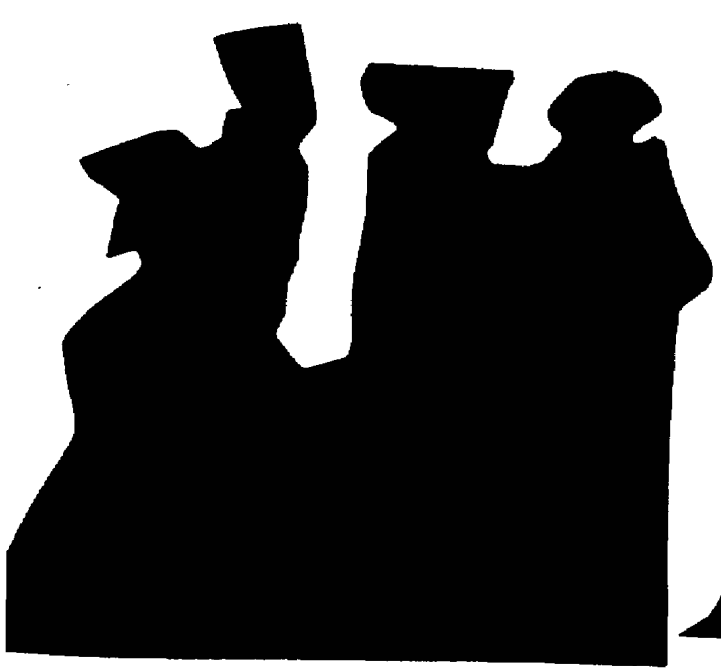
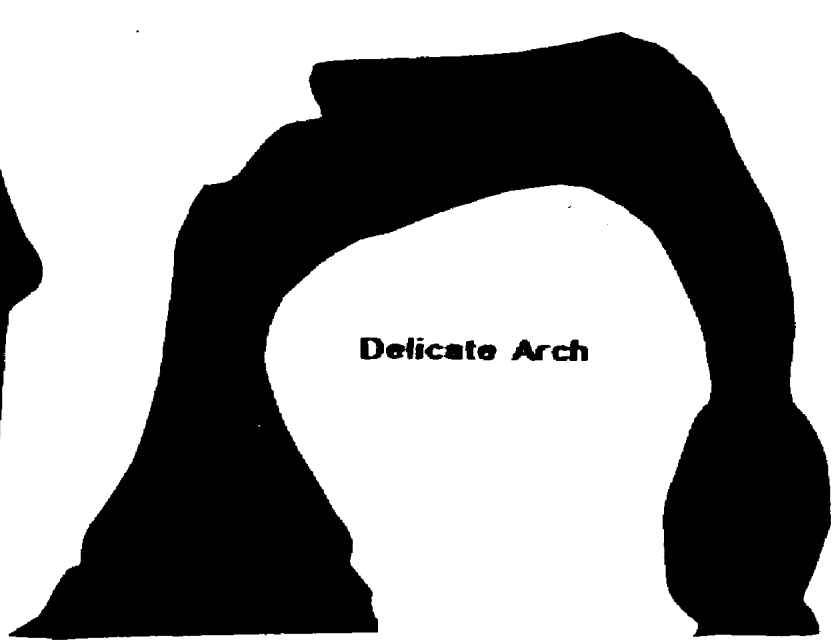
Date _____

EROSION AND WEATHERING
Landforms from Arches National Park





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EROSION AND WEATHERING

John Muir is recognized as one of America's pioneer glaciologists. His persistent research of Yosemite Valley's origins led him to be the first to promote the concept that Yosemite was carved by a glacier and was not formed by a cataclysmic phenomenon. John Muir studied glaciers in the state of Alaska, United States of America, between 1879-1899. Following are excerpts from Muir's records of his exploration of the Alaskan glacier named after him, Muir Glacier.

My Sled-Trip On Muir Glacier
by John Muir
Page One

Excerpted from " My Sled-Trip on Muir Glacier"
Mountaineering Essays by John Muir
Gibbs-Smith Publisher: Peregrine Smith Books, Salt Lake City, Utah

My Sled-Trip on the Muir Glacier

I started off the morning of July 11 on my memorable sled-trip to obtain general view of the main upper part of the Muir Glacier, and its seven principal tributaries, feeling sure that I would learn something. . . My sled was about three feet long and made as light as possible. A sack of hardtack, a little tea and sugar, and a sleeping-bag were firmly lashed on it so that nothing could drop off however much it might be jarred and dangled in crossing crevasses.

Two Indians carried the baggage over the rocky moraine to the clear glacier at the side of one of the eastern Nunatak Islands. Mr. Loomis accompanied me to this first camp and assisted in dragging the empty sled over the moraine. We arrived at the middle Nunatak Island about nine o'clock. Here I sent back my Indian carriers, and Mr. Loomis assisted me the first day in hauling the loaded sled to my second camp at the foot of Hemlock Mountain, returning the next morning.

July 13. I skirted the mountain to eastward a few miles. . . When the ice-period was in its prime much of the Muir Glacier that now flows northward into Howling Valley flowed southward into Glacier Bay as a tributary of the Muir. I had a hard time crossing the Divide Glacier, on which I camped. I slept fairly well on the sled. I heard the roar of four cascades on a shaggy green mountain on the west side of Howling Valley and saw three wild goats fifteen hundred feet up in the steep, grassy pastures.

July 14. I rose at four o'clock this cloudy and dismal morning and looked for my goats, but saw only one. I thought there must be wolves where there were goats, and in a few minutes heard their low, dismal, far-reaching howling. One of them sounded very near and came nearer until it seemed to be less that a quarter of a mile away on the edge of the glacier. They had evidently seen me, and one or more had come down to observe me, but I was unable to catch sight of any of them. After waiting half an hour or so to see what these wild dogs meant to do, I ventured to proceed on my journey to the foot of Snow Dome, where I camped for the night.

It is now half past ten o'clock and getting dusk as I sit by my little fossil-wood fire writing these notes. A strange bird is calling and complaining. A stream is rushing into a glacier well on the edge of which I am camped, back a few yards from the base of the mountain for fear of falling stones. A few small ones are rattling down the steep slope. I must go to bed.

July 15. I climbed the dome to plan a way, scan the glacier, and take bearings, etc., in case of storms. The flow of water on the glacier noticeably diminished last night though there was no frost. It is now already increasing. Stones begin to roll into the crevasses and into new positions, sliding against each other, half turning over or falling on moraine ridges. How often and by how many ways are boulders finished and finally brought to anything like permanent form and place in beds for farms and fields, forests and gardens. Moraines of washed pebbles, like those on glacier margins, are formed by snow avalanches deposited in crevasses, then weathered out and projected on the ice as shallow, raised moraines. There is one such at this camp.

I got back to camp at 7:15, not tired. After my hardtack supper I could have climbed the mountain again and got back before sunrise, but dragging the sled tires me. I have been out on the glacier examining a moraine-like mass about a third of a mile from camp.

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EROSION AND WEATHERING

My Sled-Trip On Muir Glacier

by John Muir

Page Two

To shorten the return journey I was tempted to glissade down what appeared to be a snow-filled ravine, which was very steep. All went well until I reached a bluish spot which proved to be ice, on which I lost control of myself and rolled into a gravel talus at the foot without a scratch. Just as I got up and was getting myself orientated, I heard a loud fierce scream, uttered in an exulting, diabolical tone of voice which startled me, as if an enemy, having seen me fall, was glorying in my death. Then suddenly two ravens came swooping from the sky and alighted on the jag of a rock within a few feet of me, evidently hoping that I had been maimed and that they were going to have a feast. But as they stared at me, studying my condition, impatiently waiting for bone-picking time, I saw what they were up to and shouted, "Not yet, not yet!"

July 16. At 7 A.M. I left camp to cross the main glacier. This is one of the loveliest mornings I ever saw in Alaska; not a cloud or faintest hint of one in all the wide sky.

Most of the ice-surface crossed to-day has been very uneven, and hauling the sled and finding a way over hummocks has been fatiguing. At times I had to lift the sled bodily and to cross many narrow, nerve-trying, ice-sliver bridges, balancing astride of them, and cautiously shoving the sled ahead of me with tremendous chasms on either side. I had made perhaps not more than six or eight miles in a straight line by six o'clock this evening when I reached ice so hummocky and tedious I concluded to camp and not try to take the sled any farther. I intend to leave it here in the middle of the basin and carry my sleeping-bag and provisions the rest of the way across to the west side. I am cozy and comfortable here resting in the midst of glorious icy scenery, though very tired. I crept into my sack before eight o'clock as the wind was cold and my feet wet. One of my shoes is about worn out. I may have to put on a wooden sole. This day has been cloudless throughout, with lovely sunshine, a purple evening and morning. Now the sun is down and the sky is saffron yellow, blending and fading into purple around to the south and north. It is a curious experience to be lying in bed writing these notes.

July 17. Another glorious cloudless day is dawning in yellow and purple and soon the sun over the eastern peak will blot out the blue peak shadows and make all the vast white ice prairie sparkle. I slept well last night in the middle of the icy sea. My heavy, thick-soled shoes, resoled just before starting on the trip six days ago, are about worn out and my feet have been wet every night. But no harm comes of it, nothing but good. I succeeded in getting a warm breakfast in bed. Thus refreshed, I surveyed the wilderness of crevassed, hummocky ice and concluded to try to drag my little sled a mile or two farther, then, finding encouragement, persevered, getting it across innumerable crevasses and streams and around several lakes and over and through the midst of hummocks, and at length reached the western shore between five and six o'clock this evening, extremely fatigued. This I consider a hard job well done, crossing so wildly broken a glacier, fifteen miles of it from Snow Dome Mountain, in two days with a sled weighing altogether not less than a hundred pounds. I found innumerable crevasses, some of them brimful of water. I crossed in most places just where the ice was close pressed and welded after descending cascades and was being shoved over an upward slope, thus closing the crevasses at the bottom, leaving only the upper sun-melted beveled portion open for water to collect in.

Much of the water caught in tight crevasses doubtless freezes during the winter and gives rise to many of the irregular veins seen in the structure of the glacier. Saturated snow also freezes at times and is incorporated with the ice, as only from the lower part of the glacier is the snow melted during the summer. I have noticed many traces of this action. One of the most beautiful things to be seen on the glacier is the myriads of minute and intensely brilliant radiant lights burning in rows on the banks of streams and pools and lakelets from the tips of crystals melting in the sun, making them look as if bordered with diamonds. These gems are rayed like stars and twinkle; no diamond radiates keener or more brilliant light.

I am camped to-night on what I call Quarry Mountain from its raw, loose, plantless condition, seven or eight miles above the front of the glacier. I found enough fossil wood for tea. I have had a glorious and instructive day, but am excessively weary and to bed I go.

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EROSION AND WEATHERING

My Sled-Trip On Muir Glacier

by John Muir

Page Three

July 18. I felt tired this morning and meant to rest to-day. But after breakfast 8 A.M. I felt I must be up and doing, climbing sketching new views up the great tributaries from the top of Quarry Mountain. Weariness vanished and I could have climbed, I think, five thousand feet. Anything seems easy after sled-dragging over hummocks and crevasses, and the constant nerve-strain in jumping crevasses so as not to slip in making the spring. Quarry Mountain is cut across into a series of parallel ridges by oversweeping ice. It is still overswept in three places by glacial flows a half to three quarters of a mile wide, finely arched at the top of the divides. I have been sketching, though my eyes are much inflamed and I can scarce see. All the lines I make appear double. I fear I shall not be able to make the few more sketches I want to-morrow, but must try. The day has been gloriously sunful, the glacier pale yellow toward five o'clock. The hazy air, white with a yellow tinge, gives an Indian-summerish effect. Now the blue evening shadows are creeping out over the icy plan, some ten miles long, with sunny yellow belts between them. Boulders fall now and again with dull, blunt booming, and the gravel pebbles rattle.

July 19. Nearly blind. The light is intolerable and I fear I may be long unfitted for work. I have been lying on my back all day with a snow poultice bound over my eyes. Every object I try to look at seems double; even the distant mountain-ranges are double, the upper an exact copy of the lower, though somewhat faint. This is the first time in Alaska that I have had too much sunshine. About four o'clock this afternoon, when I was waiting for the evening shadows to enable me to get nearer the main camp, where I could be more easily found in case my eyes should become still more inflamed and I should be unable to travel, thin clouds cast a grateful shade over all the glowing landscape, I gladly took advantage of these kindly clouds to make an effort to cross the few miles of the glacier that lay between me and the shore of the inlet. I made a pair of goggles but am afraid to wear them. Fortunately the ice here is but little broken, therefore I pulled my cap well down and set off about five o'clock. I got on pretty well and camped on the glacier in sight of the main camp, which from here in a straight line is only five or six miles away. I went ashore on Granite Island and gleaned a little fossil wood with which I made tea on the ice.

July 20. I kept wet bandages on my eyes last night as long as I could, and feel better this morning, but all the mountains still seem to have double summits, giving a curiously unreal aspect to the landscape. I packed everything on the sled and moved three miles farther down the glacier, where I want to make measurements. Twice to-day I was visited on the ice by a hummingbird, attracted by the red lining of the bear-skin sleeping-bag.

I have gained some light on the formation of gravel-beds along the inlet. The material is mostly sifted and sorted by successive rollings and washing along the margins of the glacier tributaries, where the supply is abundant beyond anything I ever saw elsewhere.

It has been cloudy mostly to-day, though sunny in the afternoon, and my eyes are getting better. The steamer Queen is expected in a day or two, so I must try to get down to the inlet to-morrow and make signal to have some of the Reid party ferry me over.

Near the front of the glacier the ice was perfectly free, apparently, of anything like a crevasse, and in walking almost carelessly down it I stopped opposite the large granite Nunatak Island, thinking that I would there be partly sheltered from the wind. I had not gone a dozen steps toward the island when I suddenly dropped into a concealed water-filled crevasse, which on the surface showed not the slightest sign of its existence. This crevasse like many others was being used as the channel of a stream. Into this I suddenly plunged, after crossing thousands of really dangerous crevasses, but never before had I encountered a danger so completely concealed. Down I plunged over head and ears, but of course bobbed up again, and after a hard struggle succeeded in dragging myself out over the farther side. Then I pulled my sled over close to Nunatak cliff, made haste to strip off my clothing, threw it in a sloppy heap and crept into my sleeping-bag to shiver away the night as best I could.

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by John Muir

Page Four

July 21. Dressing this rainy morning was a miserable job, but might have been worse. After wringing my sloppy underclothing, getting it on was far from pleasant. My eyes are better and I feel no bad effect from my icy bath.

I have had a fine telling day examining the ruins of the old forest of Sitka spruce that no great time ago grew in a shallow, mu-filled basin near the southwest corner of the glacier. The valley has been washed out by the stream now occupying it, one of the glacier's draining streams a mile long or more and an eighth of a mile wide.

I got supper early and was just going to bed when I was startled by seeing a man coming across the moraine, Professor Reid, who had seen me from the main camp and who came with Mr. Loomis and the cook in their boat to ferry me over. I had not intended making signals for them until to-morrow but was glad to go. I had a good rest and sleep and leisure to find out how rich I was in new facts and pictures and how tired and hungry I was.

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EROSION AND WEATHERING

John Muir's Sled-Trip on Muir Glacier

Directions: Answer the following questions, based on <u>My Sled Trip on Muir Glacier</u> by John Muir:

1. How many days was John Muir exploring the Muir Glacier and its tributaries? _____

2. At what time did John Muir record the sky getting dusk?_____

3. List the types of wildlife seen on or near the glacier:

_____

_____

4. What sounds did John Muir hear near his camps? _____

_____

5. What were some of the problems John Muir overcame on his sled-trip? _____

_____

_____

6. What could have been the cause of Jon Muir's inflamed eyes? _____

_____

7. What did John Muir find in most crevasses? _____

8. According to John Muir, which part of the glacier melts during the summer?

_____

9. Describe a moraine and how they are made. _____

_____

_____

10. If you had an opportunity to explore one of nature's great creations, what would you explore and why would you explore it? Write your answer on back of sheet.

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EROSION AND WEATHERING
Make Your Own Sugar Stalactites

Directions: This simple recipe requires adult supervision.

Water from rain and melting snow moves into three different directions. Some of it sinks into the ground. Some of it may flow to become streams and lakes. Evaporation and plant transpiration returns the rest into the atmosphere.

Gravity is the principal force that filters the water down through the soil. Some of the water resurfaces as springs. What continues into the ground fills all spaces deep below the earth's surface. This level of water placement is called the water table.

When large amounts of a particular rock called limestone is found below the water table, a gas called carbon dioxide (CO_2) combines with water to form an acid that slowly dissolves the limestone. When the water table lowers, gravity forces the dissolved limestone out of its space, thus forming a gap called a cavern.

In the cavern, acid in the water continues to pass over the limestone, dissolving it into small particles. As the open space in the cavern evaporates the water, the small particles are deposited to form interesting shapes. Formations, such as stalactites, stalagmites, and columns are a result of this process. This process is also followed when making rock candy.

How To Make Your Own Sugar Stalactites

Materials:
- water
- jar
- spoon
- string
- pencil
- measuring cup
- sugar
- pan
- hot plate

1. Boil a cup of water. Put four teaspoons of sugar in the water. Mix until sugar dissolves. Keep adding sugar until no more will dissolve.

2. Let cool. When cool, pour it into the jar. Tie a knotted string to the pencil. Put the pencil across the mouth of the jar. Let the string hang down into the solution for several weeks.

3. Draw pictures each week to record the process of what happens as the water evaporates.

4. Enjoy eating your results.

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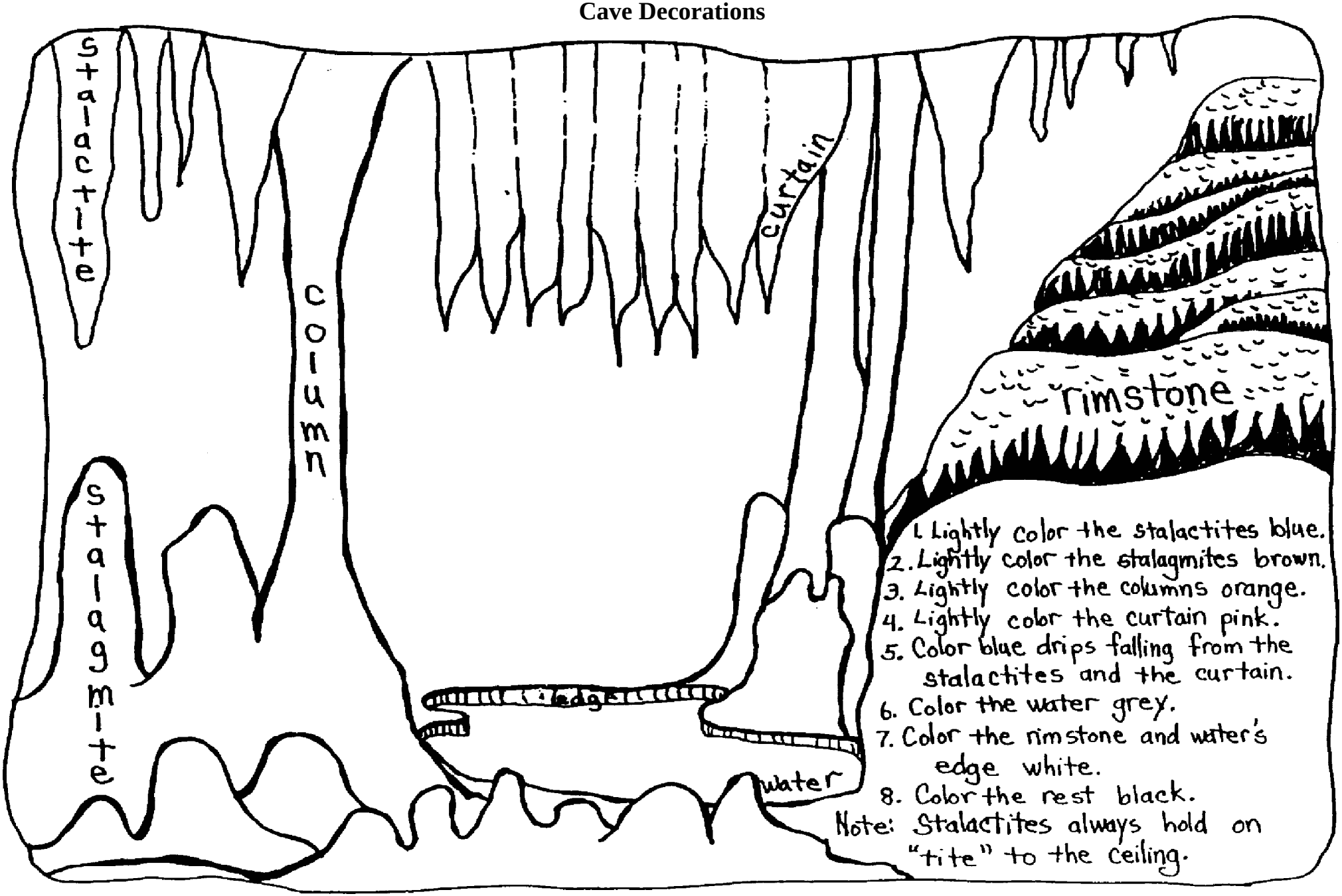
EROSION AND WEATHERING

Cave Decorations



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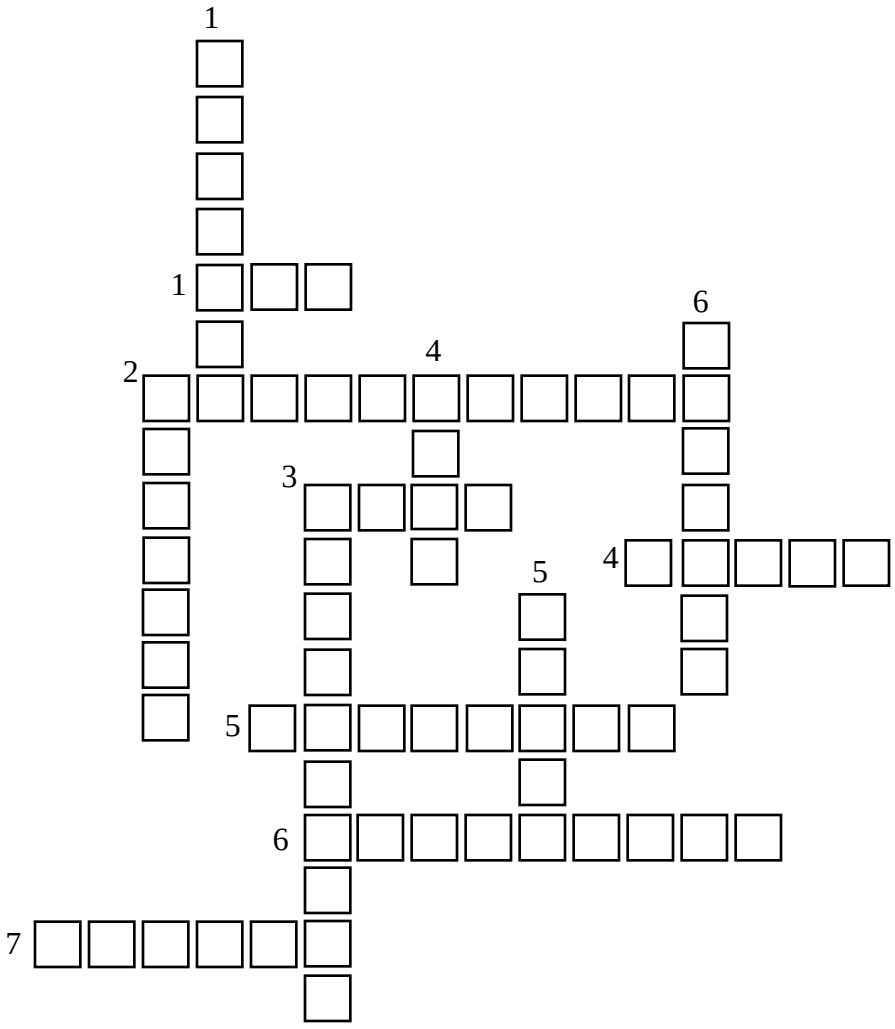
EROSION AND WEATHERING
A Cavern Crossword



Across:
1. The solid form of water that breaks rocks.
2. Water found below the earth's surface.
3. Sand dunes are formed by this erosional force.
4. The name of the flowing water that is responsible for cutting valleys and forming canyons.
5. The kind of weathering that chemically changes rock.
6. Downward rapid movement of rocks resulting in mass wasting.
7. Large underground opening formed by weathering and erosion.

Down:
1. A large thick mass of ice that moves.
2. A natural force that causes rocks to fall or roll downhill.
3. The name of the process that breaks down rocks.
4. A hill of sand deposited by the wind.
5. Solid, inorganic matter found in the earth that breaks down when weathered.
6. The transportation of material by water, wind, ice, or gravity.

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