

# CAVES AND KARST

An educational curriculum  
guide on cave and karst  
resources.

## All Related Lessons



Prepared by the National Park Service  
and their partners at the  
University of Colorado at Denver.



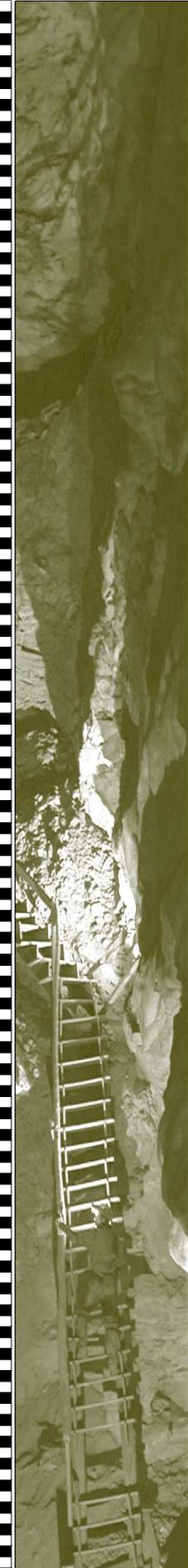
# Foreword

“Views of the National Parks” (Views) is a multimedia education program that presents stories of the natural, historical, and cultural wonders associated with America’s parks. Through the use of images, videos, sounds and text, Views allows the public to explore the national parks for formal and informal educational purposes. By employing the resources of the parks for educational purposes we hope to increase public awareness, interest and appreciation of our parks, while helping to satisfy the need for authentic education.

Nationwide interest of the National Parks makes them an easy fit into the growing demand for more authentic and meaningful curricula. In fact, “virtually all the standards documents that have been published over the past decade entreat teachers to involve students in tangible, genuine, authentic, real-world materials and experiences.”<sup>1</sup> The motivation for creating educational curriculum guides that support the Views Program was to connect formal educational topics to real-world experiences, and to offer students a real world connection to standards-based curricula.

This educational curriculum guide was designed to compliment the View’s Caves and Karst Knowledge Center, and the intended audience is students at the middle and high school grade levels. This guide aligns national park resources pertaining to caves and karst with National Education Standards through the use of interactive inquiry-based activities and instructional lesson plans. There are teacher

<sup>1</sup> Best Practice: *New Standards for Teaching and Learning in America’s Schools*; 2nd Edition. Zemelman, Daniels, and Hyde. Copyright 1998 by S. Zemelman, H. Daniels, and A. Hyde.



copies and answer keys for all applicable activities. This guide was developed as an introduction to caves and karst, and the activities, although designed as a unit, may be used independently at a teacher's discretion. Some activities were adapted from existing cave and karst educational resources. In these instances, a reference is provided to the original activity.

This curriculum guide was developed by Kristen Lucke with the support from the rest of the Views team: Bruce Nash, David Krueger, and Erika Matteo. We would like to thank the following people who helped contribute to this project: Mike Marlow, a professor at the University of Colorado at Denver, for providing professional and educational support; Ron Kerbo, the NPS Cave Coordinator, and Jim F. Wood from the Geologic Resources Division of the National Park Service for providing support and subject-matter expertise; and Andrea Croskey for taking time to review and edit this curriculum guide.

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NPS Photo by Rick Wood



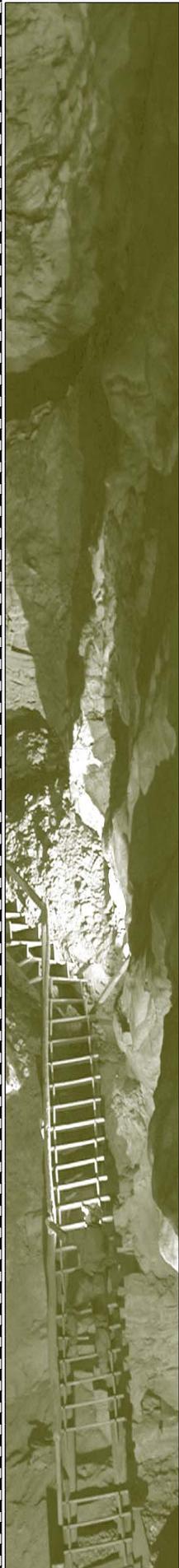
# Caves and Karst: Interactive Reading Guide #1

**Lesson Objective:** This interactive reading guide was developed to compliment the “Views of the National Parks” Knowledge Center for Caves and Karst, and the design of this guide will help students focus their attention on key concepts as they are introduced to cave and karst resources.

**Key Concepts:** cave basics, karst basics, cave and karst locations, types of caves, processes that form caves and karst, cave and karst formation, and the environment conditions inside a cave.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students



NPS Photo by Rick Wood

## Interactive Reading Guide #1

# Teacher Copy and Answer Key

# CAVES AND KARST

(To compliment the NPS Views Caves and Karst Knowledge Center)

## Interactive Reading Guide #1

Interactive reading guides are excellent strategies to use when assisting students in productive reading. They allow students to find the essential ideas within a text without being distracted by large amounts of information. Students who may find it difficult to differentiate key ideas from the supporting detail benefit from the clues and guidance of reading guides. Essentially, interactive reading guides are developed to assist students with text materials that may be too difficult for independent reading.<sup>1</sup>

This particular interactive reading guide has been developed to supplement the “Views of the National Parks” (Views) Knowledge Center for Caves and Karst, and the design of this guide will help students focus their attention as they interact with the Caves and Karst module. The introduction segment of this module is an excellent way to introduce students to cave and karst topics, and this guide has been developed in order to maximize their learning of key topics.

The instructor can download the Views DVD to the school’s public server, or if the instructor does not have a DVD they can have the students access the Knowledge Center via the internet.

**Enter the knowledge center by clicking on the “Explore Caves and Karst” link.**

**[Click on the link to Cave Basics](#)**

**1. How does the Federal Cave Resource Protection Act of 1988 define a cave?**

***“ANY NATURALLY OCCURRING VOID, CAVITY, RECESS, OR SYSTEM OF INTERCONNECTED PASSAGEWAYS BENEATH THE SURFACE OF THE EARTH.”***

**2. True or False: Caves can be filled with air, but not water. Circle one: True  False**

**3. What are 4 things that can be housed within a cave?**

- ***FRAGILE MINERAL FORMATIONS***
- ***RARE FLORA AND FAUNA***
- ***IRREPLACEABLE ARTIFACTS***
- ***DISTINCTIVE FOSSILS***

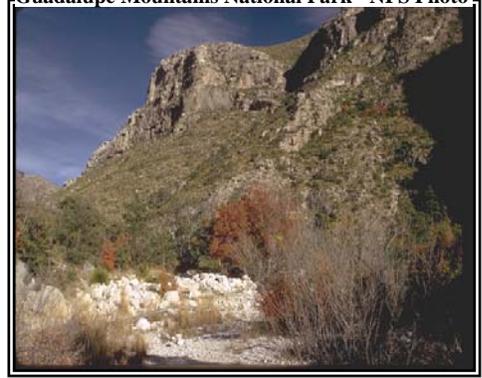
<sup>1</sup> Source: [Classroom Strategies for Interactive Learning](#), 2<sup>nd</sup> Edition. Written by Doug Buehl; Copyright 2001 by the International Reading Association, Inc.

## TEACHER COPY AND ANSWER KEY

### What is karst?

Karst is a type of topography. If we think of topography as the different features in a landscape, then karst landscapes are characterized as being formed on limestone, gypsum, and other types of rocks that dissolve in natural acid.

Guadalupe Mountains National Park - NPS Photo



[Click on the link to Karst Basics](#)

1. What type of topography does karst describe? What happens to streams in karstic areas?

*KARST DESCRIBES LANDSCAPES CHARACTERIZED BY CAVES, SINKHOLES, AND UNDERGROUND DRAINAGE.*

*IN KARSTIC LANDSCAPES, STREAMS DISAPPEAR INTO THE GROUND AND REAPPEAR ELSEWHERE AS LARGE SPRINGS.*

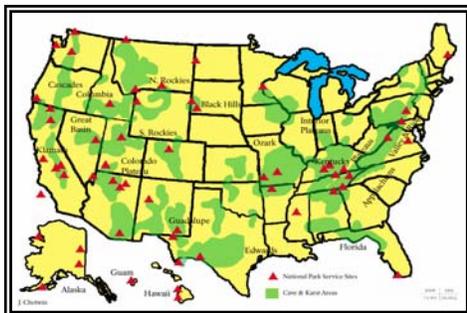
2. Name 5 surface features that are found in regions with karst:

- *VALLEYS*
- *PLATEAUS*
- *TOWERS*
- *PINNACLES*
- *PONDS*

3. Name 3 components of a drainage network:

- *CAVES*
- *FRACTURES*
- *PARTINGS*

NPS Map - Cave and Karst Locations in the USA

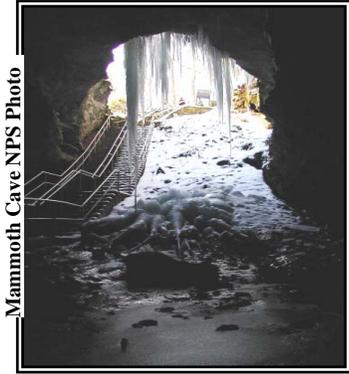


### Where are Caves and Karst?

Now that you know the cave and karst basics, let's learn about where they are found. Karst landscapes are found just about everywhere on Earth: frigid tundra, dry deserts, and tropical jungles. In temperate & tropical climates flowing water dissolves rocks. In arid environments, sulfuric acid can dissolve rocks and form caves.

[Click on the link to Cave and Karst Locations](#)

1. What portion of the landscapes in the United States is karstic? *1/5 (A FIFTH OF THE LANDSCAPE)*



## Types of Caves

There are many different types of caves that can form in many different types of locations: there are long caves, deep caves, caves that form in the desert, and caves that form near the sea.

[Click on the link to Types of Caves](#)

1. What is the longest cave? MAMMOTH CAVE
2. Where is the longest cave located? KENTUCKY
3. The deepest cave in the world is the KRUBERA (VORONJA) cave.
4. How many types of caves are there? 23

(Hint: you have to click on the “next->” link)

## What Processes Form Caves and Karst?

[Click on the link to Cave and Karst Formation](#)

(Use the link to the glossary to fill in the following blanks)

Caves are typically formed in rocks through processes like *dissolution* and *carbonation*. *Dissolution* is the act or process of DISSOLVING. If an area is warm and humid there is more water available to dissolve rock, increasing the rate of erosion and cave formation. Carbonate rocks are those that primarily consist of CARBONATE minerals. Specifically, carbonate rocks are SEDIMENTARY rocks, and go through a process called “*carbonation*”. *Carbonation* is an activity of chemical WEATHERING. It is a CHEMICAL reaction of carbonic acid in rainwater, soilwater, and groundwater, with MINERALS. *Carbonation* most strongly affects carbonate minerals and rocks, such as LIMESTONE and MARBLE.

## *Different Ways that Caves and Karst Form*

Caves and karst can form in many different ways. They can form in areas where abundant rainfall increases the rate of dissolution and carbonation. Although this type of formation is common, it is not the only way to form caves and karst. Other processes are at work forming caves and changing karstic landscapes. The following examples are common ways that caves and karst are forming all around us.

[Click on the link to Cave and Karst Formation](#)

(Use the “next ->” link to see different ways that caves and karst form)

### **1. Collapse**

• Collapse is part of cave \_\_\_\_\_ *FORMATION* \_\_\_\_\_ and \_\_\_\_\_ *EVOLUTION* \_\_\_\_\_.

• When do the ceilings of cave rooms and passages collapse?

*WHEN THEY BECOME TOO WIDE TO SUPPORT THE BEDROCK OVERLYING THEM*

• The ceilings of water-filled caves may be supported by the buoyant force of the water inside.

If this water drains out, why is there a greater potential for the cave to collapse?

*BECAUSE THE BUOYANT FORCE IS NO LONGER PRESENT TO HELP SUPPORT A CAVE'S CEILING.*

### **2. Solution Caves**

• *Finish the following paragraph:*

Earth movements cause cracks to form in the *bedrock*, which is the solid rock below the surface. These cracks, which are natural pipelines for water to seep into the ground, are called \_\_\_\_\_ *FRACTURES* \_\_\_\_\_ and \_\_\_\_\_ *JOINTS* \_\_\_\_\_. When the water mixes with the natural acids in the ground, rocks such as limestone are dissolved.

• What remains after the dissolved particles are carried away with the water?

*HOLLOW SPACES*

• **WHERE** does most cave formation and enlargement take place, and **WHY** is the circulation and dissolution of bedrock greatest at this place?

*FORMATION AND ENLARGEMENT TAKES PLACE AT OR JUST BELOW THE WATER TABLE;  
THE CIRCULATION IS GREATEST HERE BECAUSE FRACTURES ARE CONNECTED AND MOST OPEN.*

### 3. Lava Caves

- What is another name for a lava cave? LAVA TUBE

• Finish the following paragraph:

When molten, fluid LAVA flows out of a volcano, it works its way downhill. In contact with AIR, the surface of this lava stream cools and hardens into a CRUST. The lava inside remains MOLTEN, however, and continues to FLOW downhill. When the molten lava eventually DRAINS out of the interior of the hard-crust passage, a lava TUBE or CAVE remains.

### 4. Talus Caves



Devils Postpile National Monument-  
NPS Photo

- Rockslides and rockfalls produce piles of irregular shaped rocks and boulders. The spaces between these rocks are sometimes big enough to produce a cave-like configuration.

What is the name for these piles of rocks?

TALUS

- Because these types of caves can be formed when rocks break off and fall or slide into narrow canyons, talus caves are also referred to as:

BREAKDOWN CAVES

### 5. Sea Caves

- What are sea caves?

SEA CAVES ARE CLEFTS OR CAVITIES IN THE BASES OF CLIFFS AT THE EDGES OF LARGE BODIES OF WATER, TYPICALLY THE SEA BUT ALSO LARGE LAKES.

• Finish the following sentence about the formation of sea caves:

The action of WAVES pounding against rocks that line the shores of OCEANS and large LAKES form sea caves.

## TEACHER COPY AND ANSWER KEY

### 6. Ice Caves

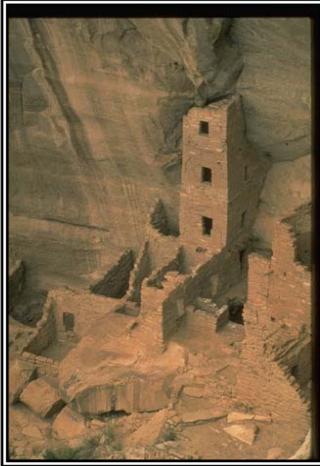
- Ice caves that form in ice are also called:

*GLACIER CAVES*

- Ice caves that are formed in rock that contain ice all year round are also referred to as:

*FROZEN CAVES*

### 7. Sandstone Caves



Mesa Verde National Park  
NPS Photo

- Early people used sandstone caves for *SHELTER*

Why?

*SANDSTONE CAVES ARE USUALLY SHALLOW AND ARE EASILY ACCESSIBLE.*

- Define *contact*: *GEOLOGICALLY SPEAKING, CONTACT IS THE SURFACE BETWEEN 2 TYPES OR AGES OF ROCKS.*

- Fluids, like groundwater, move through sandstone, easily. However, when the water reaches a layer of shale, it cannot pass through because the pore spaces are too small.

When this happens, what is groundwater forced to do?

*THE GROUNDWATER IS FORCED TO MOVE Laterally along the contact between the two rock units until it seeps out on the face of the canyon wall or at the back of an alcove, creating a spring or seep.*

### 8. Tectonic Caves

*Finish the following sentence about the formation of tectonic caves:*

The action of \_\_\_\_ *EARTHQUAKES* \_\_\_\_ form natural \_\_\_\_ *CRACKS* \_\_\_\_ in rock that can be considered \_\_\_\_ *CAVES* \_\_\_\_.



Wupatki National Monument - NPS Photo

## Inside a Cave

[Click on the "Inside a Cave" link](#)

Carlsbad Caverns National Park – NPS Photo



What do you see when you step into a cave? What do you hear? If you are near the entrance of the cave you may see bats flying in and out. You may also hear the trickling of water as it drips down the cave walls. Although, there are times that you don't see anything at all. In fact, sometimes you don't hear anything either. Stepping inside a cave is almost like stepping into another world. The following exercises are meant to help you understand what's going on inside a cave when the lights go out.

### DARKNESS

If you turn the lights out in a room, chances are your eyes will eventually adjust and you will start to see vague images of what's around you. In a cave, this may or may not be true depending on where you are. If you are near the entrance, light from outside the cave helps you to see what's around you. However, if you are in the DARKZONE, light from the outside doesn't reach you and you are in complete darkness.

• Is the following statement true or false?

Circle one: TRUE

or

FALSE

*If you are in the **darkzone** of a cave, your eyes will eventually adjust to the blackness and you will be able to see your hand if your hold it up close to your face.*

• What are 3 reasons these worlds without sunlight are important?

1. **CAVES CHALLENGE OUR ASSUMPTIONS ABOUT ECOSYSTEMS AND LIFE.**
2. **CAVES PROVIDE A SENSE OF DISCOVERY.**
3. **CAVES OPEN UP NEW AVENUES IN RESEARCH AND SCIENCE.**

## TEACHER COPY AND ANSWER KEY

### SILENCE

In general, what kinds of worlds are caves? *SILENT*

What is an example of a sound you may hear in a cave? *DRIPPING WATER*

### TEMPERATURE

The daily and seasonal fluctuations that we experience on the surface of the Earth are not seen inside a cave. This is because any change in temperature on the surface fades as heat passes through the bedrock and into the caves.

- As a result, cave temperatures are approximately equal to:

*...THE AVERAGE ANNUAL TEMPERATURE AT THE SURFACE.*

Based on this information above, answer the following questions:

- During SUMMER, are caves warmer or cooler than the outside temperature? *COOLER*
- During WINTER, are caves warmer or cooler than the outside temperature? *WARMER*

### RELATIVE HUMIDITY

Timpanogos Cave National Monument – NPS Photo



Name 3 things that seeping water moistens in a cave:

1. *CEILINGS*
2. *WALLS*
3. *FLOORS*

- What is responsible for allowing the inner part of a cave to maintain its high humidity?

*CONSTANT TEMPERATURE*

- Why is the humidity at the cave entrances relatively lower than the humidity found in the interior portions of the cave?

*THE HUMIDITY IS LOWER AT THE ENTRANCE BECAUSE CAVE ENTRANCES ARE AT THE INTERFACE BETWEEN THE SURFACE AND UNDERGROUND.*

## AIR CURRENTS

The air in most caves is constantly in motion, and at times these air currents can blow up and out of the cave. This is how some caves were discovered, like *Wind Cave* in South Dakota and *Lechuguilla Cave* in Carlsbad Caverns National Park, New Mexico.



Carlsbad Caverns National Park - NPS Photo

- What is the exchange of air between a cave and the surface a function of?

*CHANGING PRESSURE OF THE OUTSIDE ATMOSPHERE*

- The air inside a cave is constantly in motion because it is constantly adjusting itself to what?

*SURFACE CHANGES*

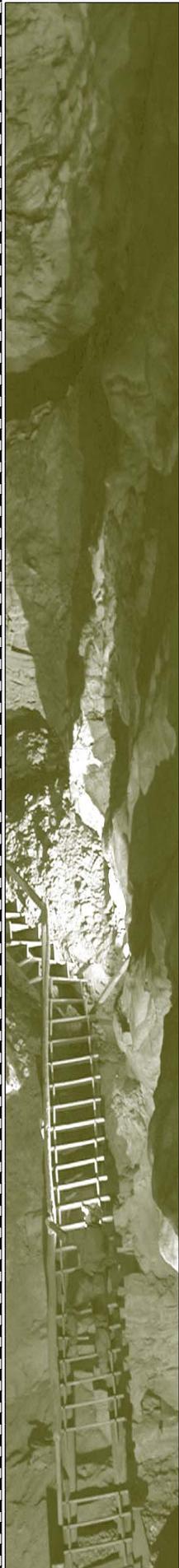
- If a cave has extremely strong air currents, what does it probably have 2 of?

*ENTRANCES*

- What is the difference between a blowing cave and a breathing cave?

*A BLOWING CAVE IS CAVE THAT HAS AN ANNUAL CYCLE IN WHICH AIR BLOWS OUT OF THE LOWER ENTRANCE ALL SUMMER AND OUT OF THE UPPER ENTRANCE ALL WINTER.*

*A BREATHING CAVE HAS A SHORTER CYCLE THAN A BLOWING CAVE; THE AIR MOVES INWARD FOR A FEW MINUTES AND THEN OUTWARD FOR A FEW MINUTES.*



NPS Photo by Rick Wood

## Interactive Reading Guide #1

# Student Copy



# CAVES AND KARST

(To compliment the NPS Views Caves and Karst Knowledge Center)

[Enter the knowledge center by clicking on the “Explore Caves and Karst” link.](#)

## Introduction to Caves

Hearing the word “caves” can bring about a variety of responses. Some people associate caves with a feeling of being trapped and lost, while others fear them because they are home to bats and other creatures of the dark. Yet, there are many people in this world that love caves for the sense of adventure and exploration that they provide.

Whatever your feelings of caves are, there is no denying their importance as unique environments that are warehouses for unique species, important geological resources, and irreplaceable artifacts.

The best way to learn what caves have to offer is to explore them, and the best way to start exploring caves is to start from the beginning. Let’s start with some important definitions and concepts about caves and karst:

[Click on the link to Cave Basics](#)

1. How does the Federal Cave Resource Protection Act of 1988 define a cave?
2. True or False: Caves can be filled with air, but not water. Circle one: True False
3. What are 4 things that can be housed within a cave?
  - 
  - 
  - 
  -

## What is karst?

Karst is a type of topography. If we think of topography as the different features in a landscape, then karst landscapes are characterized as being formed on limestone, gypsum, and other types of rocks that dissolve in natural acid.



[Click on the link to Karst Basics](#)

1. What type of topography does karst describe? What happens to streams in karstic areas?

2. Name 5 surface features that are found in regions with karst:

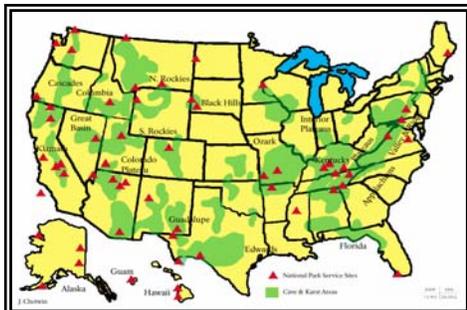
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3. Name 3 components of a drainage network:

- 
- 
- 

NPS Map - Cave and Karst Locations in the USA

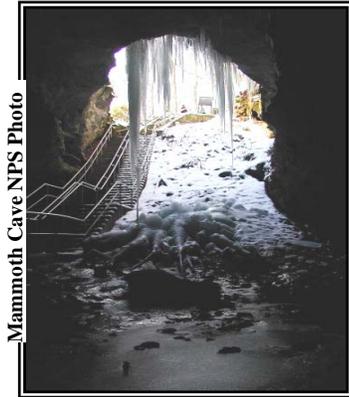
## Where are Caves and Karst?



Now that you know the cave and karst basics, let's learn about where they are found. Karst landscapes are found just about everywhere on Earth: frigid tundra, dry deserts, and tropical jungles. In temperate & tropical climates flowing water dissolves rocks. In arid environments, sulfuric acid can dissolve rocks and form caves.

[Click on the link to Cave and Karst Locations](#)

1. What portion of the landscapes in the United States is karstic? \_\_\_\_\_



Mammoth Cave NPS Photo

## *Types of Caves*

There are many different types of caves that can form in many different types of locations: there are long caves, deep caves, caves that form in the desert, and caves that form near the sea.

[Click on the link to Types of Caves](#)

1. What is the longest cave? \_\_\_\_\_
2. Where is the longest cave located? \_\_\_\_\_
3. The deepest cave in the world is the \_\_\_\_\_ cave.
4. How many types of caves are there? \_\_\_\_\_

(Hint: you have to click on the “next->” link)

## *What Processes Form Caves and Karst?*

[Click on the link to Cave and Karst Formation](#)

(Use the links to the glossary to fill in the following blanks)

Caves are typically formed in rocks through processes like *dissolution* and *carbonation*.

*Dissolution* is the act or process of \_\_\_\_\_. If an area is warm and humid

there is more water available to dissolve rock, increasing the rate of erosion and cave

formation. Carbonate rocks are those that primarily consist of \_\_\_\_\_

minerals. Specifically, carbonate rocks are \_\_\_\_\_ rocks, and go through

a process called “*carbonation*”. *Carbonation* is an activity of chemical \_\_\_\_\_.

It is a \_\_\_\_\_ reaction of carbonic acid in rainwater, soilwater, and

groundwater, with \_\_\_\_\_. *Carbonation* most strongly affects

carbonate minerals and rocks, such as \_\_\_\_\_ and \_\_\_\_\_.

## *Different Ways that Caves and Karst Form*

Caves and karst can form in many different ways. They can form in areas where abundant rainfall increases the rate of dissolution and carbonation. Although this type of formation is common, it is not the only way to form caves and karst. Other processes are at work forming caves and changing karstic landscapes. The following examples are common ways that caves and karst are forming all around us.

[Click on the link to Cave and Karst Formation](#)

(Use the “next ->” link to see different ways that caves and karst form)

### 1. COLLAPSE

- Collapse is part of cave \_\_\_\_\_ and \_\_\_\_\_.
- When do the ceilings of cave rooms and passages collapse?
- The ceilings of water-filled caves may be supported by the buoyant force of the water inside. If this water drains out, why is there a greater potential for the cave to collapse?

### 2. SOLUTION CAVES

- *Finish the following paragraph:*

Earth movements cause cracks to form in the *bedrock*, which is the solid rock below the surface. These cracks, which are natural pipelines for water to seep into the ground, are called \_\_\_\_\_ and \_\_\_\_\_. When the water mixes with the natural acids in the ground, rocks such as limestone are dissolved.

- What remains after the dissolved particles are carried away with the water?
- WHERE does most cave formation and enlargement take place, and WHY is the circulation and dissolution of bedrock greatest at this place?

### 3. LAVA CAVES

• What is another name for a lava cave? \_\_\_\_\_

• *Finish the following paragraph:*

When molten, fluid \_\_\_\_\_ flows out of a volcano, it works its way downhill. In contact with \_\_\_\_\_, the surface of this lava stream cools and hardens into a \_\_\_\_\_. The lava inside remains \_\_\_\_\_, however, and continues to \_\_\_\_\_ downhill. When the molten lava eventually \_\_\_\_\_ out of the interior of the hard-crust passage, a lava \_\_\_\_\_ or \_\_\_\_\_ remains.

### 4. TALUS CAVES



• Rockslides and rockfalls produce piles of irregular shaped rocks and boulders. The spaces between these rocks are sometimes big enough to produce a cave-like configuration.

What is the name for these piles of rocks?

• Because these types of caves can be formed when rocks break off and fall or slide into narrow canyons, talus caves are also referred to as:

### 5. SEA CAVES

• What are sea caves?

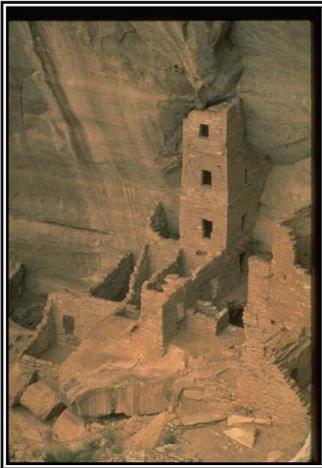
• *Finish the following sentence about the formation of sea caves:*

The action of \_\_\_\_\_ pounding against rocks that line the shores of \_\_\_\_\_ and large \_\_\_\_\_ form sea caves.

## 6. ICE CAVES

- Ice caves that form in ice are also called:
  
- Ice caves that are formed in rock that contain ice all year round are also referred to as:

## 7. SANDSTONE CAVES



Mesa Verde National Park  
NPS Photo

- Early people used sandstone caves for \_\_\_\_\_.

Why?

- Define *contact*:
  
- Fluids, like groundwater, move through sandstone, easily. However, when the water reaches a layer of shale, it cannot pass through because the pore spaces are too small.

When this happens, what is groundwater forced to do?

## 8. TECTONIC CAVES

*Finish the following sentence about the formation of tectonic caves:*

The action of \_\_\_\_\_ form natural \_\_\_\_\_ in rock that can be considered \_\_\_\_\_.



Wupatki National Monument - NPS Photo

## *Inside a Cave*

[Click on the "Inside a Cave" link](#)

Carlsbad Caverns National Park – NPS Photo



What do you see when you step into a cave? What do you hear? If you are near the entrance of the cave you may see bats flying in and out. You may also hear the trickling of water as it drips down the cave walls. Although, there are times that you don't see anything at all. In fact, sometimes you don't hear anything either. Stepping inside a cave is almost like stepping into another world. The following exercises are meant to help you understand what's going on inside a cave when the lights go out.

### DARKNESS

If you turn the lights out in a room, chances are your eyes will eventually adjust and you will start to see vague images of what's around you. In a cave, this may or may not be true depending on where you are. If you are near the entrance, light from outside the cave helps you to see what's around you. However, if you are in the DARKZONE, light from the outside doesn't reach you and you are in complete darkness.

- Is the following statement true or false?      Circle one:    TRUE      or      FALSE

*If you are in the darkzone of a cave, your eyes will eventually adjust to the blackness and you will be able to see your hand if your hold it up close to your face.*

- What are 3 reasons these worlds without sunlight are important?

- 1.
- 2.
- 3.

## SILENCE

In general, what kinds of sounds are heard in caves? \_\_\_\_\_

What is an example of a sound you may hear in a cave? \_\_\_\_\_

## TEMPERATURE

The daily and seasonal fluctuations that we experience on the surface of the Earth are not seen inside a cave. This is because any change in temperature on the surface fades as heat passes through the bedrock and into the caves.

- As a result, cave temperatures are approximately equal to:

Based on this information above, answer the following questions:

- During SUMMER, are caves **warmer** or **cooler** than the outside temperature? \_\_\_\_\_
- During WINTER, are caves **warmer** or **cooler** than the outside temperature? \_\_\_\_\_

## RELATIVE HUMIDITY

Timpanogogs Cave National Monument – NPS Photo



Name 3 things that seeping water moistens in a cave:

- 1.
- 2.
- 3.

- What is responsible for allowing the inner part of a cave to maintain its high humidity?
- Why is the humidity at the cave entrances relatively lower than the humidity found in the interior portions of the cave?

## AIR CURRENTS

The air in most caves is constantly in motion, and at times these air currents can blow up and out of the cave. This is how some caves were discovered, like *Wind Cave* in South Dakota and *Lechuguilla Cave* in Carlsbad Caverns National Park, New Mexico.



Carlsbad Caverns National Park - NPS Photo

- What is the exchange of air between a cave and the surface a function of?
- The air inside a cave is constantly in motion because it is constantly adjusting itself to what?
- If a cave has extremely strong air currents, what does it probably have 2 of?
- What is the difference between a blowing cave and a breathing cave?

# Caves and Karst: Interactive Reading Guide #2

**Lesson Objective:** This condensed\* version of the *Caves and Karst: Interactive Reading Guide #1* was developed to compliment the “Views of the National Parks” Knowledge Center for Caves and Karst, and the design of this guide will help students focus their attention on key concepts as they are introduced to cave and karst resources.

\* This interactive reading guide was developed for use during shortened class periods, or for classes who may require additional time to complete the assignment. Because it doesn't include the cave formation topics, it is intended to be used in conjunction with the *How Caves Form* webquest.

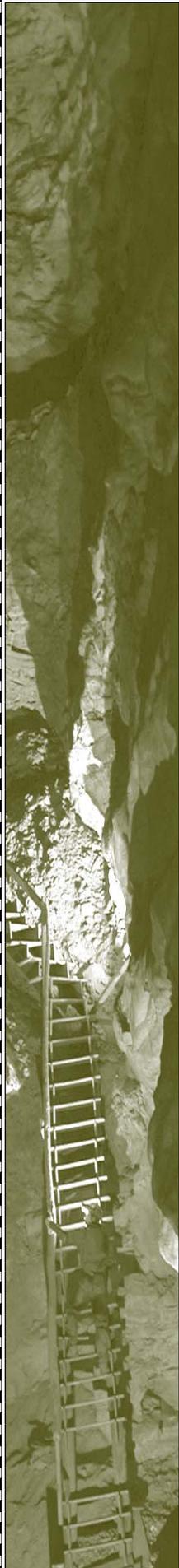
**Key Concepts:** cave basics, karst basics, cave and karst locations, types of caves, processes that form caves and karst, and the environmental conditions inside a cave.

**Duration:** 1 40-55 minute class period (depending on its use.)

**Audience:** Middle school and high school students



NPS Photo by Rick Wood



NPS Photo by Rick Wood

## Interactive Reading Guide #2

# Teacher Copy and Answer Key

# CAVES AND KARST

(To compliment the NPS Views Caves and Karst Knowledge Center)

## Interactive Reading Guide #2

Interactive reading guides are excellent strategies to use when assisting students in productive reading. They allow students to find the essential ideas within a text without being distracted by large amounts of information. Students who may find it difficult to differentiate key ideas from the supporting detail benefit from the clues and guidance of reading guides. Essentially, interactive reading guides are developed to assist students with text materials that may be too difficult for independent reading.<sup>1</sup>

This particular interactive reading guide has been developed to supplement the “Views of the National Parks” (Views) Knowledge Center for Caves and Karst, and the design of this guide will help students focus their attention as they are introduced to caves and karst resources. The introduction segment of this module is an excellent way to introduce students to cave and karst topics, and this guide has been developed in order to maximize their learning of key topics.

The instructor can download the Views DVD to the school’s public server, or if the instructor does not have a DVD they can have the students access the Knowledge Center via the internet.

**Enter the knowledge center by clicking on the “Explore Caves and Karst” link.**

**Click on the link to Cave Basics**

**1. How does the Federal Cave Resource Protection Act of 1988 define a cave?**

***“ANY NATURALLY OCCURRING VOID, CAVITY, RECESS, OR SYSTEM OF INTERCONNECTED PASSAGEWAYS BENEATH THE SURFACE OF THE EARTH.”***

**2. True or False: Caves can be filled with air, but not water. Circle one: True  False**

**3. What are 4 things that can be housed within a cave?**

- ***FRAGILE MINERAL FORMATIONS***
- ***RARE FLORA AND FAUNA***
- ***IRREPLACEABLE ARTIFACTS***
- ***DISTINCTIVE FOSSILS***

<sup>1</sup> Source: Classroom Strategies for Interactive Learning, 2<sup>nd</sup> Edition. Written by Doug Buehl; Copyright 2001 by the International Reading Association, Inc.

## TEACHER COPY AND ANSWER KEY

### What is karst?

Karst is a type of topography. If we think of topography as the different features in a landscape, then karst landscapes are characterized as being formed on limestone, gypsum, and other types of rocks that dissolve in natural acid.

Guadalupe Mountains National Park - NPS Photo



[Click on the link to Karst Basics](#)

1. What type of topography does karst describe? What happens to streams in karstic areas?

*KARST DESCRIBES LANDSCAPES CHARACTERIZED BY CAVES, SINKHOLES, AND UNDERGROUND DRAINAGE.*

*IN KARSTIC LANDSCAPES, STREAMS DISAPPEAR INTO THE GROUND AND REAPPEAR ELSEWHERE AS LARGE SPRINGS.*

2. Name 5 surface features that are found in regions with karst:

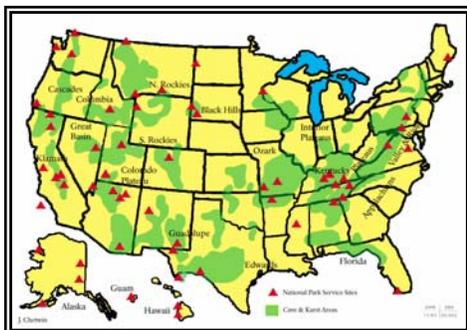
- *VALLEYS*
- *PLATEAUS*
- *TOWERS*
- *PINNACLES*
- *PONDS*

3. Name 3 components of a drainage network:

- *CAVES*
- *FRACTURES*
- *PARTINGS*

NPS Map - Cave and Karst Locations in the USA

### Where are Caves and Karst?



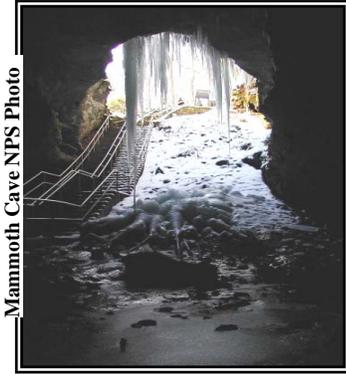
Now that you know the cave and karst basics, let's learn about where they are found.

Karst landscapes are found just about everywhere on Earth: frigid tundra, dry deserts, and tropical jungles. Warm, humid areas promote the erosion of rocks and form caves, while the sulfuric acid of arid regions also can form caves.

[Click on the link to Cave and Karst Locations](#)

1. What portion of the landscapes in the United States is karstic? *1/5 (A FIFTH OF THE LANDSCAPE)*

## Types of Caves



There are many different types of caves that can form in many different types of locations: there are long caves, deep caves, caves that form in the desert and caves that form near the sea.

[Click on the link to Types of Caves](#)

1. What is the longest cave? MAMMOTH CAVE
2. Where is the longest cave located? KENTUCKY
3. How many types of caves are there? 23

(Hint: you have to click on the “next->” link)

## What Processes Form Caves and Karst?

[Click on the link to Cave and Karst Formation](#)

(Use the link to the glossary to fill in the following blanks)

Caves are typically formed in rocks through processes like *dissolution* and *carbonation*. *Dissolution* is the act or process of DISSOLVING. If an area is warm and humid, dissolution increases the rate of erosion and cave formation. Carbonate rocks are those that primarily consist of CARBONATE minerals. Specifically, carbonate rocks are SEDIMENTARY rocks, and go through a process called “*carbonation*”. *Carbonation* is an activity of chemical WEATHERING. It is a CHEMICAL reaction of carbonic acid in rainwater, soilwater, and groundwater, with MINERALS. *Carbonation* most strongly affects carbonate minerals and rocks, such as LIMESTONE and MARBLE.

## Inside a Cave

[Click on the "Inside a Cave" link](#)

Carlsbad Caverns National Park – NPS Photo



What do you see when you step into a cave? What do you hear? If you are near the entrance of the cave you may see bats flying in and out. You may also hear the trickling of water as it drips down the cave walls. Although, there are times that you don't see anything at all. In fact, sometimes you don't hear anything either. Stepping inside a cave is almost like stepping into another world. The following exercises are meant to help you understand what's going on inside a cave when the lights go out.

### DARKNESS

If you turn the lights out in a room, chances are your eyes will eventually adjust and you will start to see vague images of what's around you. In a cave, this may or may not be true depending on where you are. If you are near the entrance, light from outside the cave helps you to see what's around you. However, if you are in the DARKZONE, light from the outside doesn't reach you and you are in complete darkness.

- Is the following statement true or false? Circle one: TRUE or **FALSE**

*If you are in the **darkzone** of a cave, your eyes will eventually adjust to the blackness and you will be able to see your hand if your hold it up close to your face.*

- What are 3 reasons these worlds without sunlight are important?

1. **CAVES CHALLENGE OUR ASSUMPTIONS ABOUT ECOSYSTEMS AND LIFE.**
2. **CAVES PROVIDE A SENSE OF DISCOVERY.**
3. **CAVES OPEN UP NEW AVENUES IN RESEARCH AND SCIENCE.**

## TEACHER COPY AND ANSWER KEY

### SILENCE

In general, what kinds of worlds are caves? *SILENT*

What is an example of a sound you may hear in a cave? *DRIPPING WATER*

### TEMPERATURE

The daily and seasonal fluctuations that we experience on the surface of the Earth are not seen inside a cave. This is because any change in temperature on the surface fades as heat passes through the bedrock and into the caves.

- As a result, cave temperatures are approximately equal to:

*...THE AVERAGE ANNUAL TEMPERATURE AT THE SURFACE.*

Based on this information above, answer the following questions:

- During SUMMER, are caves warmer or cooler than the outside temperature? *COOLER*
- During WINTER, are caves warmer or cooler than the outside temperature? *WARMER*

### RELATIVE HUMIDITY

Timpanogos Cave National Monument – NPS Photo



Name 3 things that seeping water moistens in a cave:

1. *CEILINGS*
2. *WALLS*
3. *FLOORS*

- What is responsible for allowing the inner part of a cave to maintain its high humidity?

*CONSTANT TEMPERATURE*

- Why is the humidity at the cave entrances relatively lower than the humidity found in the interior portions of the cave?

*BECAUSE CAVE ENTRANCES ARE AT THE INTERFACE BETWEEN THE SURFACE AND UNDERGROUND.*

## AIR CURRENTS

The air in most caves is constantly in motion, and at times these air currents can blow up and out of the cave. This is how some caves were discovered, like *Wind Cave* in South Dakota and *Lechuguilla Cave* in Carlsbad Caverns National Park, New Mexico.



Carlsbad Caverns National Park - NPS Photo

- What is the exchange of air between a cave and the surface a function of?

*CHANGING PRESSURE OF THE OUTSIDE ATMOSPHERE*

- The air inside a cave is constantly in motion because it is constantly adjusting itself to what?

*SURFACE CHANGES*

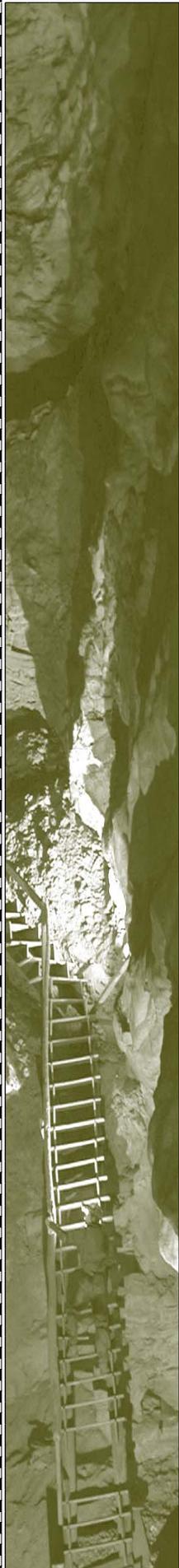
- If a cave has extremely strong air currents, what does it probably have 2 of?

*ENTRANCES*

- What is the difference between a blowing cave and a breathing cave?

*A BLOWING CAVE IS CAVE THAT HAS AN ANNUAL CYCLE IN WHICH AIR BLOWS OUT OF THE LOWER ENTRANCE ALL SUMMER AND OUT OF THE UPPER ENTRANCE ALL WINTER.*

*A BREATHING CAVE HAS A SHORTER CYCLE THAN A BLOWING CAVE; THE AIR MOVES INWARD FOR A FEW MINUTES AND THEN OUTWARD FOR A FEW MINUTES.*



NPS Photo by Rick Wood

## Interactive Reading Guide #2

# Student Copy



# CAVES AND KARST

(To compliment the NPS Views Caves and Karst Knowledge Center)

[Enter the knowledge center by clicking on the “Explore Caves and Karst” link.](#)

## Introduction to Caves

Hearing the word “caves” can bring about a variety of responses. Some people associate caves with a feeling of being trapped and lost, while others fear them because they are home to bats and other creatures of the dark. Yet, there are many people in this world that love caves for the sense of adventure and exploration that they provide.

Whatever your feelings of caves is, there is no denying their importance as unique environments that are warehouses for unique species, important geological resources, and irreplaceable artifacts.

The best way to learn what caves have to offer is to explore them, and the best way to start exploring caves is to start from the beginning. Let’s start with some important definitions and concepts about caves and karst:

[Click on the link to Cave Basics](#)

1. How does the Federal Cave Resource Protection Act of 1988 define a cave?
2. True or False: Caves can be filled with air, but not water. Circle one: True False
3. What are 4 things that can be housed within a cave?
  - 
  - 
  - 
  -

## What is karst?

Karst is a type of topography. If we think of topography as the different features in a landscape, then karst landscapes are characterized as being formed on limestone, gypsum, and other types of rocks that dissolve in natural acid.

Guadalupe Mountains National Park - NPS Photo



[Click on the link to Karst Basics](#)

1. What type of topography does karst describe? What happens to streams in karstic areas?

2. Name 5 surface features that are found in regions with karst:

- 
- 
- 
- 
- 

3. Name 3 components of a drainage network:

- 
- 
- 

NPS Map - Cave and Karst Locations in the USA

## Where are Caves and Karst?

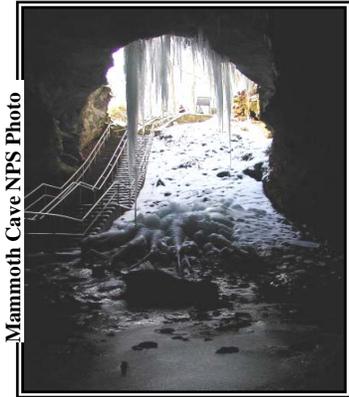


Now that you know the cave and karst basics, let's learn about where they are found.

Karst landscapes are found just about everywhere on Earth: frigid tundra, dry deserts, and tropical jungles. Warm, humid areas promote the erosion of rocks and form caves, while the sulfuric acid of arid regions also can form caves.

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1. What portion of the landscapes in the United States is karstic? \_\_\_\_\_



Mammoth Cave NPS Photo

## *Types of Caves*

There are many different types of caves that can form in many different types of locations: there are long caves, deep caves, caves that form in the desert and caves that form near the sea.

[Click on the link to Types of Caves](#)

1. What is the longest cave? \_\_\_\_\_
2. Where is the longest cave located? \_\_\_\_\_
3. How many types of caves are there? \_\_\_\_\_  
(Hint: you have to click on the “next->” link)

## *What Processes Form Caves and Karst?*

[Click on the link to Cave and Karst Formation](#)

(Use the links to the glossary to fill in the following blanks)

Caves are typically formed in rocks through processes like *dissolution* and *carbonation*. *Dissolution* is the act or process of \_\_\_\_\_. If an area is warm and humid, dissolution increases the rate of erosion and cave formation. Carbonate rocks are those that primarily consist of \_\_\_\_\_ minerals. Specifically, carbonate rocks are \_\_\_\_\_ rocks, and go through a process called “*carbonation*”. *Carbonation* is an activity of chemical \_\_\_\_\_. It is a \_\_\_\_\_ reaction of carbonic acid in rainwater, soilwater, and groundwater, with \_\_\_\_\_. *Carbonation* most strongly affects carbonate minerals and rocks, such as \_\_\_\_\_ and \_\_\_\_\_.

## Inside a Cave

[Click on the "Inside a Cave" link](#)

Carlsbad Caverns National Park – NPS Photo



What do you see when you step into a cave? What do you hear? If you are near the entrance of the cave you may see bats flying in and out. You may also hear the trickling of water as it drips down the cave walls. Although, there are times that you don't see anything at all. In fact, sometimes you don't hear anything either. Stepping inside a cave is almost like stepping into another world. The following exercises are meant to help you understand what's going on inside a cave when the lights go out.

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- Is the following statement true or false?      Circle one:    TRUE      or      FALSE

*If you are in the darkzone of a cave, your eyes will eventually adjust to the blackness and you will be able to see your hand if your hold it up close to your face.*

- What are 3 reasons these worlds without sunlight are important?

- 1.
- 2.
- 3.

## SILENCE

In general, what kinds of sounds are heard in caves? \_\_\_\_\_

What is an example of a sound you may hear in a cave? \_\_\_\_\_

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The daily and seasonal fluctuations that we experience on the surface of the Earth are not seen inside a cave. This is because any change in temperature on the surface fades as heat passes through the bedrock and into the caves.

- As a result, cave temperatures are approximately equal to:

Based on this information above, answer the following questions:

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- During WINTER, are caves **warmer** or **cooler** than the outside temperature? \_\_\_\_\_

## RELATIVE HUMIDITY

Timpanogogs Cave National Monument – NPS Photo



Name 3 things that seeping water moistens in a cave:

- 1.
- 2.
- 3.

- What is responsible for allowing the inner part of a cave to maintain its high humidity?
- Why is the humidity at the cave entrances relatively lower than the humidity found in the interior portions of the cave?

## AIR CURRENTS

The air in most caves is constantly in motion, and at times these air currents can blow up and out of the cave. This is how some caves were discovered, like *Wind Cave* in South Dakota and *Lechuguilla Cave* in Carlsbad Caverns National Park, New Mexico.



Carlsbad Caverns National Park - NPS Photo

- What is the exchange of air between a cave and the surface a function of?
- The air inside a cave is constantly in motion because it is constantly adjusting itself to what?
- If a cave has extremely strong air currents, what does it probably have 2 of?
- What is the difference between a blowing cave and a breathing cave?



# How Caves Form: A Caves and Karst Webquest

**Lesson Objective:** This webquest was developed to compliment the “Views of the National Parks” Knowledge Center for Caves and Karst, and was designed as an introduction to several processes that form caves and karst.

This activity can be used independently or in conjunction with the *Interactive Reading Guide #2*.

**Key Concepts:** caves formed by collapse, solution, lava, talus, sea, ice, sandstone, tectonic forces and acid producing bacteria.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students

How Caves Form

Teacher Copy  
and  
Answer Key



NPS Photo by Rick Wood



# HOW CAVES FORM- TEACHER COPY

## A CAVES AND KARST WEBQUEST

(To compliment the NPS Views: *Caves and Karst Knowledge Center*)

There are several processes that are at work forming caves and changing karstic landscapes. This activity will serve as an introduction to some common ways that caves and karst are forming all around us.

Enter the Views website by going to the following website:

<http://www2.nature.nps.gov/views/#>

Click on the “**Multimedia Version**” link.

Select the Knowledge Centers link, and then click on “**Explore Caves and Karst**”.

In the Introduction section, select the sidebar for “**Cave and Karst Formation**”.

Use the “**next ->**” link to see different ways that caves and karst form.

Use the information within each formation topic to answer the following questions.

### A. COLLAPSE

1. *Complete the following sentence:*

Collapse is part of cave FORMATION and EVOLUTION.

2. When do the ceilings of cave rooms and passages collapse?

**WHEN THEY BECOME TOO WIDE TO SUPPORT THE BEDROCK OVERLYING THEM.**

3. The ceilings of water-filled caves may be supported by the buoyant force of the water inside. If this water drains out, why is there a greater potential for the cave to collapse?

**BECAUSE THE BUOYANT FORCE IS NO LONGER PRESENT TO HELP SUPPORT A CAVE'S CEILING.**

## B. SOLUTION CAVES

1. *Finish the following paragraph:*

Earth movements cause cracks to form in the **BEDROCK**, which is the solid rock below the surface. These cracks, which are natural **PIPELINES** for water to seep into the ground, are called **FRACTURES** and **JOINTS**. When the water mixes with the natural acids in the ground, rocks such as **LIMESTONE** are dissolved.

2. What remains after the dissolved particles are carried away with the water?

**HOLLOW SPACES**

Follow the directions to get to the NOVA video <sup>1</sup>:

**WITHOUT CLOSING THE VIEWS WEBSITE,**

click on “File” and then “New Tab” or “New Window” to open a new window for the internet.

Go to the following website:

<http://www.pbs.org/wgbh/nova/caves/form.html>

Click on “**How Caves Form**”

(It is preferable to use the Flash version, but there is a Non-Flash text only version too.)

Watch the **RAINWATER** video and answer the following questions:

3. What type of cave is the most numerous? **LIMESTONE**
4. What has created, or fashioned, most of these caves? **RAINWATER**
5. Water and carbon dioxide form **CARBONIC** acid.
6. What is a water table? **THE LEVEL AT WHICH THE ROCK, SOIL, OR OTHER MATERIAL BECOMES SATURATED WITH WATER.**
7. What does the carbonic acid do to the limestone at the level directly below the water table? **IT DISSOLVES THE LIMSTONE, EVENTUALLY FORMING CHANNELS.**
8. When does the enlarging of the cave stop? **WHEN THE WATER TABLE LOWERS**

Return to the **Views Caves and Karst Knowledge Center**, leaving the NOVA site open.

9. Why is most cave formation and enlargement greatest at the water table?  
**THE CIRCULATION IS GREATEST HERE BECAUSE FRACTURES ARE CONNECTED AND MOST OPEN.**

## TEACHER COPY AND ANSWER KEY

### C. LAVA CAVES

Return to the NOVA website

Click on “How Caves Form”

Watch the LAVA video and answer the following questions:

1. What is lava?

**MOLTEN ROCK THAT HAS REACHED THE EARTH’S SURFACE**

2. At the deep center of a flowing channel, lava is moving: (Circle one) **FAST** or SLOW

3. Along the sides of a flowing channel, lava is moving: (Circle one) FAST or **SLOW**

Return to the Views Caves and Karst Knowledge Center

4. What is another name for a lava cave? **LAVA TUBE**

5. *Finish the following paragraph:*

When molten, fluid **LAVA** flows out of a volcano, it works its way downhill. In contact with **AIR**, the surface of this lava stream cools and hardens into a **CRUST**. The lava inside remains **MOLTEN** however, and continues to **FLOW** downhill. When the molten lava eventually **DRAINS** out of the interior of the hard-crusted passage, a lava **TUBE** or **CAVE** remains.

Without closing the Views or NOVA websites, go to the National Park Service website:

<http://www2.nature.nps.gov/geology/tour/caves.cfm>

6. Name 2 national parks that possess primary cave features: **EXAMPLES: Carlsbad Cavern NP, Great Basin NP, Mammoth Cave NP, Sequoia NP, Wind Cave NP.**

7. Name a national park that you could visit to see a lava tube: **EXAMPLES: Hawaii Volcanoes NP, Craters of the Moon NM, El Mapais NM.**

8. What national park in California has sea caves? **Point Reyes National Seashore**

## D. TALUS CAVES

1. Rockslides and rockfalls produce piles of irregular shaped rocks and boulders. The spaces between these rocks are sometimes big enough to produce a cave-like configuration.

What is the name for these piles of rocks? **TALUS**

2. Because these types of caves can be formed when rocks break off and fall or slide into narrow canyons, talus caves are also referred to as:

**BREAKDOWN CAVES**

## E. SEA CAVES

1. What are sea caves? **SEA CAVES ARE CLEFTS IN THE BASES OF CLIFFS AT THE EDGES OF LARGE BODIES OF WATER.**

2. *Finish the following sentence about the formation of sea caves:*

The action of       **WAVES**       pounding against rocks that line the shores of       **OCEANS**       and large       **LAKES**       form sea caves.

Return to the NOVA website

Click on “How Caves Form”

Watch the **WAVES** video and answer the following questions:

3. Where is the abrasive action of the waves concentrated? **AT THE BASE OF CLIFFS**
4. Sea caves are typically found in what type of rock:  
**SANDSTONE (AND OTHER SEDIMENTARY ROCKS, LIKE LIMESTONE)**
5. Where are sea caves less likely to be formed?  
**IN HARDER ROCK, LIKE GRANITE**

## F. ICE CAVES

1. Ice caves that form in ice are also called:

**GLACIER CAVES**

2. Ice caves that are formed in rock that contain ice all year round are called:

**FROZEN CAVES**

## G. SANDSTONE CAVES

1. Early people used sandstone caves for SHELTER.  
Why?

**THEY ARE USUALLY SHALLOW AND EASILY ACCESSED.**

2. Define *contact*.

**GEOLOGICALLY SPEAKING, CONTACT IS THE SURFACE  
BETWEEN 2 TYPES OR AGES OF ROCKS.**

3. Fluids, like groundwater, move through sandstone, easily. However, when the water reaches a layer of shale, it cannot pass through because the pore spaces are too small.

When this happens, what is groundwater forced to do?

**THE GROUNDWATER IS FORCED TO MOVE LATERALLY ALONG THE CONTACT  
BETWEEN THE 2 ROCKS UNITS UNTIL IT SEEPS OUT ON THE FACE OF THE CANYON  
WALL OR AT THE BACK OF AN ALCOVE, CREATING A SRPING OR SEEP.**

## H. TECTONIC CAVES

1. *Finish the following sentence about the formation of tectonic caves:*

The actions of EARTHQUAKES form natural CRACKS  
in rock that can be considered CAVES.

## TEACHER COPY AND ANSWER KEY

Return to the NOVA website

Click on “How Caves Form”

Watch the BACTERIA video and answer the following questions:

### I. CAVES FORMED BY BACTERIAL PROCESSES

1. Bacteria dissolve rock to form caves by producing a highly corrosive ACID.
2. Why are these bacteria also referred to as *extremophiles*?  
**BECAUSE THEY THRIVE IN EXTREME CONDITIONS**
3. What is the source of food that feeds these bacteria?  
**UNDERGROUND OIL DEPOSITS**
4. As the bacteria feed, what type of gas do they produce?  
**HYDROGEN SULFIDE GAS**
5. Some bacteria, such as those living in Lechuguilla Cave of Carlsbad Canyons National Park, live within the caves themselves.

What are 2 things these cave dwelling bacteria feed on in the caves?

- 1.) **HYDROGEN SULFIDE GAS**
- 2.) **MINERALS WITHIN THE ROCKS**

<sup>1</sup> The NOVA video on **How Caves Form**, by Rick Groleau, was found on the NOVA website: <http://www.pbs.org/wgbh/nova/>. This Web site was produced for PBS Online by WGBH; Web site © 1996-2006 WGBH Educational Foundation. NOVA is a trademark of WGBH.

## How Caves Form

# Student Copy



NPS Photo by Rick Wood



# HOW CAVES FORM

## A CAVES AND KARST WEBQUEST

(To compliment the NPS Views: *Caves and Karst Knowledge Center*)

There are several processes that are at work forming caves and changing karstic landscapes. This activity will serve as an introduction to some common ways that caves and karst are forming all around us.

Enter the Views website by going to the following website:

<http://www2.nature.nps.gov/views/#>

Click on the “**Multimedia Version**” link.

Select the Knowledge Centers link, and then click on “**Explore Caves and Karst**”.

In the Introduction section, select the sidebar for “**Cave and Karst Formation**”.

Use the “**next ->**” link to see different ways that caves and karst form.

Use the information within each formation topic to answer the following questions.

### A. COLLAPSE

1. *Complete the following sentence:*

Collapse is part of cave \_\_\_\_\_ and \_\_\_\_\_.

2. When do the ceilings of cave rooms and passages collapse?
3. The ceilings of water-filled caves may be supported by the buoyant force of the water inside. If this water drains out, why is there a greater potential for the cave to collapse?

---

## B. SOLUTION CAVES

1. *Finish the following paragraph:*

Earth movements cause cracks to form in the \_\_\_\_\_, which is the solid rock below the surface. These cracks, which are natural \_\_\_\_\_ for water to seep into the ground, are called \_\_\_\_\_ and \_\_\_\_\_. When the water mixes with the natural acids in the ground, rocks such as \_\_\_\_\_ are dissolved.

2. What remains after the dissolved particles are carried away with the water?

<p>Follow the directions to get to the NOVA video <sup>1</sup>:</p> <p><b>WITHOUT CLOSING THE VIEWS WEBSITE,</b></p> <p>click on “File” and then “New Tab” or “New Window” to open a new window for the internet.</p> <p>Go to the following website:</p> <p><a href="http://www.pbs.org/wgbh/nova/caves/form.html">http://www.pbs.org/wgbh/nova/caves/form.html</a></p> <p>Click on “<b>How Caves Form</b>”</p> <p>(It is preferable to use the Flash version, but there is a Non-Flash text only version too.)</p> <p>Watch the <b>RAINWATER</b> video and answer the following questions:</p>
--

3. What type of cave is the most numerous? \_\_\_\_\_

4. What has created, or fashioned, most of these caves? \_\_\_\_\_

5. Water and carbon dioxide form \_\_\_\_\_ acid.

6. What is a water table?

7. What does the carbonic acid do to the limestone at the level directly below the water table?

8. When does the enlarging of the cave stop?

<p>Return to the <b>Views Caves and Karst Knowledge Center</b>, leaving the <b>NOVA site open</b>.</p>
--

9. Why is most cave formation and enlargement greatest at the water table?

---

## C. LAVA CAVES

Return to the **NOVA** website

Click on “**How Caves Form**”

Watch the **LAVA** video and answer the following questions:

1. What is lava?
2. At the deep center of a flowing channel, lava is moving: (Circle one) FAST or SLOW
3. Along the sides of a flowing channel, lava is moving: (Circle one) FAST or SLOW

**Return to the Views Caves and Karst Knowledge Center**

4. What is another name for a lava cave? \_\_\_\_\_
5. *Finish the following paragraph:*

When molten, fluid \_\_\_\_\_ flows out of a volcano, it works its way downhill. In contact with \_\_\_\_\_, the surface of this lava stream cools and hardens into a \_\_\_\_\_. The lava inside remains \_\_\_\_\_, however, and continues to \_\_\_\_\_ downhill. When the molten lava eventually \_\_\_\_\_ out of the interior of the hard-crustad passage, a lava \_\_\_\_\_ or \_\_\_\_\_ remains.

**Without closing** the Views or NOVA websites, go to the **National Park Service** website:

<http://www2.nature.nps.gov/geology/tour/caves.cfm>

6. Name 2 national parks that primary cave features:
7. Name a national park that you could visit to see a lava tube:
8. What national park in California has sea caves?

## D. TALUS CAVES

1. Rockslides and rockfalls produce piles of irregular shaped rocks and boulders. The spaces between these rocks are sometimes big enough to produce a cave-like configuration.

What is the name for these piles of rocks? \_\_\_\_\_

2. Because these types of caves can be formed when rocks break off and fall or slide into narrow canyons, talus caves are also referred to as:
- 

## E. SEA CAVES

1. What are sea caves?
2. *Finish the following sentence about the formation of sea caves:*

The actions of \_\_\_\_\_ pounding against rocks that line the shores of \_\_\_\_\_ and large \_\_\_\_\_ form sea caves.

**Return to the NOVA website**

Click on “**How Caves Form**”

Watch the **WAVES** video and answer the following questions:

3. Where is the abrasive action of the waves concentrated?
4. Sea caves are typically found in what type of rock:
5. Where are sea caves less likely to be formed?

---

## F. ICE CAVES

1. Ice caves that form in ice are also called:
  2. Ice caves that are formed in rock that contain ice all year round are called:
- 

## G. SANDSTONE CAVES

1. Early people used sandstone caves for \_\_\_\_\_.  
Why?
2. Define *contact*.
3. Fluids, like groundwater, move through sandstone, easily. However, when the water reaches a layer of shale, it cannot pass through because the pore spaces are too small.

When this happens, what is groundwater forced to do?

---

## H. TECTONIC CAVES

1. *Finish the following sentence about the formation of tectonic caves.*

The action of \_\_\_\_\_ form natural \_\_\_\_\_  
in rock that can be considered \_\_\_\_\_.

Return to the NOVA website

Click on “How Caves Form”

Watch the **BACTERIA** video and answer the following questions:

## I. CAVES FORMED BY BACTERIAL PROCESSES

1. Bacteria dissolve rock to form caves by producing a highly corrosive \_\_\_\_\_.
2. Why are these bacteria also referred to as *extremophiles*?
3. What do these bacteria feed off of?
4. As the bacteria feed, what type of gas do they produce?
5. Some bacteria, such as those living in Lechuguilla Cave of Carlsbad Canyons National Park, live within the caves themselves.

What are 2 things these cave dwelling bacteria feed on in the caves?

- 1.)
- 2.)

---

<sup>1</sup> The NOVA video on **How Caves Form**, by Rick Groleau, was found on the NOVA website: <http://www.pbs.org/wgbh/nova/>. This Web site was produced for PBS Online by WGBH; Web site © 1996-2006 WGBH Educational Foundation. NOVA is a trademark of WGBH.

# The Rock Cycle

**Lesson Objective:** Upon completion of this activity students will have reviewed the rock cycle, and will also have been introduced to various fossil excavation processes.

## **Purpose:**

The activity serves as an introductory lesson to the caves and karst unit. It reviews key elements of the rock cycle, including the types of rocks and the processes involved.

The fossil excavation activity was intended to be an engagement activity to get the students interested in future caves and karst lessons.

**Key Concepts:** sedimentary, igneous, metamorphic rocks; rock cycle; fossil excavation.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students



NPS Photo by Rick Wood



The Rock Cycle

Teacher Copy,  
Answer Key, and  
Supplemental  
Photographs

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## THE ROCK CYCLE REVIEW AND FOSSIL EXCAVATION

### TEACHER COPY

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#### Lesson Objective:

This activity is meant as an introduction to the caves and karst unit; upon completion of this activity students will have been introduced to fossil excavation processes and will also have reviewed the rock cycle.

Note: The fossil excavation activity is meant as a way to get the students interested in the unit; there are more detailed fossil activities later in the unit. The rock cycle will also be revisited in later activities.

#### Materials:



- Plaster of Paris
- Sawdust or dirt
- 1 small paper cup per group.
- Mixing container
- “Fossils” = 1 small chicken bone or sea shell per group.
- Small paintbrushes
- Bamboo skewers or craft sticks
- Construction paper
- Printed **Excavation Directions** for each group.
- Printed worksheet for each student.
- Set of activity sheets for each student/group.

#### Teacher Preparation: To be done a day or two before beginning the lesson.

1. Mix the Plaster of Paris with the dirt or sawdust until the consistency is almost as thick as mashed potatoes.
2. Fill each cup (one per student) 1/3 full with the plaster mixture.
3. Drop a “fossil” onto the mixture and cover with more plaster mixture.
4. Allow to dry for a day or two and then remove the paper cups.

#### Procedure:

1. Before the students arrive:
  - a. Have the classroom arranged so that the students are working with a partner or in small groups.
  - b. Have the following materials ready each group:
    - i. A previously prepared hidden fossil
    - ii. A small paintbrush
    - iii. A bamboo skewer or craft stick
    - iv. A copy of the Excavation Directions.

## TEACHER COPY AND ANSWER KEY

2. Begin class with a brief introduction to the new unit.
3. As a way to get the students interest, start with the fossil excavation activity.
  - a. This is meant as a self- guided exploration activity, so there is no need for a big explanation.
4. Give the students 10 minutes to excavate their fossils.
5. Allocate an appropriate amount of time for clean-up (~ 5 minutes).
6. After the room is cleaned up and the students are back at their seats, introduce the next activity.
  - a. This is a unit centered on caves so briefly discuss how the processes of the rock cycle are the driving forces behind fossil and cave formation. This will tie the fossil excavation activity that they just completed to the rock cycle, and how they both tie into the caves unit.

### Example Introduction:

*Ask the students how they think fossils tie into their new unit on caves. Then ask them how if they know what kinds of rocks most fossils are found in. (Don't give them the answer...the worksheet will explain it. Just get them thinking.) Tell the students that the different types of rocks influence what types of caves are formed, and the formation of the rock itself determines if fossils can be formed and preserved.*

7. Pass out the **Rock Cycle** worksheets, and have the students spend the remaining class time reading and completing the worksheets.

---

## Suggested Answers to Questions

- 1.) **THEY ARE FORMED FROM CONSOLIDATED ROCK FRAGMENTS**
- 2.) **MAGMA IS MOLTEN ROCK.**
- 3.) **ERODED MATERIAL IS CARRIED AWAY BY RIVERS, WIND OR GLACIERS.**
- 4.) **THE GEOLOGIC EVENTS THAT FORMED DEVILS TOWER ARE:**
  - Stage 1: **DEPOSITION OF THE SEDIMENTARY ROCKS**
  - Stage 2: **UPLIFT OF THE BLACK HILLS**
  - Stage 3: **INTRUSION OF MAGMA**
  - Stage 4: **REGIONAL UPLIFT AND EROSION**
- 5.) The Rock Cycle:
  1. **IGNEOUS ROCK**
  2. **SEDIMENTARY ROCK**
  3. **METAMORPHIC ROCK**
  4. **MAGMA**
  5. **SEDIMENTS**

---

**★AN ADDITIONAL ROCK CYCLE PICTURE AND PHOTOGRAPH OF DEVILS TOWER ARE INCLUDED FOR TEACHERS TO USE AT THEIR OWN DISCRETION. ★**

# THE ROCK CYCLE

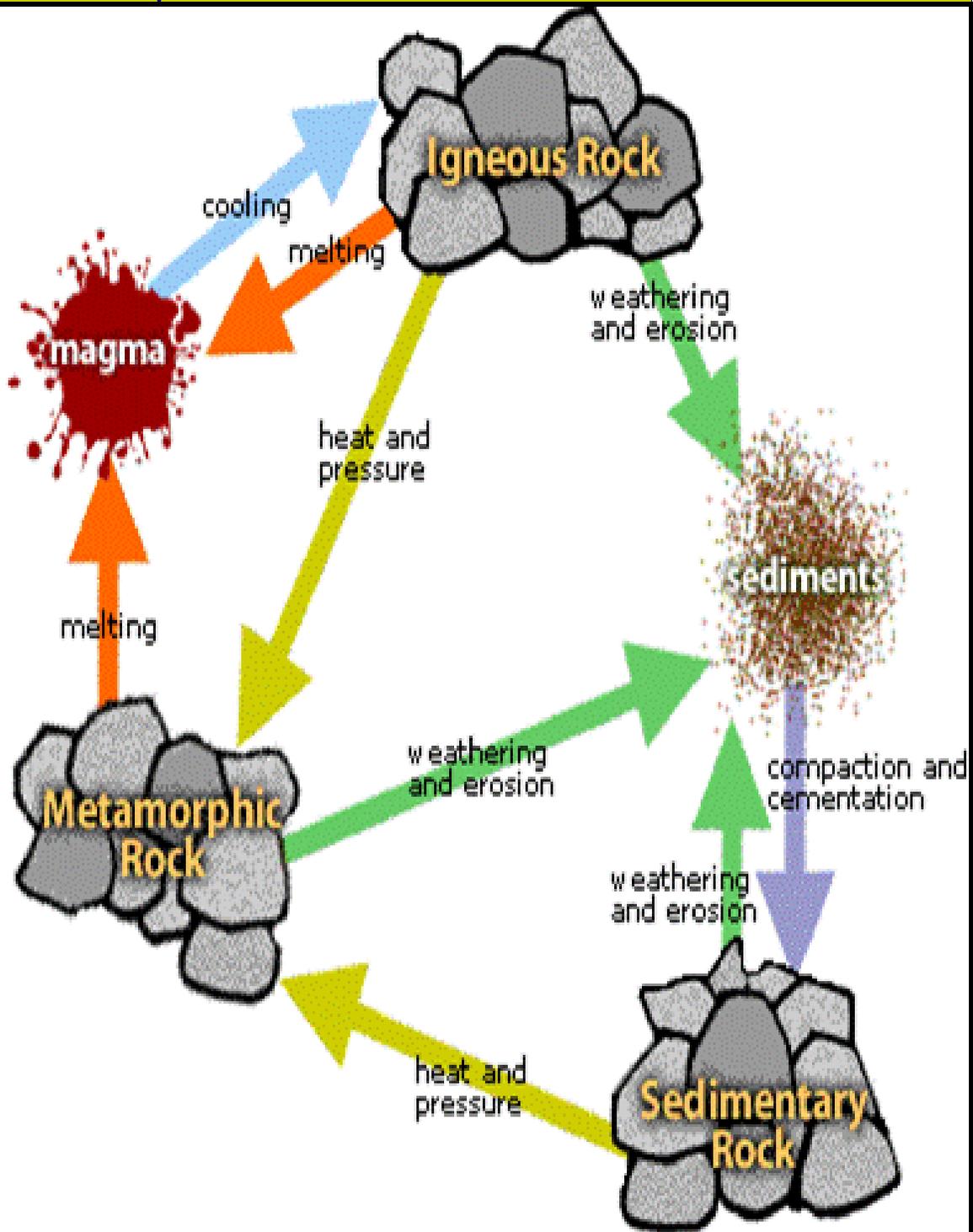
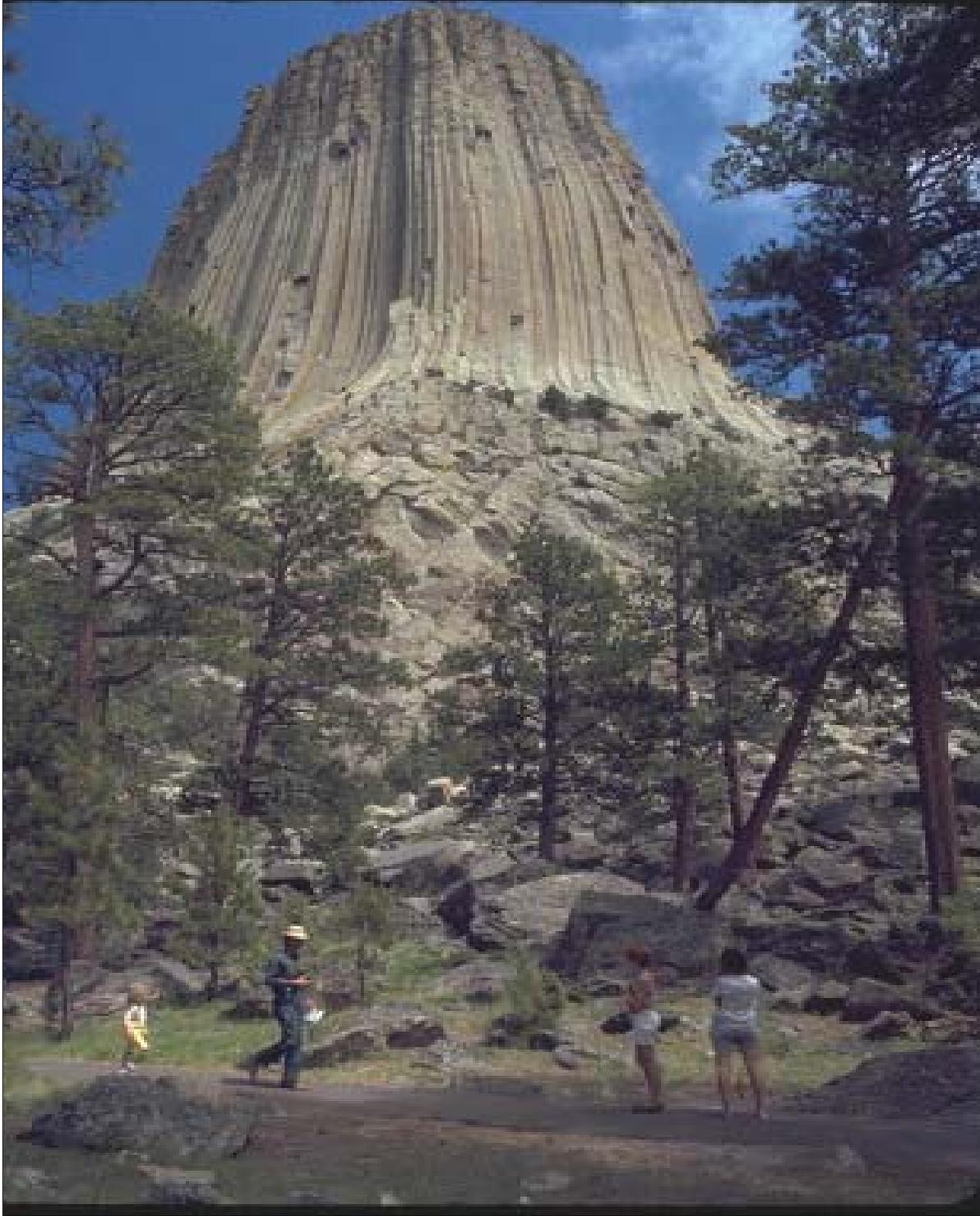


Illustration Source: <http://www.teacher-lab.org/ps101/bglasgold/rocks/lessoon3rocksysle.htm>

# Devils Tower National Monument



NPS Photo: Courtesy of National Park Service Digital Image Archives

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## EXCAVATION DIRECTIONS

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**Step 1:** Use the **bamboo skewer** or craft stick to pick away at the substance surrounding your fossil.



Work slowly and be careful not to damage the fossil inside!

**Step 2:** Once you find your fossil, use the **paintbrush** to remove any remaining small particles of the substance surrounding the fossil.



---

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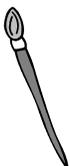
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**Step 1:** Use the **bamboo skewer** or craft stick to pick away at the substance surrounding your fossil.



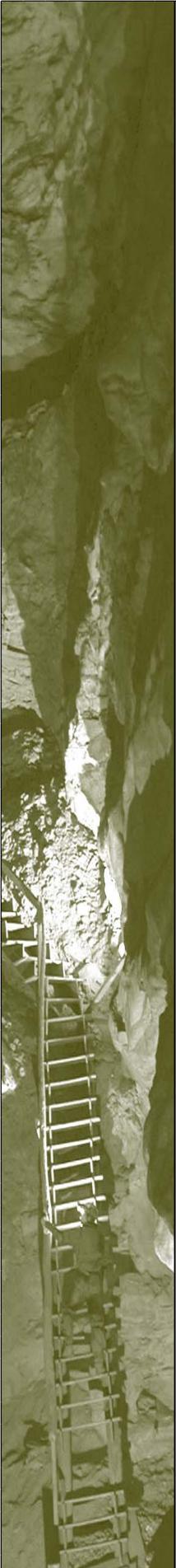
Work slowly and be careful not to damage the fossil inside!

**Step 2:** Once you find your fossil, use the **paintbrush** to remove any remaining small particles of the substance surrounding the fossil.



## The Rock Cycle

# Student Copy



NPS Photo by Rick Wood

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# THE ROCK CYCLE

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## The Rocks

There are three main rock types: **igneous**, **sedimentary**, and **metamorphic**:

1. **Igneous rocks** are formed when magma cools and solidifies to form a rock.
  2. **Sedimentary rocks** are formed when rock fragments are compacted and cemented together as a rock.
  3. **Metamorphic rocks** are formed when rocks change under extreme heat and pressure.
- 

## The Rock Cycle

Any one type of rock can become any other type through the processes of the **rock cycle**. One way we can look at the rock cycle is to begin with molten rock (magma), which, if cooled, forms **igneous rocks**. These rocks get uplifted and then begin to weather and erode. The eroded material is carried away by rivers, wind, and glaciers, and deposited elsewhere as sediments. These sediments are then buried and geological processes consolidate the loose sediments into **sedimentary rocks**. Sedimentary rocks can be buried, subjected to heat, pressure, and fluids, and become **metamorphic rocks**. Eventually, these metamorphic rocks may be heated to the point where they again melt into magma, and the cycle can start all over again.

It is important to note that the rock cycle doesn't have to work this way; sometimes igneous rocks metamorphose without ever eroding, and sometimes you uplift and erode sedimentary and metamorphic rocks, rather than melting them. It is also possible for rocks to remain un-eroded and unchanged in stable regions for long periods of time.

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### In Summary:

- ★ Igneous rocks can change into sedimentary rocks or into metamorphic rocks.
  - ★ Sedimentary rocks can change into metamorphic rocks or into igneous rocks.
  - ★ Metamorphic rocks can change into igneous rocks or into sedimentary rocks.
-

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## Devils Tower National Monument in the Black Hills of Wyoming

The sequence of geologic events that created Devils Tower is a great way to illustrate the powerful processes of the rock cycle.

### **Stage 1: Deposition of Sedimentary Rocks**

The layers of sedimentary rocks in the Black Hills area are nearly two miles (3.2 km) thick. Most of these layers were deposited in shallow seas beginning about 500 million years ago.

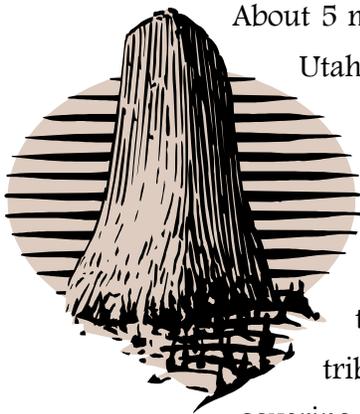
### **Stage 2: Uplift of the Black Hills**

Tectonic processes formed the Black Hills about 60 million years ago. The rocks were uplifted, fractured, and faulted.

### **Stage 3: Intrusion of Magma**

About 50 million years ago magma (molten rock) welled up into the older sedimentary rocks. One of these magma bodies would later become Devils Tower. However, the magma that formed the tower cooled underground, never reaching the surface. Thus, Devils Tower remained buried under more than a mile of sedimentary rock for many millions of years.

### **Stage 4: Regional Uplift and Erosion**



About 5 million years ago, the entire Rocky Mountain region (including Utah, Colorado, Wyoming, and Montana) was uplifted high above sea level. As a result, the rivers in the region began to flow aggressively, cutting rapidly downward into the soft sedimentary rocks. Rivers carried the eroded material away and deposited it into the Gulfs of Mexico and California. In the Devils Tower area, the Belle Fourche River and its tributaries removed many layers of softer sedimentary rocks covering the Tower. Hence, the harder igneous rock of Devils Tower was eventually exposed at the surface.

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### **Want to learn more about Devil's Tower?**

Visit the Devil's Tower Virtual Experience in the Views of the National Parks multimedia education program:

<http://www2.nature.nps.gov/views/#>

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## Questions

1.) From what source are sedimentary rocks formed?

2.) What is magma?

3.) What are 3 ways the eroded sediments of rocks can be carried away?

4.) What are the 4 geologic events that formed Devils Tower?

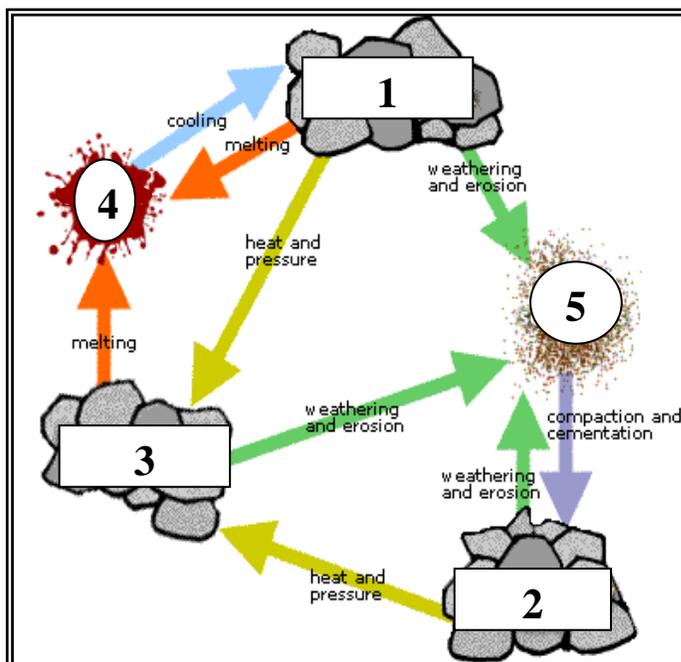
Stage 1:

Stage 2:

Stage 3:

Stage 4:

5.) Correctly label the rock cycle below:



1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

5. \_\_\_\_\_

Illustration Source: <http://www.teacher-lab.org/ps101/bglasgold/rocks/lesson3rocksysle.htm>

# Making a Cave

**Lesson Objective:** After making clay models of caves students will learn about weathering processes and be able to conceptualize how water creates caves and cave formations.

**Key Concepts:** physical, biological, and chemical weathering; dissolution; precipitation; carbonic acid.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students



NPS Photo by Rick Wood

Making a Cave

# Teacher Copy and Answer Key



NPS Photo by Rick Wood

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# MAKING A CAVE<sup>1</sup> - TEACHER COPY

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## Lesson Objective:

After making clay models of caves students will learn more about weathering processes, and be able to conceptualize how water creates caves and cave formations.

## Background:

**Weathering** occurs when rocks and minerals are broken down into smaller particles or sediment. There are 3 different types of weathering: physical or mechanical, biological, and chemical. **Physical weathering**, also referred to as mechanical weathering, is when the shape or size of a rock is changed without changing the chemical composition. **Biological weathering** occurs when organisms assist in breaking down rocks into smaller sediments. **Chemical weathering** refers to the process when rocks react with water, solutions, or gases and their chemical structure is changed. During this process, elements may be added or removed from the rocks. This lab activity will focus on a chemical weathering process called dissolution.

**Dissolution** occurs when rocks are dissolved. Caves are formed when dissolved particles are washed away and leave hollow spaces behind. One type of rock that is easily dissolved is carbonate rocks, and caves are often formed in this type of sedimentary rock. **Sedimentary rocks** are formed when other rocks are broken down into smaller pieces, called sediments, and are then cemented back together as new rocks.



Precipitation is the deposit of water on Earth from the atmosphere, and can present itself as hail, mist, rain, sleet, or snow. Precipitation, such as rainwater or snowmelt, can pick up carbon dioxide from the air and also from decaying plants in the soil. When this water mixes with carbon dioxide it forms carbonic acid. The acidic water flows through cracks on the earth's surface and seeps down into the rocks below. There, carbonic acid dissolves certain kinds of rock, like limestone, which is a type of sedimentary rock. Once the acidic water reaches the carbonate rocks under the soil, it enters into the cracks and dissolves away the rock to create the rooms, passageways and speleothems of a cave.

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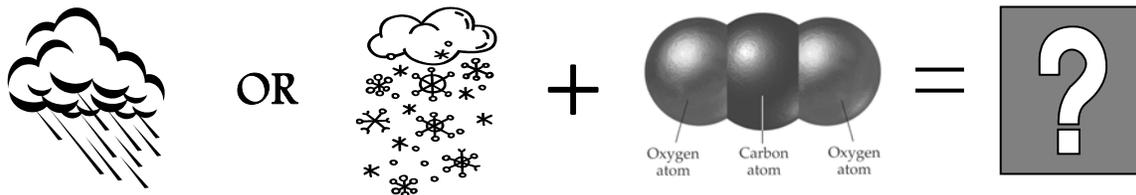
<sup>1</sup> Activity adapted from *Exploring Caves and Karst: A Curriculum Guide* The American Cave Conservation Association. Inc.

Test Your Cave Formation Knowledge:

A. Match the following terms with their definitions.

Matching Definition	Term	Definition
<i>E</i>	1. Carbonic Acid	A. This type of rock is created when rocks are broken down and then cemented back together as a new rock.
<i>C</i>	2. Chemical Weathering	B. The deposition of water on Earth from the atmosphere.
<i>F</i>	3. Dissolution	C. A process that occurs when rocks react with water, solutions, or gases and their chemical structure is changed.
<i>G</i>	4. Physical Weathering	D. A process that occurs when organisms assist in breaking down rocks into smaller sediments.
<i>B</i>	5. Precipitation	E. This is produced when water mixes with carbon dioxide.
<i>A</i>	6. Sedimentary Rock	F. The act or process by which rocks are dissolved.
<i>D</i>	7. Biological Weathering	G. A process that changes the shape or size of a rock without changing its chemical composition.

B. Use the following picture clues to complete the sentence:



When *RAIN* or *SNOW* mixes with *CARBON DIOXIDE* it forms *CARBONIC ACID*.

## Creating a Cave:

You will now make a cave using sugar cubes, modeling clay, and water.

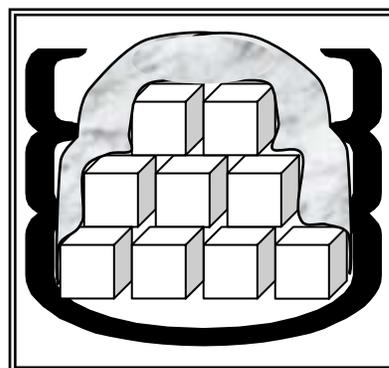
- The sugar cubes will represent the limestone that comes into contact with the carbonic acid.
- The clay will represent the rocks that remain undissolved.
- The water sprayed on the cave will represent the carbonic acid found in precipitation.

## Materials:

1. Modeling clay (4 oz. per student or small group)
2. Sugar cubes (3-6 per cave)
3. 1 see-through bowl per student or group (Cutting the top off of 2-liter bottles works well).
4. Toothpick
5. Spray bottle filled with warm water.

## Procedure:

1. Organize the sugar cubes into a half pyramid along the bottom of the bowl.
  - a. Make sure the sugar is pressed up against one side of the bowl.
2. Seal the cubes tightly with the modeling clay, making sure there are no gaps.
  - a. The clay layer should be about 1/8 inch deep.
  - b. The sugar cubes that are pressed up against the glass should remain visible. This will act as a window into your cave.
3. Poke holes through the top of the clay with the tooth pick, making sure that the holes go all the way through to the sugar cubes.



## Questions:

- What do the holes in the clay represent?  
*THE HOLES REPRESENT THE CRACKS AND HOLES IN THE EARTH'S SURFACE*
- What do you think will happen to the sugar cubes when water is sprayed over the top of the clay? **Be specific...** what do you think it will look like?

*RESULTS MAY VARY*

## TEACHER COPY AND ANSWER KEY

4. Use the spray bottle with warm water and begin spraying the top of the cave.
  - a. The holes may need to be made bigger to get the water percolating.
5. As the water seeps through the clay and into the sugar cubes, record your observations below.
6. Continue spraying until the sugar cubes are no longer in their original shape or they have completely dissolved.

### Observations:

1. Describe what happened to the sugar cubes as the water seeped into your cave.

*RESULTS MAY VARY*

2. Draw a picture or describe what your cave looked like when finished.

*RESULTS MAY VARY*

### Interpretation:

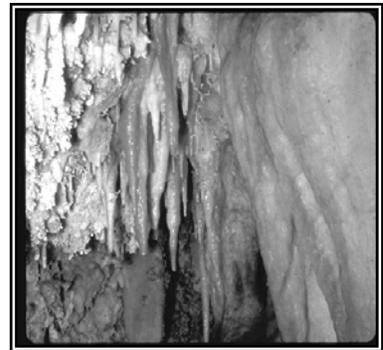
1. The caves of our National Parks house some extraordinary formations. How do you think water contributed to the formation of these real cave formations?

#### SIMPLE ANSWER:

*AS WATER SEEPS FROM A CAVE CEILING IT DRIPS DOWN DUE TO GRAVITY. THE MINERALS IN THE DROPS ACCUMULATE AND CAN FORM FORMATIONS SUCH AS STALACTITES.*

#### ADVANCED ANSWER:

*THIN HOLLOW TUBES GROW FROM THE CEILINGS OF CAVES AS WATER RUNS DOWN INSIDE THEM AND DEPOSITS RINGS OF CALCITE AT THEIR TIPS. THESE ARE CALLED "SODA STRAWS". STALACTITES, WHICH ARE ICICLE-LIKE DEPOSITS, FORM AFTER THE CENTER OF SODA STRAWS BECOME PLUGGED AND CALCITE IS DEPOSITED ON THE OUTSIDE OF THE STRAW.*



Stalactites from  
Timpanogos Cave  
National Monument, Utah.  
NPS Photo

## Making a Cave

# Student Copy



NPS Photo by Rick Wood

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# MAKING A CAVE

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## Background:

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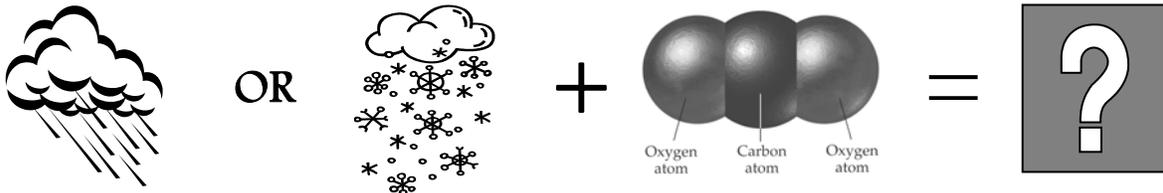
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_____	5. Precipitation	E. This is produced when water mixes with carbon dioxide.
_____	6. Sedimentary Rock	F. The act or process by which rocks are dissolved.
_____	7. Weathering	G. A process that occurs when organisms assist in breaking down rocks into smaller sediments.

B. Use the following picture clues to complete the sentence:



When \_\_\_\_\_ or \_\_\_\_\_ mixes with \_\_\_\_\_ it forms \_\_\_\_\_.

## Creating a Cave:

You will now make a cave using sugar cubes, modeling clay, and water.

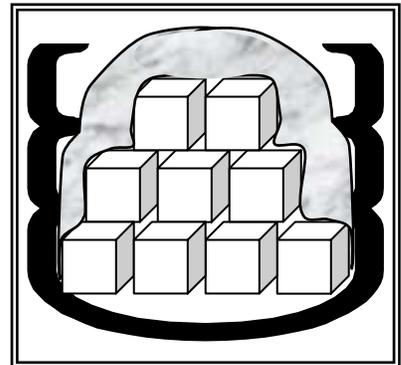
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5. Spray bottle filled with warm water.

## Procedure:

1. Organize the sugar cubes into a half pyramid along the bottom of the bowl.
  - a. Make sure the sugar is pressed up against one side of the bowl.
2. Seal the cubes tightly with the modeling clay, making sure there are no gaps.
  - a. The clay layer should be about 1/8 inch deep.
  - b. The sugar cubes that are pressed up against the glass should remain visible. This will act as a window into your cave.
3. Poke holes through the top of the clay with the tooth pick, making sure that the holes go all the way through to the sugar cubes.



## Questions:

- What do the holes in the clay represent?
- What do you think will happen to the sugar cubes when water is sprayed over the top of the clay? **Be specific...** what do you think it will look like?



# Growing Speleothems

**Lesson Objective:** After completing this activity students will be able to understand and simulate the processes involved with speleothem formation. Students will also plot solution data on a graph and then use the graph to extrapolate information.

**Key Concepts:** carbon dioxide; carbonic acid; speleothems; calcite; rate of solution; slope.

**Duration:** 2 55-minute class periods

**Audience:** Middle school and high school students



NPS Photo by Rick Wood

Growing Speleothems

Teacher Copy  
and  
Answer Key



NPS Photo by Rick Wood

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# GROWING SPELEOTHEMS - TEACHER COPY

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## Lesson Objective:

After completing this lesson the students will be able to understand and simulate the processes involved with speleothem formation, as well as plot data and extrapolate information from the graphs.

---

## Speleothem Materials – Each group of students needs:

- 1 cup of Epsom Salts
- 2 identical jars or disposable cups
- 1 spoon
- 1 saucer or piece of aluminum foil.
- Two paper clips
- 20 cm thick cotton string.
- Hot water
- Calculator

---

## Instructor Directions:

### Day 1

1. Give a brief introduction of the activity to the class and pass out the **Growing Speleothems** handouts.
2. Give a quick demonstration of how to set up the lab.
3. Instruct the students to follow the directions on their handout and set up their experiments.
4. After setting up their experiments, have the students read the **Background** section of their handout and then answer the **Questions**.
5. With about 10 minutes left in class, remind the students that they need to record their observations of their speleothem experiments in the data table provided in the **Observation** section of the handout.
6. Remind the students that they will need the handout again for Day 2!

## TEACHER COPY AND ANSWER KEY

### Day 2

1. At the beginning of the class period give the students 5-10 minutes to observe their speleothem experiments and record the observations in the **Observations** section of their handout.
2. When the students are back in their seats instruct them to complete the **Results** and **Conclusions** section of their handout. Give them 20 minutes to do this.
3. When the students have finished their conclusions, give a brief introduction to the solution activity.
4. Give them the rest of the class period to complete the solution activity.

## SUGGESTED ANSWERS

---

### Questions:

1. How does carbon dioxide get into the soil?

*FROM DECAYING ORGANIC MATERIAL (LIKE PLANTS) AND  
ALSO FROM MOLECULES IN THE AIR.*

2. What is produced when water mixes with carbon dioxide?

*CARBONIC ACID*

3. What is the term used for cave formations?

*SPELEOTHEMS*

## TEACHER COPY AND ANSWER KEY

---

### Results:

1. What do you see happening to the string?

*RESULTS MAY VARY*

2. What do you see happening below the sag in the string?

*RESULTS MAY VARY*

---

### Conclusions:

1. How is this experiment similar to the way speleothems form in caves?

*CRYSTALS FORM FROM DROPLETS OF SATURATED WATER*

2. How is this experiment different from the way speleothems form in caves?

*SPELEOTHEMS GROW DUE TO CHANGES IN  $CO_2$  LEVELS INSIDE THE CAVE, AND ALSO DUE TO THE PROCESS OF EVAPORATION AS MINERALS ARE LEFT BEHIND TO COLLECT AND EVENTUALLY BUILD UP TO FORM SPELEOTHEMS.*

3. Use your observations from this experiment to describe the development of speleothems in caves

*IN BOTH SITUATIONS, MINERALS ARE RELEASED FROM A SATURATED SOLUTION AND THE PRECIPITATED MATERIAL COLLECTS AND FORMS DEPOSITS OF DIFFERENT SHAPES.*



---

## SOLUTION ACTIVITY

---

### Data Interpretation:

1. Using your graph, how long would it take for a drip of acid to dissolve through 1 cm of limestone?

**39 days**

2. Using your graph, how many days would it take for a drip of the same acid to dissolve a pit through the entire block of limestone?

**97 days**

3. Follow the steps to double-check your answer for Question #2.

Use the following equations:

Equation for a straight line:  $y = mx + b$       “b” = y intercept (0, b)

Slope:  $m = (y_2 - y_1) / (x_2 - x_1)$

**Step 1:** Calculate the slope of the line

Choose 2 points:    Location A = (28, 7)    Location B = (68, 18)

$$m = (y_2 - y_1) / (x_2 - x_1)$$

$$m = (18 - 7) / (68 - 28)$$

$$m = 0.275$$

**Step 2:** Calculate “b” using a known location point from the graph.

Use the equation for a straight line and solve for “b”.

We will use the data point from Question #1 = (39, 10)

$$b = y - mx$$

$$b = 10 - (0.275)(39)$$

$$b = - 0.725$$

## TEACHER COPY AND ANSWER KEY

**Step 3:** Calculate the time it would take for the block of limestone to be dissolved by the carbonic acid solution.

**Known Variables:**      **point on y-axis = 26 mm**

**slope = 0.275**

**b = - 0.725**

**Use the equation for a straight line and solve for x**

$$x = (y - b) / m$$

$$x = (26 - (-0.725)) / 0.275$$

$$\boxed{x = 97.18}$$

---

## Conclusion

1. What could you change in this experiment to increase the rate at which limestone is dissolved?

***THE CONCENTRATION OF THE ACID; THE RATE THE ACID DRIPPED ONTO THE LIMESTONE; PURITY OF THE LIMESTONE.***

2. What natural changes in the environment could occur that would increase the rate of limestone dissolution?

***EXAMPLE ANSWER: AN INCREASING IN THE AMOUNT OF DECAYING PLANTS AND ANIMALS WOULD INCREASE THE AMOUNT OF CARBON DIOXIDE IN THE SOIL AND CHANGE THE CONCENTRATION OF THE CARBONIC ACID.***

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<sup>iii</sup> Lesson Plan adapted from *Exploring Caves and Karst*; the American Cave Conservation Association, Inc.

<sup>ii</sup> Solution Activity adapted from *Discovering Caves Activities*; Australian Geological Survey Organization, 2000.

Growing Speleothems  
Student Copy



NPS Photo by Rick Wood

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# GROWING SPELEOTHEMS

---

## Lesson Objective:

After completing this activity you will be able to understand and simulate the processes involved with speleothem formation, as well as plot data and extrapolate information from the graphs.

---

## Materials – Each group of students needs:

- 1 cup of Epsom Salts
- 2 identical jars or disposable cups
- 1 spoon
- 1 saucer or piece of aluminum foil.
- Two paper clips
- 20 cm thick cotton string.
- Hot water
- Calculator

---

## Procedure:

1. Pour warm water into the 2 jars until they are almost full.
2. Add half of the Epsom salts into each of the jars.
3. Stir until the solution is saturated. (Most of the Epsom salts will not dissolve and will remain at the bottom of the jars.)
4. Tie a paper clip to each end of the string
5. Wet each end of the string well with tap water.
6. Place the ends of the string into the jars.
  - a. The paper clips should rest on the bottom of the jars.
7. Place the jars so that the string sags in the middle.
8. Place a saucer or piece of aluminum foil beneath the sag in the string.
9. Place your experiment in a location where it will be away from drafts and disturbance.
10. Use the rest of the class period to read the **Background** section on the following page and complete the questions.
11. Record your **Observations** at the end of Day 1 and Day 2 in the table provided.
12. Complete the **Results** and **Conclusions** section on Day 2.
13. After you have completed step 12, complete the **Solution Activity** at the end of the handout.



---

## Background:

**Carbon dioxide** can enter the soil in different ways. One way it can enter the soil is from decaying organic material, like plants. As the organic material decomposes it releases carbon dioxide into the soil where it can interact with groundwater. Carbon dioxide is also found in the air, and may be picked up by rainwater as it falls to earth and then seeps into the soil.

When water and carbon dioxide combine they form a weak acid called **carbonic acid**. As the acidic water seeps through the soil it may flow down through bedrock and dissolve minerals, commonly calcite, along the way. When the water reaches a cave, the carbon dioxide in the water is released and the minerals are deposited on the cave walls, ceilings and floors as cave formations. This is the reason why so many cave formations consist of calcite.

Cave formations are referred to as “**speleothems**”. The word speleothem is derived from the Greek words “spelaion” meaning cave, and “thema” meaning deposit. There are many varieties of speleothems, and some have been said to resemble beehives, toadstools, bacon, and waterfalls.

---

## Questions:

1. How does carbon dioxide get into the soil?
2. What is produced when water mixes with carbon dioxide?
3. What is the term used for cave formations?

---

**Observations:**

	End of Day 1	Day 2
String		
Below Sag in String		

---

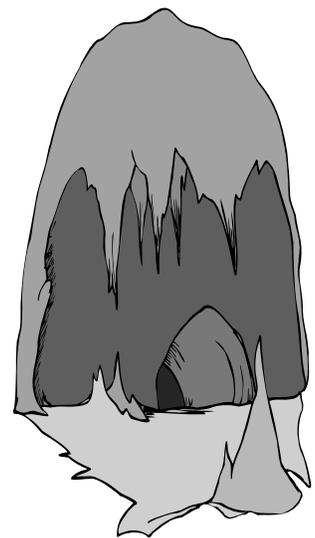
**Results:**

1. What do you see happening to the string?
  
  
  
  
  
  
  
  
  
  
2. What do you see happening below the sag in the string?

---

## Conclusions:

1. How is this experiment similar to the way speleothems form in caves?
2. How is this experiment different from the way speleothems form in caves?



---

# SOLUTION ACTIVITY

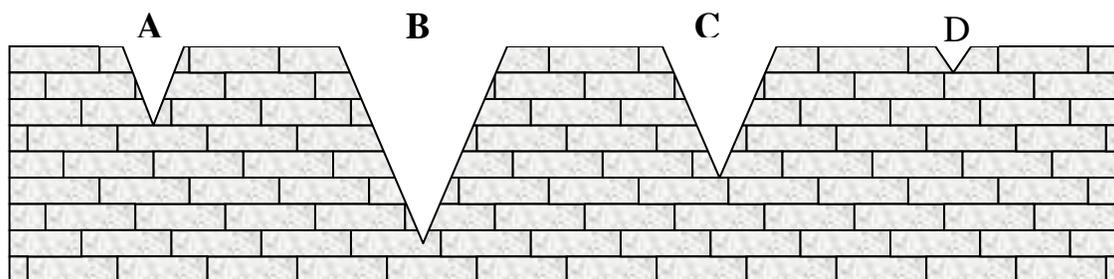
---

## THE CREATION OF CARLSBAD CAVERNS NATIONAL PARK

The creation of Carlsbad Cavern began 250 million years ago with the formation of a 400-mile-long reef in an inland sea that covered this region. Cracks developed in the reef as it grew seaward. Eventually the sea evaporated and the reef was buried under deposits of salts and gypsum. Then, a few million years ago, uplift and erosion of the area began to uncover the buried rock reef. Rainwater, made slightly acidic after mixing with carbon dioxide in the air and soil, seeped down into the cracks in the reef. The water slowly dissolved the limestone and began the process that would form large underground chambers.

*In this activity the dissolution of limestone will be simulated to help you understand cave forming process.*

A block of limestone 26 mm thick was set up in a laboratory underneath a container of dilute carbonic acid. The carbonic acid was allowed to drip onto the limestone block in four locations (A, B, C, and D) which slowly dissolved the block to form small pits. At each location, the solution was allowed to drip for varying periods of time so that each pit is a different size.



The following table showed the measurements for the maximum depth of each pit in millimeters (mm).

Location	Time Period of Dripping	Maximum Depth of Pit (mm)
A	28 days	7 mm
B	68 days	18 mm
C	44 days	11 mm
D	12 days	2.5 mm

1. Using the graph paper on page 8, plot the depth of the pit (y-axis) against the number of days (x-axis).

Make your **x-axis extend up to 120 days** and your **y-axis extend down to at least negative 10 mm**.

---

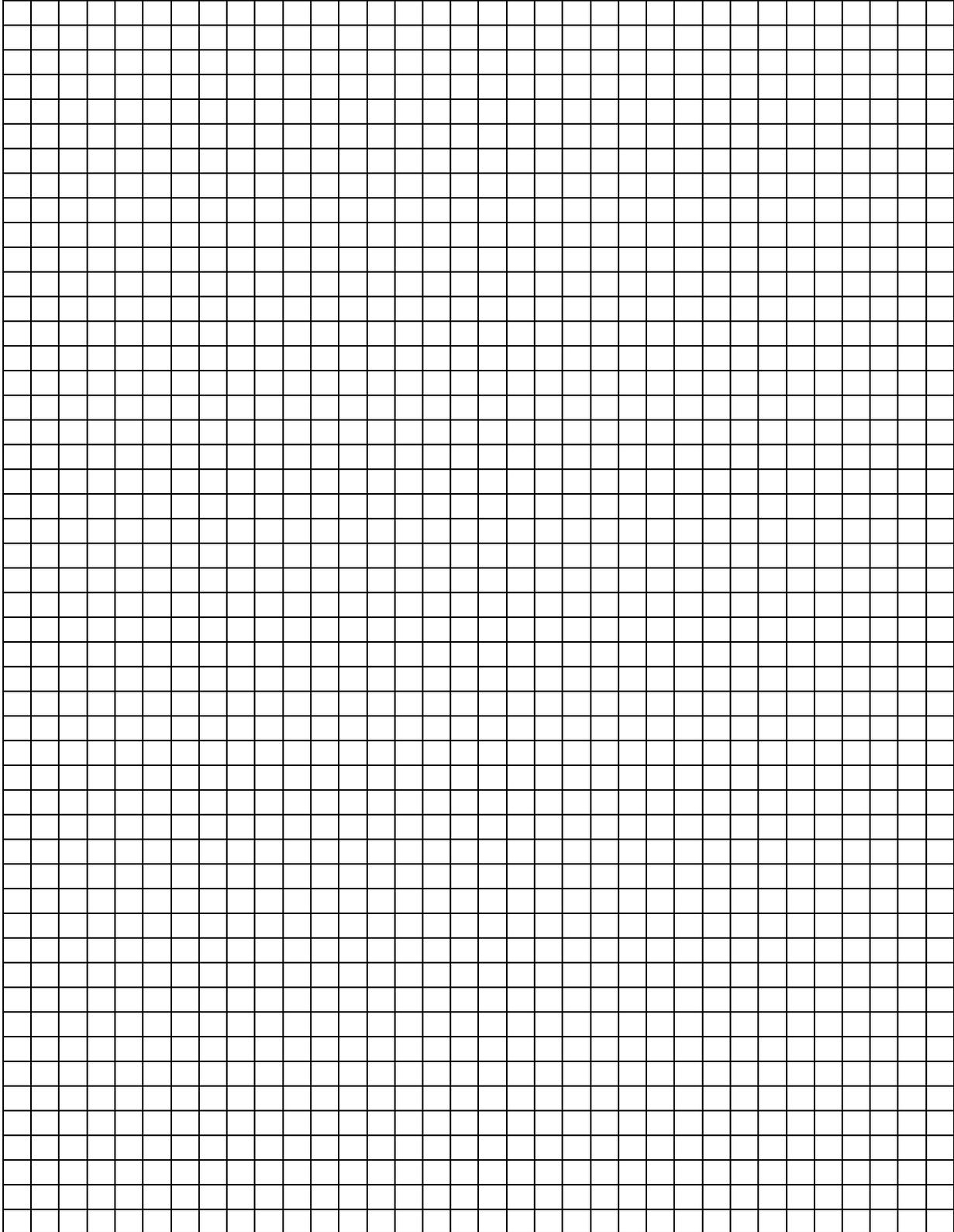
## Data Interpretation:

1. Using your graph, how long would it take for a drip of acid to dissolve through 1 cm of limestone?
2. Using your graph, how many days would it take for a drip of the same acid to dissolve a pit through the entire block of limestone?
3. Follow the steps below to double-check your answer for Question #2.  
Use the following equations:  
Equation for a straight line:  $y = mx + b$  ; “b” = y intercept (0, b)  
Slope:  $m = (y_2 - y_1) / (x_2 - x_1)$

**Step 1:** Calculate the slope of the line

**Step 2:** Calculate “b” using a known location point from the graph.





# Speleothems: A Webquest

**Lesson Objective:** After completing this webquest, students will have learned the fundamental characteristics of 14 of the most common types of speleothems.

**Key Concepts:** cave balloons, boxwork, cave flowers, coatings, columns, coralloids, draperies, flowstone, frostwork, helictites, moonmilk, cave pearls, stalactites, and stalagmites.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students



NPS Photo by Rick Wood

Speleothems: A Webquest

# Teacher Copy and Answer Key



NPS Photo by Rick Wood

# Speleothems

## Teacher Copy and Answer Key

---

**Follow the directions below to access the “Views of the National Parks” Multimedia Education Program.**

- 1.) Open the Views of the National Parks program using a Views CD/DVD or the internet at:  
<http://www2.nature.nps.gov/views/#>
- 2.) Select the “Multimedia Version”
- 3.) Open the “Knowledge Centers”
- 4.) Click on “Caves and Karst”
- 5.) Enter the module by clicking on “Explore Caves and Karst”
- 6.) Click on “Underground” in the top menu bar
- 7.) Select the “Speleothems” side bar

---

**Answer the following questions as you read through the speleothems section of the Caves and Karst Knowledge Center.**

---

1. The one thing that all speleothems have in common is where they form. Explain how the water table influences the formation of caves and their speleothems.

*ALTHOUGH THE FORMATION OF CAVES TYPICALLY TAKES PLACE BELOW THE WATER TABLE IN THE ZONE OF SATURATION, THE DEPOSITION OF SPELEOTHEMS IS NOT POSSIBLE UNTIL CAVES ARE ABOVE THE WATER TABLE IN THE ZONE OF AERATION. AS SOON AS THE CHAMBER IS FILLED WITH AIR, THE STAGE IS SET FOR THE DECORATION PHASE OF CAVE BUILDING TO BEGIN.*

2. What does the term “speleothem” refer to? Give an example.

*IT REFERS TO THE MODE OF OCCURRENCE OF A MINERAL - I.E., ITS MORPHOLOGY OR HOW IT LOOKS IN A CAVE, NOT ITS COMPOSITION*

3. What is the most common cave mineral?

*CALCITE*

---

Learn about 14 different types of speleothems by clicking on each type and then answering the following questions.

---

1. Cave Balloons

- a. Complete the following sentence about cave balloons:

“Cave balloons are ROUND - shaped, THIN - walled speleothems with GAS inside of a mineralized bag-like POUCH .”

- b. Explain why cave balloons are so rare and fragile.

*IT IS BELIEVED THAT BALLOONS ARE SHORT-LIVED; THEY QUICKLY DRY, CRACK, DEFLATE, AND CHANGE IN LUSTER (ESPECIALLY IN LOW HUMIDITY ENVIRONMENTS).*

- c. The picture shown is from Mammoth Cave National Park. Name another national park where you could find an impressive display of cave balloons?

*JEWELL CAVE NATIONAL MONUMENT*

---

2. Boxwork

- a. What does boxwork resemble?

*BOXWORK RESEMBLES A MAZE OF POST OFFICE BOXES*

- b. What does a mineral need to be in order for it to create boxwork?

*BOXWORK CAN BE COMPOSED OF ANY MINERAL MORE RESISTANT THAN IT'S SURROUNDING MEDIUM.*

- c. Boxwork is mostly composed of what mineral?

*CALCITE*

---

3. Cave Flowers

- a. What is the mineral that typically forms cave flowers?

*GYPSUM*

- b. Use the picture and text to name 2 national parks where you can find gypsum flowers.

*CARLSBAD CAVERNS and MAMMOTH CAVE NATIONAL PARKS*

---

#### 4. Coatings

a. List 4 places in a cave that you could find cave coatings:

- *WALLS*
- *FLOORS*
- *CEILINGS*
- *POOLS*

b. What type of cave mineral can form cave coatings? Be specific and use examples.

*PRACTICALLY EVERY CAVE MINERAL KNOWN CAN FORM COATINGS. THIS INCLUDES COMMON MINERALS, LIKE CALCITE AND ARGONITE, AS WELL AS RARE MINERALS THAT CONTAIN ELEMENTS SUCH AS MAGNESIUM AND IRON.*

---

#### 5. Columns

a. How is a column formed?

*COLUMNS FORM WHEN A STALAGMITE GROWS TOGETHER WITH ITS COUNTERPART FEEDER STALACTITE.*

b. Why are the largest cave columns usually found along ceiling joints?

*THIS IS WHERE THE GREATEST AMOUNT OF WATER IS DRIPPING INTO A CAVE.*

---

#### 6. Coralloids

a. What does the term coralloid describe?

*CORALLOID (OR CORALLITE) IS A CATCHALL TERM THAT DESCRIBES KNOBBY, NODULAR, BOTRYOIDAL, OR CORAL-LIKE SPELEOTHEMS.*

b. List 3 examples of speleothems that can be considered coralloids:

*Possible answers include:*

- *CAVE POPCORN*
- *CAULIFLOWER*
- *GRAPES*
- *GLOBULARITES*
- *KNOBSTONE*
- *GRAPEFRUIT*
- *CORAL*

c. Where can coralloids form?

*CORALLOIDS CAN FORM BOTH IN THE OPEN AIR AND UNDERWATER.*

## 7. Draperies

- a. Describe the formation of cave draperies.

*DRAPERIES FORM WHEN WATER DROPS FLOW DOWN A SLOPED CEILING BEFORE DRIPPING TO THE FLOOR, AND CALCITE BUILDS UP IN A LINE. THESE LINES GRADUALLY BUILD UP TO FORM DRAPERIES.*

- b. What are 2 sources that can give draperies bacon-like stripes?

*IRON OXIDE OR ORGANIC SOLUTIONS*

---

## 8. Flowstone

- a. What is flowstone usually composed of?

*CALCITE OR OTHER CARBONATE MINERALS*

- b. How are the minerals of flowstones deposited?

*FLOWING WATER DEPOSITS MINERALS IN LAYERS OR BANDS*

- c. Explain the difference between flowstone and coatings.

*FLOWSTONES FORM FROM DEPOSITS OF FLOWING WATER;  
COATINGS FORM FROM DEPOSITS OF SEEPING WATER.*

- d. Flowstones can resemble a petrified or frozen \_\_\_\_\_ *WATERFALL* \_\_\_\_\_.
- 

## 9. Frostwork

- a. The needle-like habit of what type of mineral gives most frostwork their particular appearance?

*ARAGONITE*

- b. Frostwork is most commonly found with \_\_\_\_\_ *CORALLOIDS* \_\_\_\_\_.

- c. Explain a downside to the dazzling beauty of frostwork.

*THEIR BEAUTY MAKES THEM PRIME TARGETS FOR VANDELISM.*

---

10. Helictites

- a. What is the Greek root for the term helictite, and what does it mean?

*IT COMES FROM THE GREEK ROOT “HELIX”, MEANING “TO SPIRAL”.*

- b. What is the one thing that all helictites have in common?

*THEY ALL POSSESS TINY CENTRAL CHANNELS THROUGH WHICH THEIR EXTREMITIES AND DIAMETERS ARE FED AND INCREASED BY SEEPING CAPILLARY WATER.*

---

11. Moonmilk

- a. What does the milky appearance of moonmilk form from?

*MOONMILK’S FINE-GRAINED PARTICLES BECOME SUSPENDED IN WATER WHICH GIVES IT THE APPEARANCE OF MILK.*

- b. What are 4 medicinal purposes of moonmilk?

- *A POULTICE TO STOP BLEEDING*
- *FOR DIARRHEA*
- *FOR FEVERS*
- *AS AN ANTACID*

---

12. Cave Pearls

- a. List 4 objects that cave pearls have been compared to:

*Possible answers include:*

- *MARBLES*
- *CIGARS*
- *BALLS*
- *HAILSTONES*
- *ORANGES*
- *PEARLS*
- *CUPCAKES*
- *PIGEON’S EGGS*

- b. Where do cave pearls normally grow?

*IN SHALLOW CAVE POOLS*

- c. How do sand grains and bat bones influence the growth of cave pearls?

*THEY CAN ACT AS NUCLEI FOR CAVE-PEARL GROWTH; THEY BECOME ROUNDED AS THEY GROW INTO CAVE PEARLS OF DIFFERENT SHAPES.*

**13. Stalactites**

- a. **What do stalactites resemble and where are they found?**

*STALACTITES RESEMBLE ICICLES OR CARROTS HANGING FROM CAVE CEILINGS*

- b. **What do all stalactites begin their growth as?**

*SODA STRAWS*

- c. **Describe the first stage in the growth of a stalactite.**

*A WATER DROPLET COLLECTS ON THE CAVE CEILING BY CONDENSATION OR BY WATER COMING THROUGH A FRACTURE IN A ROCK.*

- d. **What sticks or “adheres” the thin film of carbonate material left behind by a water droplet to the ceiling of a cave?**

*SURFACE TENSION*

- e. **As long as water continues to drip, what eventually develops and is enlarged by the dripping water?**

*A HOLLOW TUBE (OR SODA STRAW)*

---

**14. Stalagmites**

- a. **What are stalagmites?**

*THEY ARE CONVEX FLOOR DEPOSITS BUILT UP BY WATER DRIPPING FROM AN OVERHEAD STALACTITE OR FROM THE CAVE CEILING.*

- b. **How does the splash of falling water droplets affect the growth of stalagmites?**

*IT CAUSES THE STALAGMITES TO SPREAD OUT AS THEY GRADUALLY BUILD UP FROM THE FLOOR*

- c. **Describe the difference between the top of a stalagmite and the tip of a stalactite.**

*STALAGMITES HAVE ROUNDED TOPS; STALACTITES HAVE POINTED TIPS.*

Speleothems: A Webquest

# Student Copy



NPS Photo by Rick Wood

---

# Speleothems

---

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- 7.) Select the “Speleothems” side bar

---

**Answer the following questions as you read through the speleothems section of the Caves and Karst Knowledge Center.**

---

1. The one thing that all speleothems have in common is where they form. Explain how the water table influences the formation of caves and their speleothems.
  
  
  
  
  
  
  
  
  
  
2. What does the term “speleothem” refer to? Give an example.
  
  
  
  
  
  
  
  
  
  
3. What is the most common cave mineral?

---

**Learn about 14 different types of speleothems by clicking on each type and then answering the following questions.**

---

**1. Cave Balloons**

a. Complete the following sentence about cave balloons:

“Cave balloons are \_\_\_\_\_ - shaped, \_\_\_\_\_ - walled speleothems with \_\_\_\_\_ inside of a mineralized bag-like \_\_\_\_\_.”

b. Explain why cave balloons are so rare and fragile.

c. The picture shown is from Mammoth Cave National Park. Name another national park where you could find an impressive display of cave balloons?

---

**2. Boxwork**

a. What does boxwork resemble?

b. What does a mineral need to be in order for it to create boxwork?

c. Boxwork is mostly composed of what mineral?

---

**3. Cave Flowers**

a. What is the mineral that typically forms cave flowers?

b. Use the picture and text to name 2 national parks where you can find gypsum flowers.

---

---

#### 4. Coatings

a. List 4 places in a cave that you could find cave coatings:

- 
- 
- 
- 

b. What type of cave mineral can form cave coatings? Be specific and use examples.

---

#### 5. Columns

a. How is a column formed?

b. Why are the largest cave columns usually found along ceiling joints?

---

#### 6. Coralloids

a. What does the term coralloid describe?

b. List 3 examples of speleothems that can be considered coralloids:

- 
- 
- 

c. Where can coralloids form?



---

## 10. Helictites

- a. What is the Greek root for the term helictite, and what does it mean?
  
- b. What is the one thing that all helictites have in common?

---

## 11. Moonmilk

- a. What does the milky appearance of moonmilk form from?
  
- b. What are 4 medicinal purposes of moonmilk?
  - 
  - 
  - 
  -

---

## 12. Cave Pearls

- a. List 4 objects that cave pearls have been compared to:
  - 
  - 
  - 
  -
  
- b. Where do cave pearls normally grow?
  
- c. How do sand grains and bat bones influence the growth of cave pearls?

---

### 13. Stalactites

- a. What do stalactites resemble and where are they found?
  
- b. What do all stalactites begin their growth as?
  
- c. Describe the first stage in the growth of a stalactite.
  
- d. What sticks or “adheres” the thin film of carbonate material left behind by a water droplet to the ceiling of a cave?
  
- e. As long as water continues to drip, what eventually develops and is enlarged by the dripping water?

---

### 14. Stalagmites

- a. What are stalagmites?
  
- b. How does the splash of falling water droplets affect the growth of stalagmites?
  
- c. Describe the difference between the top of a stalagmite and the tip of a stalactite.



# Sediments and Solution Caves: Part 1

**Lesson Objective:** After reading about sediments and the formation of solution caves, and making their own sedimentary rocks, students will be able to identify layers of sediments and determine the order in which they settled.

**Key Concepts:** sediments; sedimentary rocks; stratification; erosion; solution caves; carbonic acid; sulfuric acid; and dissolution.

**Duration:** 30 minutes (*Caves and Fossils* activity will take up the remaining class time).

**Audience:** Middle school and high school students



Sediments and Solution Caves:  
Part 1

Teacher Copy  
and  
Answer Key

---

## SEDIMENTS AND CAVES: PART 1 – TEACHER COPY

---

### Sedimentation Activity Materials:

Each group needs:

- Various coarse and fine-grained sediments: sand, silt, mud, gravel/pebbles (using different colored sediments make differentiating between the sediments easier).
- Two-liter plastic soda bottle
- Cement solution: 1 cup water with  $\frac{1}{2}$  cup Epsom salt
- Plastic funnel
- Organic matter: various shells, sticks (optional: mini plastic animals and insects).

### Teacher Instructions:

1. Begin class by having the students read the introduction section and answer the following questions.  
(10 minutes)
2. Demonstrate the Sedimentation Activity Procedure, as outlined on page 3 of the Student Copy of this activity.  
(5 minutes)
3. Give the students time to complete the sedimentation activity.  
(10 minutes).
4. Allow time for clean-up. Make sure that the students leave their bottles in an area that will not be disturbed.  
(5 minutes)
5. Pass out the Caves and Fossils worksheet and give the students the remainder of the class period to complete it.

## Answer Key

---

### Questions:

1. What are the 3 main factors that influence the settling of sediments?

- *WIND*
- *WATER*
- *GRAVITY*

2. What binds sediments together to form a solid sedimentary rock?

*DECAYING ORGANIC MATTER AND MINERALS FROM GROUNDWATER*

3. What is “stratification”?

*THE LAYERS OF SEDIMENTS THAT ACCUMULATE IN SEDIMENTARY ROCKS*

4. Where are sedimentary rocks naturally weak and easily broken?

*AT THE BOUNDARY BETWEEN THE SEDIMENTARY ROCK LAYERS*

5. What are 2 types of acids that can dissolve rocks and form caves?

*CARBONIC ACID AND SULFURIC ACID*

6. What is dissolution?

*THE ACT OR PROCESS OF DISSOLVING*

A vertical photograph of a cave interior. A wooden ladder is leaning against a rock wall on the left side. The cave walls are rugged and textured. The lighting is somewhat dim, highlighting the textures of the rock and the structure of the ladder.

# Sediments and Solution Caves: Part 1

# Student Copy

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## SEDIMENTS AND SOLUTION CAVES: PART 1

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*Sediments* may consist of soil, salt, sand, seashells, plant and/or animal remains. Along with the differences in the sediments themselves, there are 3 main factors that determine how they settle: wind, water, and gravity. As a result, sediments settle at different rates and accumulate in different locations. *Sedimentary rocks* form as sediments accumulate and build up into thick layers, and the presence of layers in rocks is referred to as “*stratification*”. The sediments themselves are “glued” together with a mixture of dead and decaying organisms and minerals from groundwater. These materials form a cement-like bond around the sediments and bind them into solid rock.

The boundary between sedimentary rock layers is naturally weak and can be easily broken. Fluids can flow through cracks formed between the rock layers and wear away the rock in a process called *erosion*. If acidic water flows along and adjacent to joints (fractures), faults, and layers in the rock, it can further erode them and lead to the formation of caves. These types of caves are called *solution caves*.

Acidic water can be produced when water and carbon dioxide mix to form *carbonic acid*. Another cave-forming acid is *sulfuric acid*. Many geologists believe that fresh rainwater mixed with deeper salty water to produce the sulfuric acid that dissolved the caves of Carlsbad Cavern National Park. The act or process of dissolving substances of any kind, including rocks, is called “*dissolution*”.

---

## Questions:

1. What are the 3 main factors that influence the settling of sediments?
  - 
  - 
  -
2. What binds sediments together to form a solid sedimentary rock?
3. What is “stratification”?
4. Where are sedimentary rocks naturally weak and easily broken?
5. What are 2 types of acids that can dissolve rocks and form caves?
6. What is “dissolution”?

---

## Sedimentation Activity Materials:

- Various coarse and fine-grained sediments: sand, silt, mud, gravel/pebbles (using different colored sediments make differentiating between the sediments easier).
- Two-liter plastic soda bottle
- Cement solution: 1 cup water with ½ cup Epsom salt
- Plastic funnel
- Organic matter: various shells, sticks (optional: mini plastic animals and insects)

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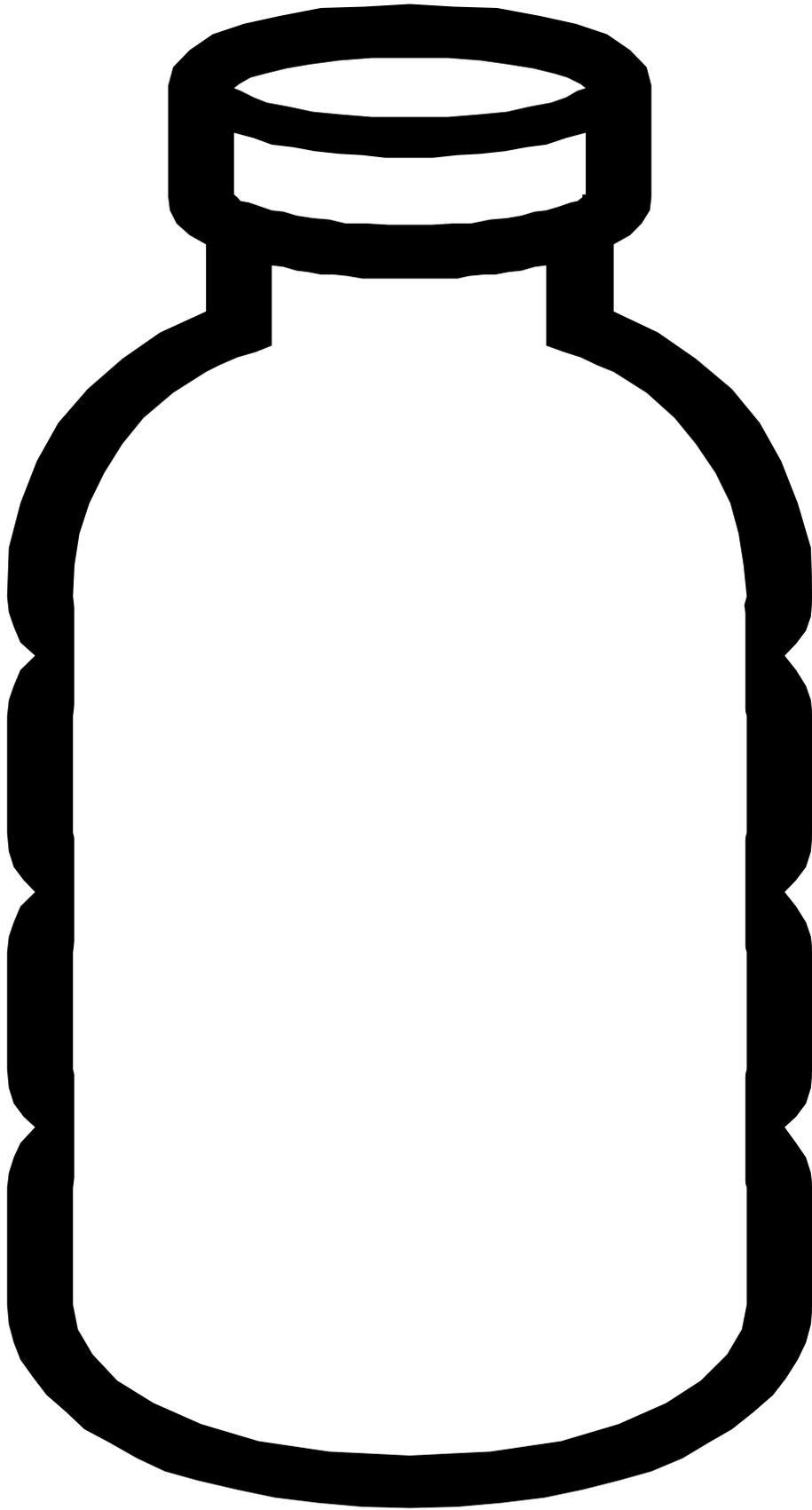
## Sedimentation Activity Procedure:

1. Students should get into small groups of up to 4 students per group.
2. Using the funnel, add one layer of each sediment type into the plastic bottle. Each layer should be about 1 cm deep.
3. Add several seashells, plant remains, and any other organic matter.
4. Add enough cement solution to completely cover the sediments with about 1 inch extra on top of the sediments.
5. Screw the cap on the bottle cap tightly and shake for 2- 3 minutes.
6. Place the bottle on a flat surface and watch the sediments settle in the bottle.
7. After about 5 minutes, carefully observe the various sediments as they settle out of the water.
8. Record the order in which the sediments settled.
  - Use the bottle diagram on page 4 to draw the sediments as they settled out in your bottle, including any organic matter.
  - Be sure to label each sediment layer and any organic matter found in each layer.
9. Answer the following questions in the **Observations** section.
10. Leave your bottle to harden overnight.
11. Use the rest of the class time to complete the Caves and Fossils worksheet.

---

## Observations:

1. Which sediments settle out first?
2. Why do you think these sediments settled out first?
3. Which sediments settle out last?
4. Why do you think these sediments settled out last?



# Caves and Fossils

**Lesson Objective:** This activity was designed to introduce students to paleontology, the natural resources of cave systems, and cave fossils.

**Key Concepts:** caves; fossils; paleontology; geologic time; sedimentary rocks.

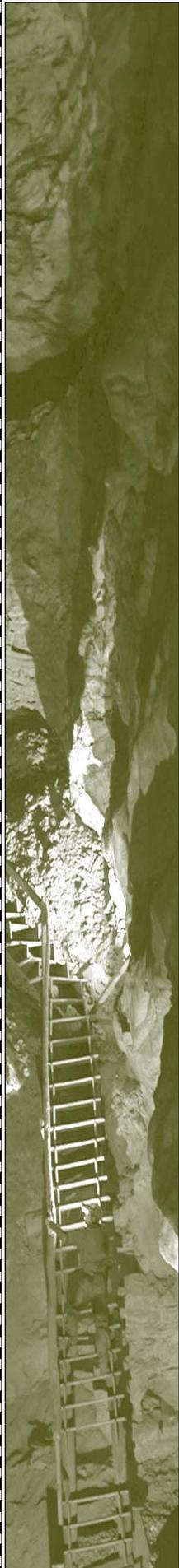
**Duration:** 25 minutes\*

\* This is the 2nd half of a 55 minute lesson, and is designed as part of the **Sediments and Solution Caves: Part 1** lesson.)

**Audience:** Middle school and high school students



NPS Photo by Rick Wood



NPS Photo by Rick Wood

Caves and Fossils

# Teacher Copy and Answer Key

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# CAVES AND FOSSILS~ TEACHER COPY

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## Background:

Our planet is a dynamic environment that has been continuously changing over the past 4.6 billion years. In order to make sense of these changes, scientists have developed a geologic time scale that separates the history of the Earth into distinctive periods of time. To accurately separate geologic time, paleontologists use clues, like fossils. These clues are used to reconstruct prehistoric environments and answer questions about the interactions between organisms and interactions between organisms and their environment. Fossils are critical resources to paleontologists because they represent life throughout history.

*paleos or palaois* = “old”  
*on* = “being, creature”  
*logy or lego* = “the study of”

**Paleontology** = the study of the forms of life existing in prehistoric or geologic times, especially as represented by fossils.

## Questions:

- 1.) What is the name for the scale paleontologists use to separate the history of the Earth into distinct time periods?

### ***GEOLOGIC TIME SCALE***

- 2.) What is the definition of paleontology?

### ***THE STUDY OF THE FORMS OF LIFE EXISTING IN PREHISTORIC OR GEOLOGIC TIMES, ESPECIALLY AS REPRESENTED BY FOSSILS.***

---

## National Parks and their Natural Resources<sup>1</sup>:

Our national parks, and their extensive resources, are ideal places to learn about paleontology. Some parks, like Mammoth Cave National Park, have extremely diverse cave ecosystems that date back millions of years. The geologic time line for the formation of Mammoth Cave extends back millions of years starting from the Mississippian Period (359 – 318 million years ago)<sup>2</sup> and extending up into the Paleo-Indian Period (10,000 BC to 15 AD). Throughout this time fossils were continuously being formed, and researchers have found remnants that range from prehistoric marine organisms to bones washed into caves during times of flooding.

## Question:

- 1.) Name the 2 geological time periods that witnessed the formation of Mammoth Cave.

### ***THE MISSISSIPPIAN PERIOD AND THE PALEO-INDIAN PERIOD***

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<sup>1</sup> Source: *Introduction, Background, and Participation*; Sharon Ganci: Environmental Education Coordinator for Mammoth Cave NP.

<sup>2</sup> Source: NPS Views program – Geologic Time Knowledge Center.

## Cave Fossils:

There are 2 ways that caves can house paleontological resources. First, fossils can be



preserved within the cave-forming rock and may become exposed through cave-forming processes. Second, fossils accumulate within the cave and karst features, such as in cave openings, sinkholes, and tubes. These features are natural traps for animals and can be important resources for paleontologists who use these accumulations to associate what types of organisms have inhabited an area.

Cave environments are conducive to the preservation of these paleontological resources. The relatively constant temperature and humidity of caves aid in the long-term preservation of organic material. Fossils formed inside the caves are protected from the harmful effects of solar radiation, as well as the forces of weathering and erosion.

### Questions:

- 1.) Complete the following sentences about the 2 ways that fossils can form in caves:
  - Fossils can be **PRESERVED** within the cave-forming rock.
  - Fossils **ACCUMULATE** within cave and karst features, such as in cave openings, sinkholes, and tubes.
- 3.) What are 2 things that remain relatively constant in caves that aids in the preservation of fossil resources? **TEMPERATURE AND HUMIDITY**

---

## Sedimentary Rocks

Of the 3 main types of rocks, igneous, metamorphic, and sedimentary, nearly all of the fossils that have been retrieved are found in sedimentary rocks. Sedimentary rocks form as pieces of sediment are redistributed and then re-consolidated, and as a result, fossils are often formed in the rocks as they solidify. Therefore, the formation of these rocks can tell us a great deal about the fossils they contain and also how they got there.

### Questions:

- 1.) What are the 3 main types of rocks? **IGNEOUS, METAMORPHIC, AND SEDIMENTARY**
- 2.) In which type of rock are nearly all fossils found? **SEDIMENTARY**
- 3.) How do sedimentary rocks form?  
**THEY FORM FROM THE NATURAL PROCESS OF WEATHERING AS PIECES OF SEDIMENT ARE REDISTRIBUTED AND THEN RE-CONSOLIDATED.**

# Caves and Fossils

# Student Copy



NPS Photo by Rick Wood

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# CAVES AND FOSSILS

---

## Background:

Our planet is a dynamic environment that has been continuously changing over the past 4.6 billion years. In order to make sense of these changes, scientists have developed a geologic time scale that separates the history of the Earth into distinctive periods of time. To accurately separate geologic time, paleontologists use clues, like fossils. These clues are used to reconstruct prehistoric environments and answer questions about the interactions between organisms and interactions between organisms and their environment. Fossils are critical resources to paleontologists because they represent life throughout history.

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*on* = “being, creature”  
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## Questions:

- 1.) What is the name for the scale paleontologists use to separate the history of the Earth into distinct time periods?
- 2.) What is the definition of paleontology?

---

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## Question:

- 1.) Name the 2 geological time periods that witnessed the formation of Mammoth Cave.

---

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Cave environments are conducive to the preservation of these paleontological resources. The relatively constant temperature and humidity of caves aid in the long-term preservation of organic material. Fossils formed inside the caves are protected from the harmful effects of solar radiation, as well as the forces of weathering and erosion.

### Questions:

- 1.) Complete the following sentences about the 2 ways that fossils can form in caves:
  - Fossils can be \_\_\_\_\_ within the cave-forming rock.
  - Fossils \_\_\_\_\_ within cave and karst features, such as in cave openings, sinkholes, and tubes.
- 3.) What are 2 things that remain relatively constant in caves that aids in the preservation of fossil resources?

---

## Sedimentary Rocks and Fossils

Of the 3 main types of rocks, igneous, metamorphic, and sedimentary, nearly all of the fossils that have been retrieved are found in sedimentary rocks. Sedimentary rocks form as pieces of sediment are redistributed and then re-consolidated, and as a result, fossils are often formed in the rocks as they solidify. Therefore, the formation of these rocks can tell us a great deal about the fossils they contain and also how they got there.

### Questions:

- 1.) What are the 3 main types of rocks?
- 2.) In which type of rock are nearly all fossils found?
- 3.) How to sedimentary rocks form?



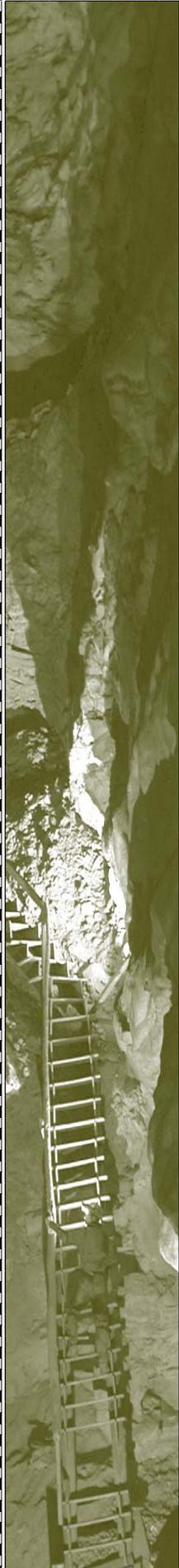
# Sediments and Solution Caves: Part 2

**Lesson Objective:** Upon completing this activity, students will understand how the creation of solution caves in sedimentary rocks affects fossil formation. Students will also understand the process of fossil excavation and will be introduced to stratigraphic columns.

**Key Concepts:** sediments and sedimentary rocks; sedimentation; limestone; fossils; rock matrix, solution caves; stratigraphic column.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students



Sediments and Solution Caves:  
Part 2

Teacher Copy  
and  
Answer Key

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## SEDIMENTATION LAB: PART 2 – TEACHER COPY

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**Materials:**

1. Sediments and Solution Caves: Part 2 handout for each student.
2. Excavation Directions for each group.
3. Excavation tools for each group: bamboo skewers or craft sticks; small paintbrush.
4. Newspaper to cover the tables.

---

### SUGGESTED ANSWERS

**Observation and Explanation:**

1. Observe how the sediments settled in the bottle and propose an explanation based on the information above.

*RESULTS MAY VARY, BUT IT IS IMPORTANT TO NOTE THAT HEAVY OBJECTS SETTLE OUT QUICKER THAN LIGHTER OBJECTS.*

---

**Excavation:**

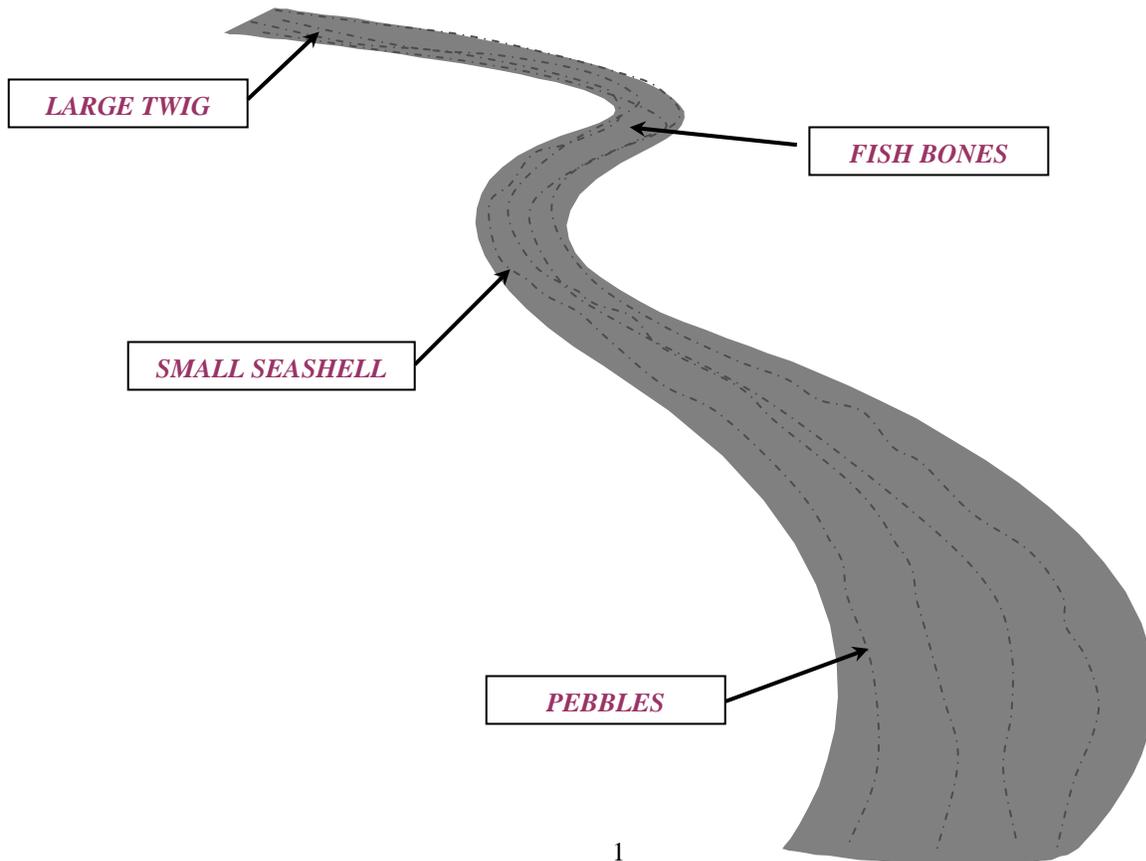
Data Table 1: *RESULTS MAY VARY*

---

Stratigraphic Columns: *RESULTS MAY VARY*

---

**Sedimentation:**





---

Questions:

1. What primary factor influenced your choices when labeling the sediments in the river diagram on page 3?

*THE WEIGHT OF THE OBJECTS*

2. What other factor(s) could have affected the order in which the sediments settled on the river bottom?

*THE SHAPE, TEXTURE, AND SIZE OF THE SEDIMENTS COULD ALSO HAVE AFFECTED THE RATE AT WHICH THEY SETTLED.*

3. How does the rate at which sediments settle affect the sediments found in caves?

*HEAVIER OBJECTS MAY SETTLE OUT BEFORE THEY GET TO THE CAVE*

4. How do the factors that affect the settling of sediments apply to the sediments in your soda bottle?

*HEAVIER OBJECTS SHOULD SETTLE OUT BEFORE THE LIGHTER ONES AND THEREFORE, WOULD BE ON THE BOTTOM OF THE SODA BOTTLE*

# Sediments and Solution Caves: Part 2

## Student Copy



NPS Photo by Rick Wood

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## SEDIMENTS AND SOLUTION CAVES: PART 2

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### **Introduction:**

Sedimentary rocks form from the accumulation and cementing of sediments, and as a result they tend to accumulate large amounts of debris in their layers. Some of the debris may become fossilized as these layers are slowly compressed over time. These fossils can be discovered if the surrounding rocks (*rock matrix*) are dissolved and the particles are washed away, such as in the formation of solution caves. The fossils can also be exposed as constant weathering by wind, rain, and ice wears down or causes fractures in the rocks.

Solution caves are formed as rock is dissolved along and adjacent to joints (fractures), faults, and layers. Gradually, as more and more rock is dissolved and removed, a cave is formed. When caves form in sedimentary rocks, such as limestone, fossils and other sediments may be revealed in the cave walls.

Examples of solution caves formed in limestone include the caves of Great Basin National Park in Nevada. These caves formed as rain water, turned slightly acidic by chemically reacting with surface vegetation, found its way into hairline cracks deep in the limestone. Trickling downward, the water dissolved the stone, enlarging the cracks and eventually forming areas large enough to be considered caves.

---

### **Materials:**

1. Your sedimentary rock from Part 1 of this lab.
  2. Newspaper to cover desk or table.
  3. Excavation tools: bamboo skewers or craft sticks, small paintbrush.
  4. Excavation directions sheet.
-

---

**Excavation:**

1. Place your soda bottle in a tray.
2. Carefully cut open the plastic bottle and remove the sedimentary rock.
3. Follow the directions on your excavation sheet to reveal the fossils in your rock.
4. Measure and describe the sediment core in Data Table 1.

---

**Data Table 1:**

Stratigraphic Order		Layer Thickness (cm)	Sediment Type	Fossils Found in Layer
(top layer)				
(bottom layer)				

---

## Stratigraphic Columns:

A *stratigraphic column* is a drawing done by a geologist that describes the sequence of rocks that would be present in a vertical section of rock. This allows other geologists, who may never have seen these rocks in person, to understand the geology of that area.

Below is an example of a how a geologist would create a stratigraphic column from the rocks of Grand Canyon National Park in Arizona.

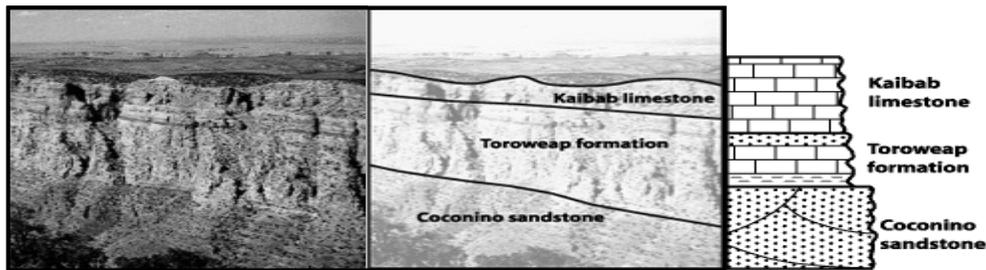


Image and text from: [http://www.priweb.org/ed/pgws/geology/stratigraphic\\_column.html](http://www.priweb.org/ed/pgws/geology/stratigraphic_column.html)

Using the style of stratigraphic column pictured above on the **far right side**, redraw the sediment layers from your soda bottle in the space below.

\* Label your layers

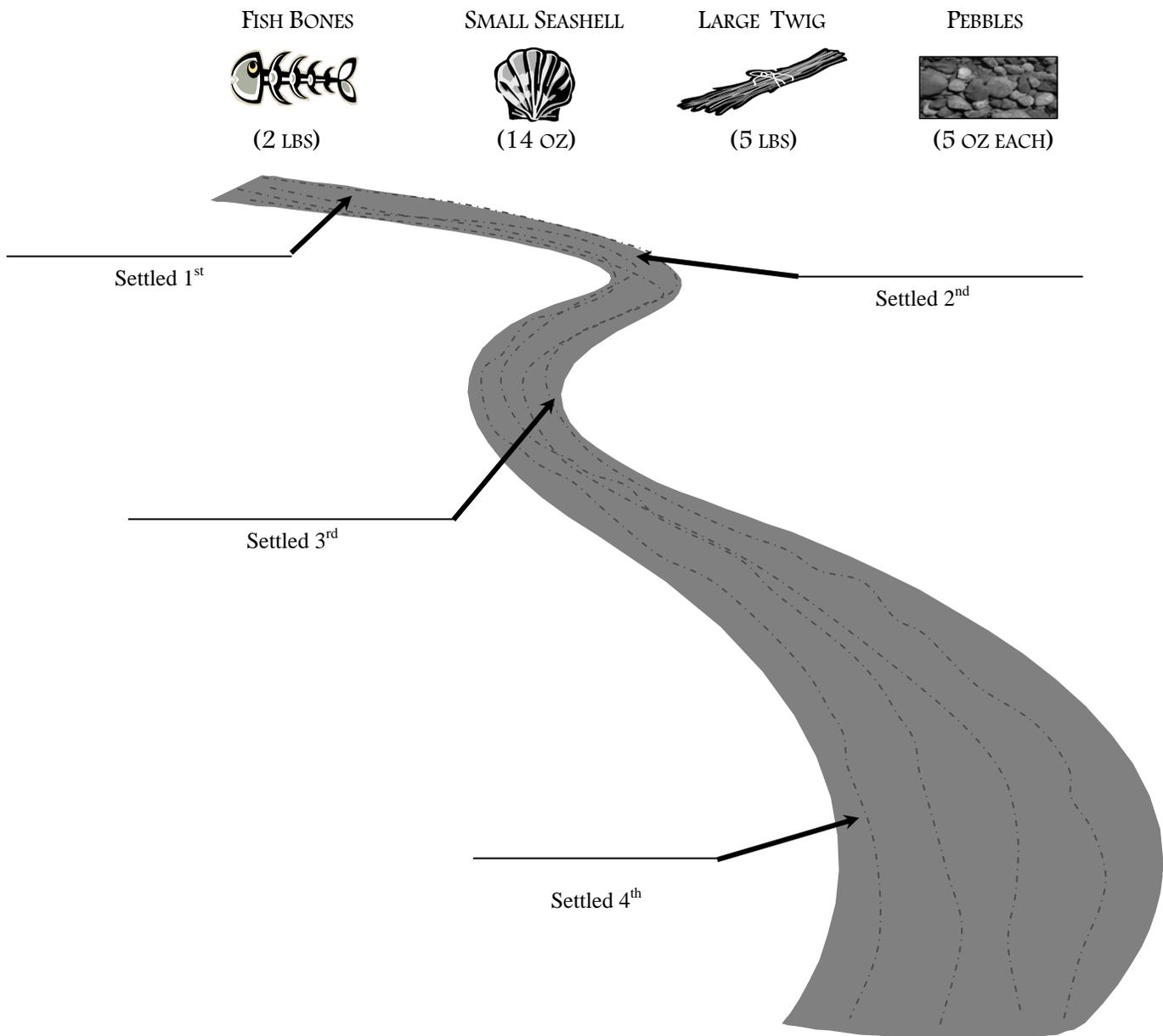
\* Differentiate between the soil layers by using different colors or textures for each layer

---

## Sedimentation:

As sediments are carried along by water, how far they are transported greatly depends on their mass (as affected by gravity) and the speed of the water. As water slows down it cannot hold as much mass and heavier items begin to settle.

Label the following diagram to show where the following sediments would settle during a flood if rainwater washed them down a river:





---

## Questions:

1. What primary factor influenced your choices when labeling the sediments in the river diagram on page 3?
2. What other factor(s) could have affected the order in which the sediments settled on the river bottom?
3. How does the rate at which sediments settle affect the sediments found in caves?
4. How do the factors that affect the settling of sediments apply to the sediments in your soda bottle?

# Hidden Treasures

**Lesson Objective:** This lesson will increase a student's understanding of the process involved with, and the importance of, paleontological resources and fossil formation.

**Key Concepts:** fossils; volcanic fossils; rock cycle; rock cycle processes: cooling, weathering and erosion, compaction and cementation, heat and pressure, melting; packrats; cave animals classification: troglodite, troglophile, and troglobite; midden; amberat; radio carbon dating.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students



NPS Photo by Rick Wood



Hidden Treasures

Teacher Copy,  
Answer Key, and  
Activity Fact Cards

# HIDDEN TREASURES- TEACHER COPY

## Activity #1: THE WASP

The age of fossils and the rocks in which they are found are important in telling us about historic environments. Explain how fossilized organisms, such as this wasp, can help scientists learn about the organisms and the environment they once lived in.

*Example answer:*

*By studying the fossil record we can tell how long life has existed on Earth, and how different plants and animals are related to each other. Often we can work out how and where they lived, and use this information to find out about ancient environments. The most direct information the fossil record provides is of an organism's physical structure and what it may have looked like, thereby enabling it to be classified. Other information such as its environment, its diet, and its life cycle is deduced from its physical attributes, from other fossils found in association, and from the types of rocks containing the fossils.*

## Activity #2: THE ROCK CYCLE

The rock cycle is a model of how the Earth's geological processes create, modify, and destroy rocks.

Use the following terms to correctly label the rock cycle.

Cooling	Sediments	Compaction & Cementation
Igneous Rock	Heat & Pressure	Metamorphic Rock
Melting	Sedimentary Rock	Weathering & Erosion

1. Magma
2. Cooling
3. Igneous Rock
4. Weathering & Erosion
5. Sediments
6. Compaction & Cementation
7. Sedimentary Rock
8. Heat & Pressure
9. Metamorphic Rock
10. Melting

### Summary:

Using the rock cycle handout and your answers from above as guides, summarize the processes of the rock cycle. **Start with the formation of magma** and work your way through the cycle.

*The rock cycle starts with molten rock (magma), which cools to form igneous rocks. These rocks weather and erode, and the eroded material is called sediments. These sediments are compacted and then cemented into sedimentary rocks. Then these sedimentary rocks are subjected to heat and pressure, which forms metamorphic rocks. Eventually, these metamorphic rocks may be heated to the point where they again melt into magma.*

## Activity #3: VOLCANIC FOSSILS

Students may benefit from having the “Views” Florissant Fossil Beds Virtual Experience on a computer for them to reference during the activity. If a computer is available, use the following links to access the appropriate section:

1. Access the Views website: <http://www2.nature.nps.gov/views/#>
2. Click on “Multimedia Version”
3. Click on “Virtual Experiences”
4. Click on “Florissant Fossil Beds”
5. Click on “Introduction”
6. Click on “Tours”
7. Click on “Eocene Epoch”
8. Click on “Geologic Story”

CARD TITLE	SUMMARY OF EVENTS
<i>Florissant Valley</i>	The mountain meadows of the Florissant Valley are home to a variety of fossils and fossils.
<i>Volcanic Activity</i>	A series of volcanic eruptions in the Florissant Valley created the conditions needed for the formation and preservation of fossils.
<i>Mudflows</i>	Volcanic mudflows are called lahars, and they are a mixture of sediment and debris. Lahars flowed down and buried the trees.
<i>Fossilized Trees</i>	The silica-rich lahars preserved the trees through “permineralization”, which is a type of fossilization.
<i>Lake Formation</i>	Another lahar flowed through the valley blocking the stream and causing the water to back and form lakes within the valley.
<i>Raining Ash &amp; Clay Lakes</i>	The volcanic complex remained active for many years and subsequent eruptions released ash and pumice into the air. Rain washed the ash into the lake where it became clay.
<i>Trapped!</i>	Organisms settle into the clay at the bottom of the lakes.
<i>The Formation of Fossils</i>	The layers of organisms in the clay built up and over time compacted into shale. The formation of the shale created carbonized compressions and impression fossils of the organisms trapped inside.
<i>Fossil Protection</i>	A final lahar formed a protective caprock that helped shield and protect the fossils.

**\* A pictorial answer key is also provided. \***

## Activity #4: **PACKRATS**

Cave animals are categorized based on the amount of time they spend in caves. There are three categories of cave animals: **trogloxenes** (cave visitors), **troglophiles** (animals that spend considerable amounts of time in caves, but are not dependent on them), and **troglobites** (animals that are found exclusively in caves). Packrats, also known as woodrats and trade rats, are troglloxenes and their visits to caves have huge impacts on the paleontological resources.

This activity will introduce you to these furry cave guests and help you understand their affects on cave fossils.



**WE SUGGEST HAVING THE STUDENTS TAKE TURNS  
READING THE PACKRATS HANDOUT ALOUD TO  
THE OTHER GROUP MEMBERS.**



1.) What terms describe the following types of cave dwellers?

- Animals that are found exclusively in caves: **TROGLOBITES**
- Animals that periodically visit caves: **TROGLOXENES**
- Animals that love caves: **TROGLOPHILES**

2.) What are packrat nests called? **MIDDENS**

3.) Name 4 objects that could possibly be found in a packrat nest:

- **BONES**
- **PLANT MATERIAL**
- **STICKS**
- **SPOON OR WATCH**

4.) True or False: Packrats only use their nest once and build a new one year after year. **FALSE**

5.) True or False: Packrats urinate on their nests. **TRUE**

6.) What is amberat? **WHEN PACKRAT URINE HARDENS OVER TIME IT HAS A GLOSSY, HARD YELLOW APPEARANCE WHICH IS CALLED AMBERAT.**

7.) What is a technique that researchers have used to find out how old a packrat nest is?

**RADIO CARBON DATING**



Hidden Treasures

Activity  
Fact Cards

NPS Photo by Rick Wood

# THE WASP

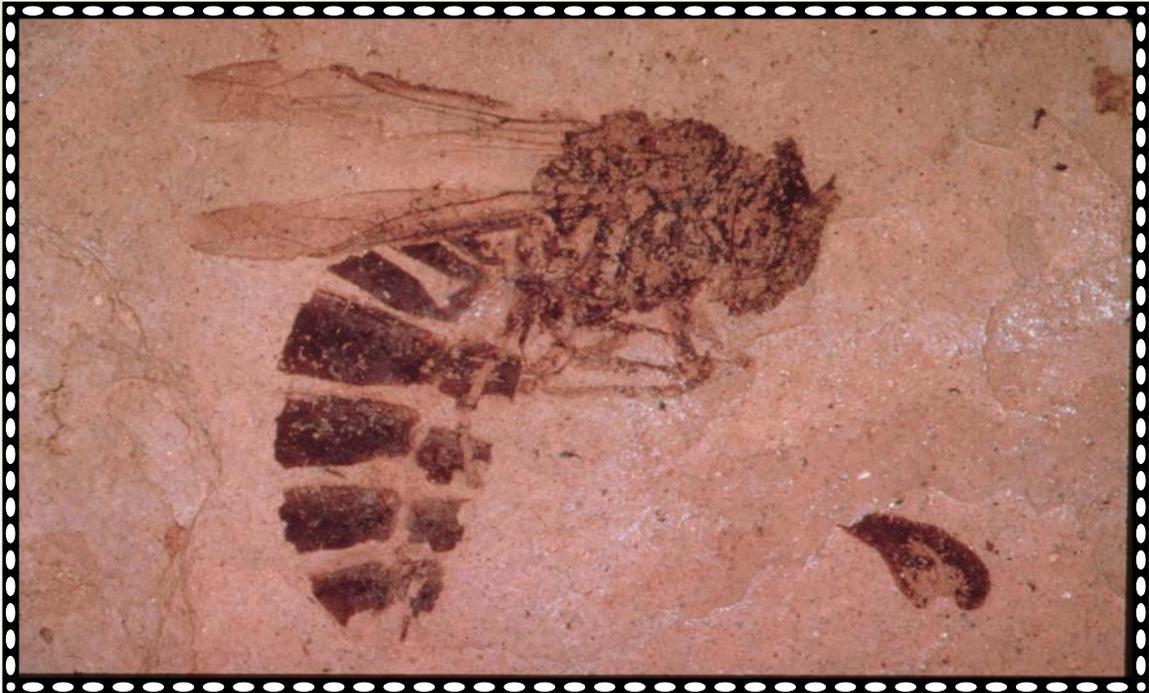
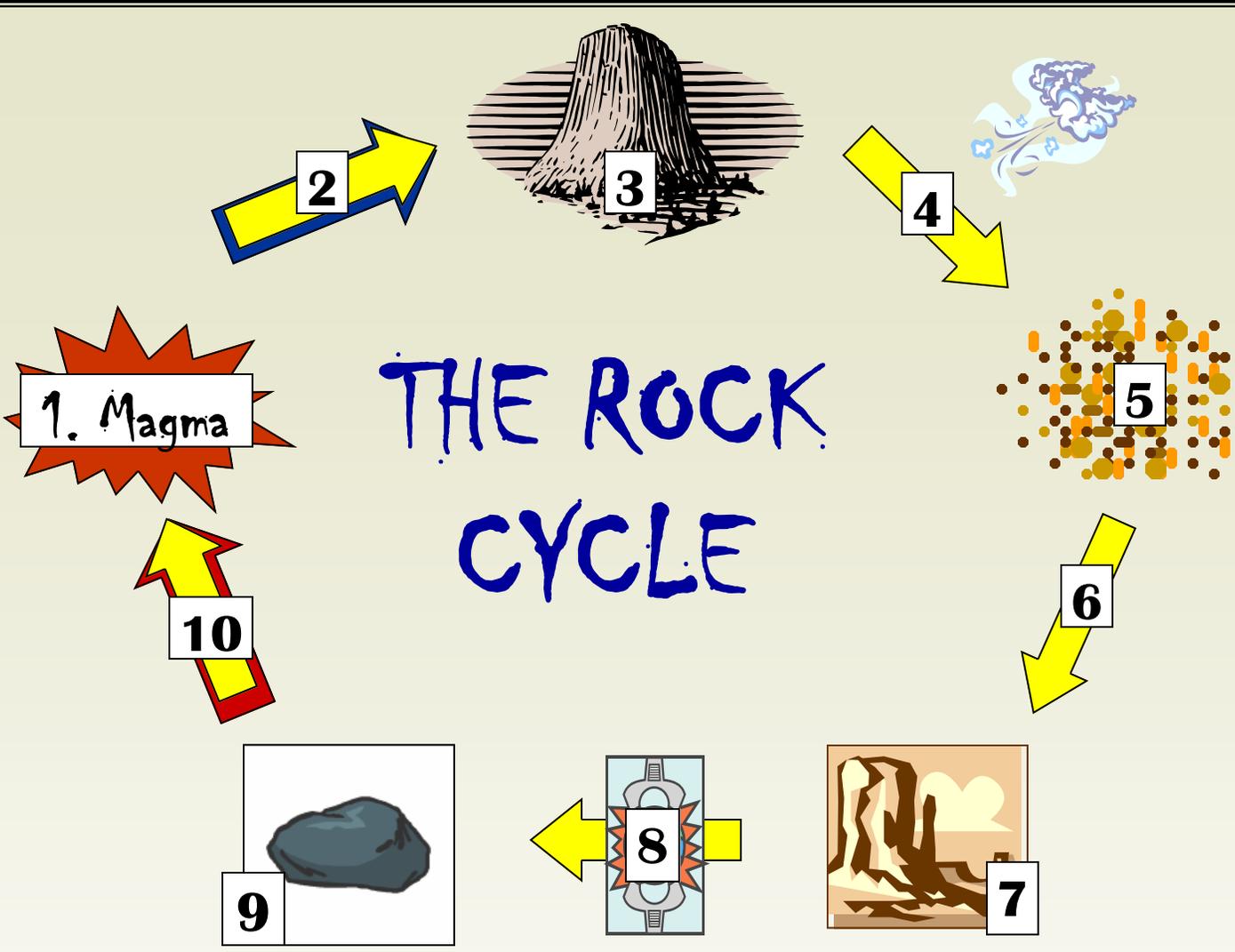


Photo courtesy of Florissant Fossil Beds National Monument

This is a photograph of a fossilized wasp found in Florissant Fossil Beds National Monument. Explain WHAT and HOW fossilized organisms, such as this wasp, can tell us about the environment they once lived in.

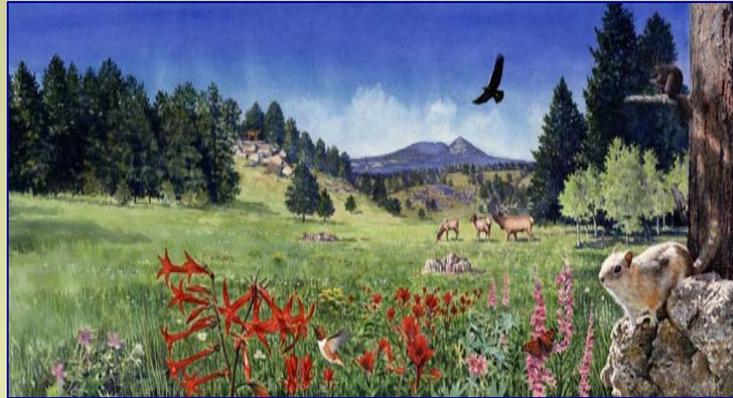
# THE ROCK CYCLE



USE THE FOLLOWING TERMS TO LABEL THE ROCK CYCLE

Cooling	Sediments	Compaction & Cementation
Igneous Rock	Heat & Pressure	Metamorphic Rock
Melting	Sedimentary Rock	Weathering & Erosion

# FLORISSANT VALLEY

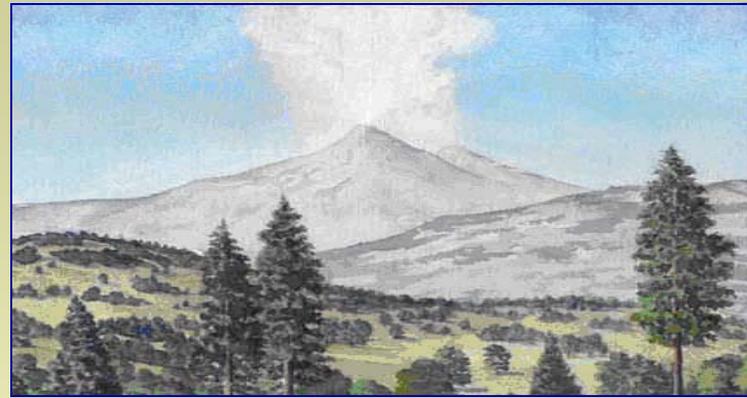


Original artwork by Rob Wood

The mountain meadows and forests of Colorado's Florissant Valley are home to a variety of wildlife.

The valley is also rich in fossils.

# VOLCANIC ACTIVITY



Original artwork by Rob Wood

A series of volcanic eruptions occurred in the Florissant Valley during the Eocene Epoch.

These eruptions created the conditions needed for the formation and preservation of fossilized organisms.

# MUDFLOWS



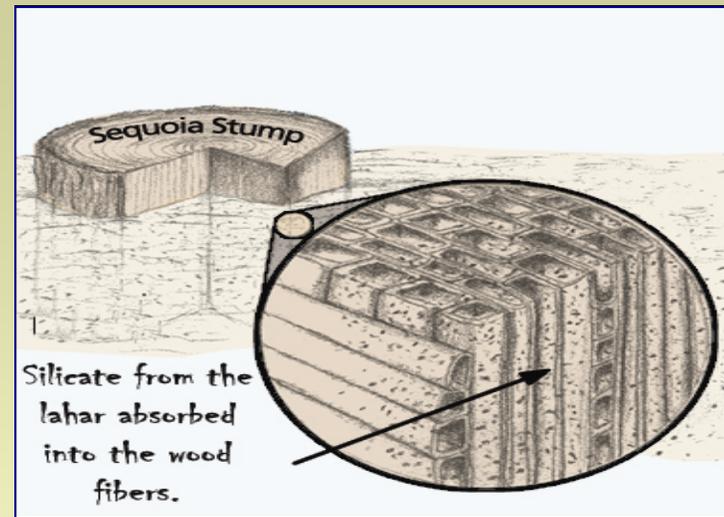
Original artwork by Rob Wood

The eruptions in the Florissant Valley created mudflows called *lahars*.

Lahars are a mixture of volcanic sediments and debris.

These lahars flowed down from the volcano and buried the surrounding trees.

# Fossilized TREES



Original artwork by Linda Lutz-Ryan

The burial in the silica-rich lahar preserved and fossilized the tree trunks through a process called “permineralization”.

Permineralization is a type of fossilization where the original hard parts of an organism have additional mineral material deposited in their pore spaces.

Source: Bates and Jackson (1984)

# LAKE FORMATION



After the burial and preservation of the trees, another lahar flowed through the valley and blocked the stream.

With no escape path, the stream backed up and filled the valley with water. This surplus of water formed lakes in the valley, such as the ancient Lake Florissant.

# RAINING ASH & LAKES OF CLAY



Following the formation of the lakes, the volcanic complex remained active for many years.

Subsequent volcanic eruptions released ash and pumice into the air.

Rainstorms would then wash the ash into the lakes where it settled to the bottom and eventually became clay.

# TRAPPED!



Original artwork by Rob Wood

Many organisms settled to the bottom of the lakes and became buried in the clay.

Insects and plant parts (leaves, cones, berries) settled to the bottom in great numbers.

Fish, mammals, and other creatures living in the area also settled to the bottom of the lakes.

# THE FORMATION OF FOSSILS



NPS Photos courtesy of Florissant Fossils Beds National Monument

The layers of organisms and sediments buried in the clay built up and were compacted and cemented into *shale*.

The formation of the shale created carbonized compressions and impression fossils of the organisms trapped inside.

# Fossil Protection



Original artwork by Rob Wood

A final lahar covered the shale and formed a protective *caprock*.

This caprock shielded the shale from erosion and helped to preserve and protect the fossils.

# Answer Key

1

## FLORISSANT VALLEY



The mountain meadows and forests of Colorado's Florissant Valley are home to a variety of wildlife.

The valley is also rich in fossils.

2

## VOLCANIC ACTIVITY



A series of volcanic eruptions occurred in the Florissant Valley during the Eocene Epoch.

These eruptions created the conditions needed for the formation and preservation of fossilized organisms.

3

## MUDFLOWS

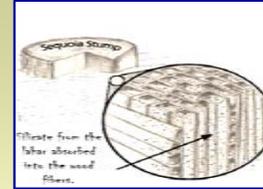


The eruptions in the Florissant Valley created mudflows called *lahars*.

Lahars are a mixture of volcanic sediments and debris.

4

## FOSSILIZED TREES



The burial in the silica-rich lahar preserved and fossilized the tree trunks through a process called "permineralization".

**Permineralization** is a type of fossilization where the original hard parts of an organism have additional mineral material deposited in their pore spaces.

Source: Bates and Jackson (1984)

5

## LAKE FORMATION



After the burial and preservation of the trees, another lahar flowed through the valley and blocked the stream.

With no escape path, the stream backed up and filled the valley with water. This surplus of water formed lakes in the valley, such as the ancient Lake Florissant.

6

## RAINING ASH & LAKES OF CLAY



Following the formation of the lakes, the volcanic complex remained active for many years.

Subsequent volcanic eruptions released ash and pumice into the air.

Rainstorms would then wash the ash into the lakes where it settled to the bottom and eventually became clay.

7

## TRAPPED!



Many organisms settled to the bottom of the lakes and became buried in the clay.

Insects and plant parts (leaves, cones, berries) settled to the bottom in great numbers.

Fish, mammals, and other creatures living in the area also settled to the bottom of the lakes.

8

## THE FORMATION OF FOSSILS



The layers of organisms and sediments buried in the clay built up and were compacted and cemented into *shale*.

The formation of the shale created carbonized compressions and **impression fossils** of the organisms trapped inside.

9

## FOSSIL PROTECTION



A final lahar covered the shale and formed a protective *caprock*.

This caprock shielded the shale from erosion and helped to preserve and protect the fossils.



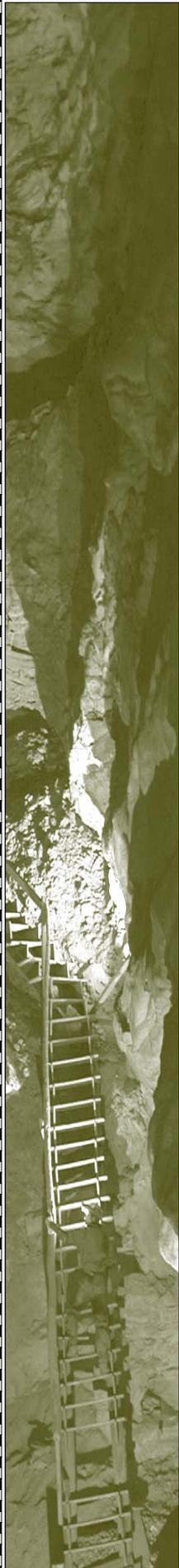
# Packrats

Packrats are small mammals that collect objects to build their nests, which are called middens. These opportunistic creatures will pick up anything they find, including plant matter, bones, vegetation, and other available material. Packrats find an object, such as a piece of cactus, and scurry back to their home with it in their mouth. If they find something better along the way, they drop their current treasure and trade it for the new object. Many a miner or camper in the past has awakened to find a cone or stick in place of a spoon or watch.

Generations of packrats can live in the same area, building middens of tremendous proportions. Some are 5-feet tall and 10-feet wide. These middens are fortresses of tangled vegetation, bones, sticks and other items that are held together by organic glue...the urine of the packrat. This urine hardens over time and because of its glossy, hard yellow appearance, is called *amberat*. Analysis of the amberat can offer insights into the physiology of the packrats themselves.

Middens have persisted for thousands of years, becoming storehouses of scientific information. Researchers have used radiocarbon dating to discover some middens over 35,000 years old! Paleoecologists study ancient middens to research ancient climates, and biologists can use middens to determine what species lived in an area thousands of years ago. Its exciting to think that there are still more discoveries to be found in these biological warehouses.





NPS Photo by Rick Wood

Hidden Treasures  
Student Copy



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## Activity #2: THE ROCK CYCLE

The rock cycle is a model of how the Earth's geological processes create, modify, and destroy rocks.

Use the following terms to correctly label the rock cycle.

Cooling	Sediments	Compaction & Cementation
Igneous Rock	Heat & Pressure	Metamorphic Rock
Melting	Sedimentary Rock	Weathering & Erosion

1. Magma
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_
10. \_\_\_\_\_

### Summary:

Using the rock cycle handout and your answers from above as guides, summarize the processes of the rock cycle. **Start with the formation of magma** and work your way through the cycle.

---

## Activity #3: VOLCANIC FOSSILS

The environment where a fossil is found can sometimes tell us how that fossil was formed. For example, fossils found within the structural rocks of caves have been preserved within the cave-forming rock. Fossilized insects found in amber were once stuck in the sap of trees, and when the sap turned into amber the insect was trapped inside. Volcanic activity can also produce the necessary conditions for the formation of fossils.

In this activity we will use the explosive history of the **Florissant Fossil Beds National Monument** as an example of how volcanoes can create and conserve fossils. Read through the provided information cards and put them in the correct geological order. Once you have them in order, fill in the titles of the cards in the boxes on the left and summarize the cards on the right.

CARD TITLE	SUMMARY OF EVENTS
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	

# Activity #4: PACKRATS

Cave animals are categorized based on the amount of time they spend in caves. There are three categories of cave animals: **trogloxenes** (cave visitors), **troglophiles** (animals that spend considerable amounts of time in caves, but are not dependent on them), and **troglobites** (animals that are found exclusively in caves). Packrats, also known as woodrats and trade rats, are troglloxenes and their visits to caves have huge impacts on the paleontological resources.

This activity will introduce you to these furry cave guests and help you understand their affects on cave fossils. Read the information on the Packrats handout and then answer the questions below:

1.) What terms describe the following types of cave dwellers?

- Animals that are found exclusively in caves: \_\_\_\_\_
- Animals that periodically visit caves: \_\_\_\_\_
- Animals that love caves: \_\_\_\_\_

2.) What are packrat nests called?

3.) Name 4 objects that could possibly be found in a packrat nest:

- 
- 
- 
- 

4.) True or False: Packrats only use their nest once and build a new one year after year.

5.) True or False: Packrats urinate on their nests.

6.) What is amberat?

7.) What is a technique that researchers have used to find out how old a packrat nest is?



NPS sketch: Craters of the Moon National Monument and Preserve

# Porosity Mini-Lab

**Lesson Objective:** After completing this activity students will have a better understanding of pore space and a simple way to measure the relative pore space of 2 different particle samples.

**Key Concepts:** pore space and porosity; aquifer.

**Duration:** 1 approximately 40-minute class period

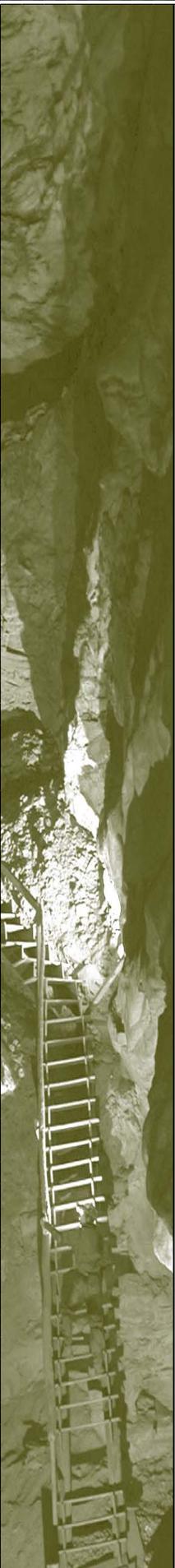
**Audience:** Middle school and high school students



NPS Photo by Rick Wood

Porosity Mini-Lab

Teacher Copy  
and  
Answer Key

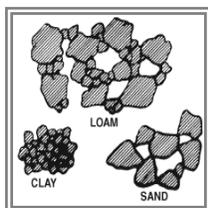


NPS Photo by Rick Wood

## MINI-LAB: POROSITY<sup>i</sup> ~ TEACHER COPY

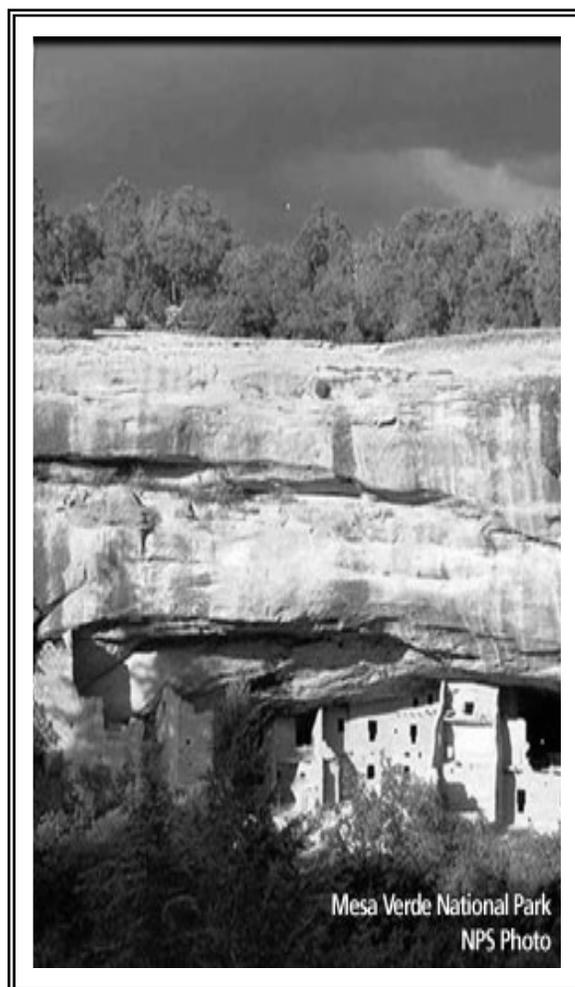
### *How can you measure pore space?*

#### Background:



What we perceive as solid rock is often not so solid. Rock formations made from sedimentary rocks, like sandstone, have spaces between the sediments. These spaces, or pores, are the result of irregular shaped particles not fitting together. (The picture on the left illustrates 3 classifications of soil textures and their relative pore spaces.) Spaces may be formed between soil particles due to the movement of roots, worms, and insects; expanding gases trapped within these spaces by groundwater; and/or the dissolution of the rock.

Sandstone caves can form through weathering processes where sandstone and shale meet. Water readily percolates down through sandstone but is trapped and cannot pass through shale beds because their pore spaces are so small. The groundwater is forced to move laterally along the contact between the two rock units until it seeps out on the face of the canyon wall or at the back of an alcove, creating a spring or seep. The prolonged flow of water along these spring and seep zones ultimately dissolves the calcium carbonate cement and loosens individual sand particles and blocks of sandstone, thus forming a void that enlarges with time. These voids can develop into caves similar to the ones early people used at Mesa Verde National Park (see photo on the right).



---

## Why is this important?

There are many reasons why it is important to study and understand pore spaces and how they affect their soil environment. The first reason is that underground aquifers hold the groundwater we drink within the pore spaces of rock formations. Approximately 40% of the U.S. population relies upon karst aquifers for drinking water. It is very important to protect these underground water resources. You see this by looking at the flow through the Mammoth Cave Karst aquifer. Approximately 1000 to 10,000 feet of water per day flow through this aquifer. Contaminants entering the karst aquifer can thus be rapidly transported and spread.

**Aquifer:** a porous rock formation that transports underground water resources.

Another important aspect of soil concerns our transportation: 50% of U.S. citizens obtain part or all of the oil and gas found within pore spaces.<sup>ii</sup> Crude oil is the “raw” source from which we manufacture gasoline, and there have been many conflicts, even wars, waged over this natural resource. A final reason to study the porosity of soils is because of the oxygen found within these pore spaces. All plants need oxygen for respiration, so a well-aerated soil is desired by the farmers that produce the crops we eat.

***IN SUMMARY...SOMETHING AS SIMPLE AS THE SPACES BETWEEN PARTICLES OF SOIL CAN AFFECT THE WATER WE DRINK, THE FOOD WE EAT, AND THE WAY WE GET FROM PLACE TO PLACE!***



### Questions:

- 1.) What are 3 factors that may result in the formation of pore spaces between soil particles?
  - **MOVEMENT OF ROOTS, WORMS, AND INSECTS**
  - **EXPANDING GASES TRAPPED WITHIN THESE SPACES BY GROUNDWATER**
  - **DISSOLUTION OF THE ROCK (THE ROCK DISSOLVED AND LEFT BEHIND SPACES)**

## TEACHER COPY AND ANSWER KEY

- 2.) Explain the difference between the movement of water through sandstone and through shale.

***WATER MOVES EASILY THROUGH THE SANDSTONE; SHALE HAS SMALLER PORE SPACES AND THEREFORE, WATER CANNOT PASS THROUGH.***

- 3.) What is an aquifer?

***A POROUS ROCK FORMATION THAT TRANSPORTS UNDERGROUND WATER RESOURCES***

- 4.) List 3 ways pore spaces can affect the human population:

- ***THEY HOLD THE WATER WE DRINK IN AQUIFERS***
- ***THEY HOLD OIL THAT WE USE FOR TRANSPORTATION***
- ***OXYGEN TRAPPED WITHIN THE PORE SPACES IS NEEDED BY PLANTS FOR RESPIRATION***

---

### Mini-Lab Procedure:

1. Put 100ml of sand in one beaker and 100ml of gravel in another beaker.
2. Fill a graduated cylinder with 100 ml of water.
3. Pour the water slowly into the gravel and stop when the water just covers the top of the gravel.
4. Record the amount of water used in the table to the right.
5. Repeat step 3 with the sand.
6. Record the amount of water used in the table to the right.
7. Answer the following questions:

Particle Type	Volume of Water Used (ml)
Sand	
Gravel	

**Which substance has more pore space: gravel or sand?**

***GRAVEL***

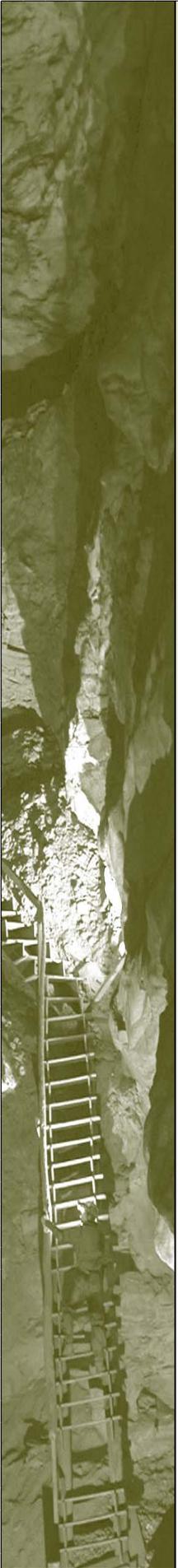
**How did you make this decision?**

***GRAVEL HAS MORE PORE SPACE BECAUSE THERE ARE LARGER SPACES IN-BETWEEN THE SEDIMENTS. THE LARGER SPACES ARE A RESULT OF THE IRREGULAR SHAPES OF THE GRAVEL PARTICLES. SAND IS SMOOTHER AND ROUNDER, WHICH HELPS IT FIT TOGETHER BETTER AND LEAVE LESS SPACE IN-BETWEEN THE PARTICLES.***

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<sup>i</sup> Lab adapted from: Merrill *Earth Science* by Glencoe. Macmillan/McGraw-Hill. Copyright 1993 by the Glencoe Division of Macmillan/McGraw-Hill School Publishing Company.

<sup>ii</sup> *Soils in our Environment*, 7<sup>th</sup> Edition by Miller and Donahue. Copyright 1995 by Prentice-Hall Inc.



NPS Photo by Rick Wood

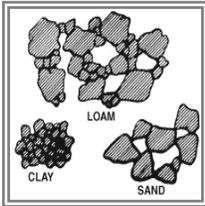
## Porosity Mini-Lab

# Student Copy

# MINI-LAB: POROSITY

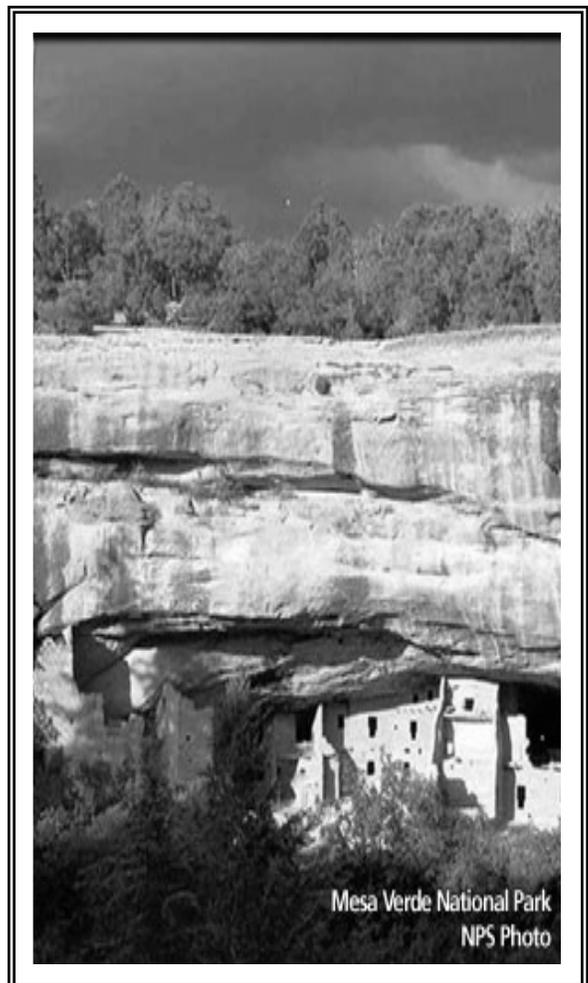
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***IN SUMMARY...SOMETHING AS SIMPLE AS THE SPACES BETWEEN PARTICLES OF SOIL CAN AFFECT THE WATER WE DRINK, THE FOOD WE EAT, AND THE WAY WE GET FROM PLACE TO PLACE!***



### Questions:

1.) What are 3 factors that may result in the formation of pore spaces between soil particles?

- 
- 
-

2.) Explain the difference between the movement of water through sandstone and through shale.

3.) What is an aquifer?

4.) List 3 ways pore spaces can affect the human population:

- 
- 
- 

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### Mini-Lab Procedure:

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Gravel	

Which substance has more pore space: gravel or sand?

How did you make this decision?

---

<sup>i</sup> *Soils in our Environment*, 7<sup>th</sup> Edition by Miller and Donahue. Copyright 1995 by Prentice-Hall Inc.

# Porosity of Sediments

**Lesson Objective:** After completing this activity students will have a better understanding of how to measure and calculate pore space, and what properties influence the porosity of varying sediments.

**Key Concepts:** sedimentary rock (sandstone); pores and pore space; calculating porosity; particle size; properties that influence porosity: sorting, grain type, grain shape, grain size, grain packing.

**Duration:** 1 55-minute class period

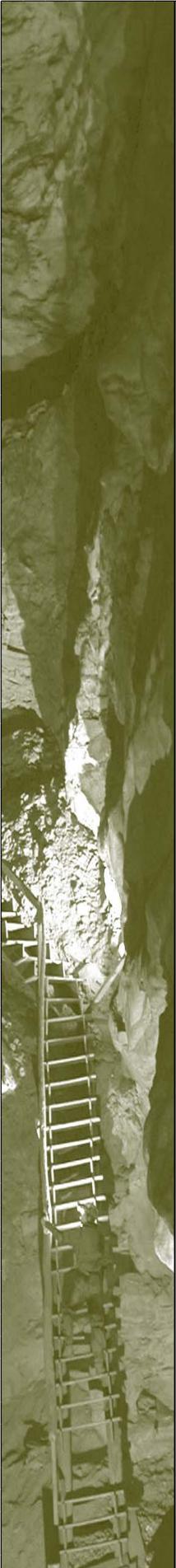
**Audience:** Middle school and high school students



NPS Photo by Rick Wood

Porosity of Sediments

Teacher Copy  
and  
Answer Key



NPS Photo by Rick Wood

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# POROSITY OF SEDIMENTS LAB <sup>i</sup> ~ TEACHER COPY

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*How much open space is there in sandstones composed of varying sediment types?*

## Lesson Objective:

After completing this activity students will gain a better understanding of how to measure and calculate pore space, and what properties influence the porosity of varying sediments.

## Background:

Rock formations made from sedimentary rocks have spaces between the sediments called pores. These pores are the result of irregular shaped particles not fitting together. Sedimentary rocks, like sandstone, can be composed of a variety of sediments and each sediment type has a unique number of pores. The difference in pores, and the corresponding pore space, results in different types of rocks having different pore volumes. Liquids, like oil, gas, or water, move through the different types of rocks at different rates due to the difference in pore volumes.

## Materials:

- Gravel
- Sand
- Water
- Calculator
- Magnifying Glass
- 100 mL Graduated Cylinder
- Small, plastic beads
- Large, plastic beads
- 4 Beakers

## Investigation 1:

1. Beaker #1:-----Fill to 100 mL with the large, plastic beads.
2. Beaker #2:-----Fill to 100 mL with the small, plastic beads.
3. Graduated cylinder: :-----Fill to 50 mL with water.
4. Slowly pour the water into Beaker #1 until the water just reaches the top of the beads.
  - a. Record exactly how much water was used in Data Table A.
  - b. If you need more than 50 mL, fill the graduated cylinder again.
5. Follow Step 4 again for Beaker #2.
6. Fill the graduated cylinder with 100 mL of water.
7. Now mix the large beads with the small beads.
8. Follow Step 4 again for the mixed beads.

### Data Table A:

Type of Sediment	Volume of Water (Pore Space)	Volume of Sediment	% Pore Space (Porosity)
Large Beads			
Small Beads			
Large + Small Beads			

### Calculating Porosity:

For each sediment type, calculate the porosity by dividing the volume of water that you were able to pour into the sediment by the total volume of the material. Then express this as a percentage:

$$\frac{\text{Volume of Water (Pore Space)}}{\text{Volume of Sediment}} = \% \text{ Pore Space (Porosity)}$$

### Investigation 2:

1. Use the magnifying glass and classify the gravel and sand in the table below:

Sediment Type	%Round : % Angular	Well-Sorted	Poorly Sorted
Gravel	<i>RESULTS MAY VARY</i>	<i>NO</i>	<i>YES</i>
Sand	<i>RESULTS MAY VARY</i>	<i>YES</i>	<i>NO</i>

2. Beaker #1:-----Fill to 100 mL with gravel.
3. Beaker #2:-----Fill to 100 mL with sand.
4. Graduated cylinder: :-----Fill to 50 mL with water.
5. Slowly pour water into Beaker #1 until the water just reaches the top of the gravel.
  - a. Record exactly how much water was used in Data Table B.
  - b. If you need more than 50 mL, fill the graduated cylinder again.
6. Follow Step 5 again for Beaker #2.
7. Fill the graduated cylinder with 100 mL of water.
8. Now mix the gravel with the sand.
9. Follow Step 5 again for the mixed sediments.

Data Table C:

Type of Sediment	Volume of Water (Pore Space)	Volume of Sediment	% Pore Space (Porosity)
Gravel			
Sand			
Gravel + Sand			

Conclusions:

1. Compare the large bead porosity to the small bead porosity.

***THE LARGER BEADS HAVE A GREATER POROSITY THAN THE SMALLER BEADS.***

2. Explain how the bead porosity depends on particle size.

***BASED ON THIS INVESTIGATION, THE LARGER BEADS HAVE A LARGER POROSITY AND THE SMALLER BEADS HAVE A SMALLER POROSITY. THIS IS BECAUSE THE LARGER BEADS HAVE BIGGER VOID SPACE IN THE CENTER.***

3. Explain the effect of mixing bead sizes on porosity.

***MIXING THE BEAD SIZES LOWERED THE POROSITY BECAUSE THE SMALL BEADS FILLED IN THE VOIDS.***

4. Compare the gravel porosity to the sand porosity of the sediments in your investigation.

***RESULTS MAY VARY***

**Teacher Copy and Answer Key**

5. In general, well-sorted sediments, like sand, have a high porosity and poorly-sorted sediments, like gravel, have a low porosity. Does your porosity values compare to this sorting observation, or not? Explain.

***RESULTS MAY VARY***

6. In general, sphere-shaped sediments, like sand, will pack more closely together and have a low porosity. Do your observations of grain shape for the sand support this statement? Explain

***RESULTS MAY VARY***

7. Explain the effect of mixing sediment types on porosity.

***MIXING THE SEDIMENT TYPES LOWERED THE POROSITY BECAUSE THE SMALLER, SPHERE-SHAPED SAND PARTICLES FILLED IN THE VOIDS OF THE ANGULAR GRAVEL.***

8. Based on these investigations, list 5 properties of sediments that influence porosity:

Property 1: ***SORTING***

Property 2: ***GRAIN TYPE***

Property 3: ***GRAIN SHAPE***

Property 4: ***GRAIN SIZE***

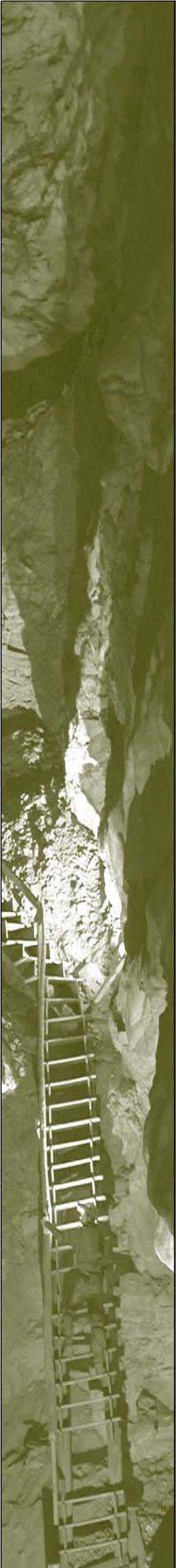
Property 5: ***GRAIN PACKING (How they are packed together)***

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<sup>i</sup> Lab adapted from: <http://www.seed.slb.com/en/scictr/lab/porosity/>, and <http://www.uwsp.edu/water/portage/undrstnd/soil.htm>

Porosity of Sediments

# Student Copy



NPS Photo by Rick Wood

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# POROSITY OF SEDIMENTS LAB

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*How much open space is there in sandstones composed of varying sediment types?*

## Background:

Rock formations made from sedimentary rocks have spaces between the sediments called pores. These pores are the result of irregular shaped particles not fitting together. Sedimentary rocks, like sandstone, can be composed of a variety of sediments and each sediment type has a unique number of pores. The difference in pores, and the corresponding pore space, results in different types of rocks having different pore volumes. Liquids, like oil, gas, or water, move through the different types of rocks at different rates due to the difference in pore volumes.

## Materials:

- Gravel
- Sand
- Water
- Calculator
- Magnifying Glass
- 100 mL Graduated Cylinder
- Small, plastic beads
- Large, plastic beads
- 4 Beakers

## Investigation 1:

1. Beaker #1:----- Fill to 100 mL with the large, plastic beads.
2. Beaker #2:----- Fill to 100 mL with the small, plastic beads.
3. Graduated cylinder: :----- Fill to 50 mL with water.
4. Slowly pour the water into Beaker #1 until the water just reaches the top of the beads.
  - a. Record exactly how much water was used in Data Table A.
  - b. If you need more than 50 mL, fill the graduated cylinder again.
5. Follow Step 4 again for Beaker #2.
6. Fill the graduated cylinder with 100 mL of water.
7. Now mix the large beads with the small beads.
8. Follow Step 4 again for the mixed beads.

### Data Table A:

Type of Sediment	Volume of Water (Pore Space)	Volume of Sediment	% Pore Space (Porosity)
Large Beads			
Small Beads			
Large + Small Beads			

### Calculating Porosity:

For each sediment type, calculate the porosity by dividing the volume of water that you were able to pour into the sediment by the total volume of the material. Then express this as a percentage:

$$\frac{\text{Volume of Water (Pore Space)}}{\text{Volume of Sediment}} = \% \text{ Pore Space (Porosity)}$$

### Investigation 2:

1. Use the magnifying glass and classify the gravel and sand in the table below:

Sediment Type	%Round : % Angular	Well-Sorted	Poorly Sorted
Gravel			
Sand			

2. Beaker #1:-----Fill to 100 mL with gravel.
3. Beaker #2:-----Fill to 100 mL with sand.
4. Graduated cylinder: :-----Fill to 50 mL with water.
5. Slowly pour water into Beaker #1 until the water just reaches the top of the gravel.
  - a. Record exactly how much water was used in Data Table B.
  - b. If you need more than 50 mL, fill the graduated cylinder again.
6. Follow Step 5 again for Beaker #2.
7. Fill the graduated cylinder with 100 mL of water.
8. Now mix the gravel with the sand.
9. Follow Step 5 again for the mixed sediments.

### Data Table C:

Type of Sediment	Volume of Water (Pore Space)	Volume of Sediment	% Pore Space (Porosity)
Gravel			
Sand			
Gravel + Sand			

### Conclusions:

1. Compare the large bead porosity to the small bead porosity.

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2. Explain how the bead porosity depends on particle size.

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3. Explain the effect of mixing bead sizes on porosity.

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4. Compare the gravel porosity to the sand porosity of the sediments in your investigation.

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5. In general, well-sorted sediments, like sand, have a high porosity and poorly-sorted sediments, like gravel, have a low porosity. Does your porosity values compare to this sorting observation, or not?

Explain. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

6. In general, sphere-shaped sediments, like sand, will pack more closely together and have a low porosity. Do your observations of grain shape for the sand support this statement? Explain.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

7. Explain the effect of mixing sediment types on porosity. \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

8. Based on these investigations, list 5 properties of sediments that influence porosity:

Property 1: \_\_\_\_\_

Property 2: \_\_\_\_\_

Property 3: \_\_\_\_\_

Property 4: \_\_\_\_\_

Property 5: \_\_\_\_\_



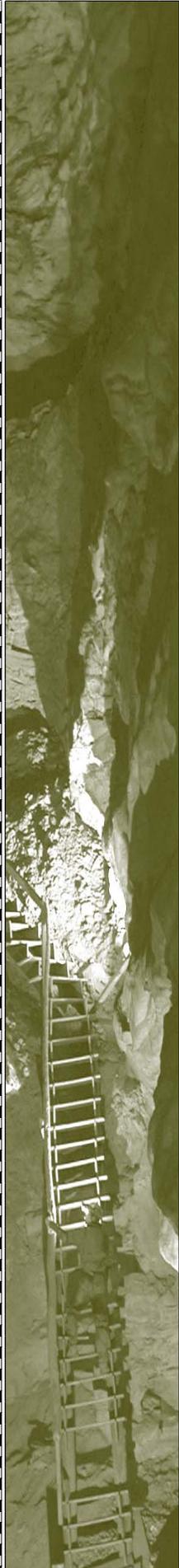
# Cave Life: A “Jigsaw” Activity

**Lesson Objective:** After reading an assigned text on cave animal classifications or cave zones, students will be able to answer questions relative to their assigned text and then present the information to their cooperative group members.

**Key Concepts:** cave life; cave zones: entrance zone, twilight zone, variable temperature zone and complete darkness, and dark zone; cave animal classification: troglonenes, troglonhiles, and troglonbites; cooperative learning.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students



NPS Photo by Rick Wood

Cave Life: A Jigsaw Activity  
Teacher Copy,  
Answer Key, and  
Activity Fact Cards

# CAVE LIFE: TEACHER COPY

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## A “Jigsaw” Cooperative Learning Strategy

### Lesson Objective:

After reading an assigned text on cave life, students will be able to answer questions about the text and present the information to their group members.

### Materials:

1. Cave Life Facts Sheets (4 different fact sheets for each group).
2. Cave Life Worksheets for each student

### Teacher Instructions:

1. Predetermine groups of 4 students and assign a different cave animal fact sheet to each group member.
2. At the beginning of class, have students get together in their assigned groups.
3. Explain how a jigsaw works:
  - a. Explain that the students will have 10 minutes to independently read their assigned section and answer the questions.
  - b. Next, the students will get together in 4 large groups to briefly discuss the answers to the questions for their assigned selections and share key concepts. (Should take no more than about 8 minutes).
  - c. Finally, they will get back together in their original groups of 4 and report out their answers and key concepts to their group members.
    - i. This will take the rest of the class period: Approximately 8 minutes per group member.
4. After the activity has been explained, begin by passing out the 4 different fact sheets to each group.
  - a. Depending on the nature of the class/groups, the teacher may decide to assign selections because some have more text than others.
5. The teacher’s role for the rest of the class is to keep track of time and monitor that each student/group remains on-task.

## Suggested Answers:

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### The 4 Life Zones of Cave

- 1<sup>st</sup> Zone = *ENTRANCE ZONE*
  - a. This life zone supports what kind of organisms?  
*ORGANISMS THAT NEED FULL SUNLIGHT FOR SURVIVAL*
  - b. What are 3 examples of organisms that are found here?  
*POSSIBLE ANSWERS: FERNS, MOSSES, SNAILS, SPIDERS, MOTHS, AND WILDFLOWERS*
- 2<sup>nd</sup> Zone = *TWILIGHT ZONE*
  - a. Where does this zone start and extend to?  
*THIS ZONE STARTS AT THE ENTRANCE OF THE CAVE AND EXTENDS TO THE FARTHEST POINT IN THE CAVE THAT SUNLIGHT REACHES.*
  - b. What are 3 examples of organisms that are found here?  
*MOSS, BATS, SKUNKS, FROGS, AND PACK RATS*
- 3<sup>rd</sup> Zone = *VARIABLE TEMPERATURE ZONE AND COMPLETE DARKNESS*
- 4<sup>th</sup> Zone = *DARK ZONE*
  - a. What characterizes this zone?  
*A COMPLETE LACK OF SUNLGH*
  - b. Describe what organisms in this zone must have in order to survive?  
*THE ORGANISMS MUST HAVE SPECIAL ADAPTATONS THAT ALLOW THEM TO SURVIVE IN DARK CONDITIONS.*

---

### Trogloxenes

- 1.) What are the Greek words that “trogloxene” came from and what do the words mean?  
*“TROGLOS” (CAVE) AND “XENOS” (GUEST)*

## TEACHER COPY AND ANSWER KEY

2.) What are 3 possible reasons for these animals to spend their time in caves?

- *TO FIND REFUGE FROM THE ELEMENTS*
- *TO HIBERNATE*
- *TO BEAR THEIR YOUNG*

3.) What are 3 examples of troglomen:

*POSSIBLE ANSWERS: BATS, SKUNKS, RACOONS, MOTHS, FROGS, BEETLES, SOME BIRDS, AND PEOPLE.*

4.) What are the special adaptations these organisms have that help them survive in caves?

*NONE - THESE ANIMALS SHOW NO SPECIAL ADAPTATIONS TO CAVE ENVIRONMENTS.*

---

## Troglophiles

1.) What are the Greek words that “troglophile” came from and what do the words mean?

*“TROGLOS” (CAVE) AND “PHILEO” (LOVE)*

2.) How can troglophiles live outside of a cave?

*IF THE ENVIRONMENT IS MOIST AND DARK*

3.) Why do you think a troglophile would venture outside of the cave?

*TO FIND FOOD*

4.) What are 3 examples of troglophile:

*POSSIBLE ANSWERS: EARTHWORMS, SALAMANDARS, BEETLES, CRUSTEANS (CRAYFISH).*

5.) If an animal of a particular species is a troglophile, do all the other animals of the same species also have to be one? Explain.

*SOME TROGLOPHILES MAY SPEND THEIR ENTIRE LIFE CYCLE IN A CAVE, BUT OTHER INDIVIDUALS OF THE SAME SPECIES LIVE OUTSIDE.*

## Troglobites

- 1.) What are the Greek words that “troglobite” came from and what do the words mean?

*“TROGLOS” (CAVE) AND “BIOS” (LIFE)*

- 2.) Where are troglobite found?

*THEY LIVE PERMANENTLY IN THE DARK ZONES OF CAVES AND ARE FOUND EXCLUSIVELY IN CAVES.*

- 3.) Describe how the physical adaptations of these organisms are devoted to sustaining energy.

*THE PHYSICAL ADAPTATIONS THAT PROVIDE A BENEFIT ARE ENHANCED, AND THOSE THAT DO NOT ARE DEGENERATED.*

- 4.) What are 2 features that these organisms do not have that are adaptations to the lack of sunlight?

*EYES AND PIGMENT (COLOR)*

- 5.) From which group of cave animals did troglobites evolved from?

*TROGLOPHILES*

---

### As a group:

Cave animals have developed different adaptations depending on where, and how long, they live in caves. **Give a brief explanation of another group of animals that have developed adaptations specific to where they live.**

*Example Answers:*

*1. THE LONG NECK OF A GIRAFFE ALLOWS THEM TO FEED ON THE PLANT MATERIAL AT THE TOPS OF TREES. IN AN ENVIRONMENT WHERE VEGETATION CAN BECOME SCARCE DURING THE DRY SEASONS, THIS HELPS GIRAFFES EAT FOOD THAT ISN'T AVAILABLE TO OTHER (SHORTER) SPECIES.*

*2. THE KIDNEYS OF DESERT ANIMALS, SUCH AS THE KANGAROO MOUSE, HAVE EVOLVED TO RETAIN AS MUCH WATER AS POSSIBLE. THIS ALLOWS THESE SPECIES TO SURVIVE IN ARID ENVIRONMENTS.*

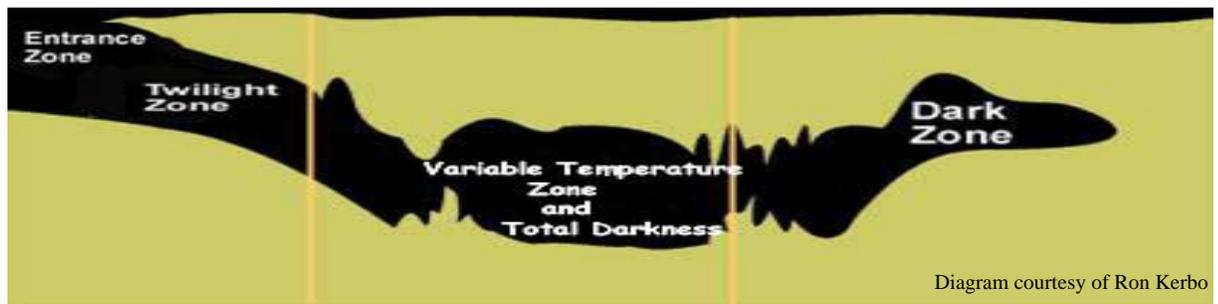


NPS Photo by Rick Wood

Cave Life

# Activity Fact Cards

# The 4 Life Zones of Caves



Cave experts are now acknowledging 4 life zones within caves: the entrance zone, the twilight zone, the zone of variable temperatures and total darkness, and the dark zone.

The **entrance zone** supports those organisms that need full sunlight for survival. For example, ferns and mosses thrive in the cool, moist condition of a cave, but require sunlight for photosynthesis. Other examples of plants and animals that may live in this zone are snails, spiders, moths and wildflowers.

The **twilight zone** is next in the series of cave zones. This area extends from the entrance of the cave to the farthest point in the cave that sunlight reaches. Some plants may be able to grow in these conditions, like moss, and many animals are found living or visiting this zone. Examples include bats, skunks, frogs, and pack rats.

There is a transition zone between the twilight zone and the final zone and it is appropriately named the **variable temperature zone and total darkness**. This zone has only recently been considered to be a distinct cave life zone, but is becoming increasingly acknowledged by cave experts.

The final zone is the **dark zone**, which is characterized by a complete lack of sunlight. Organisms that live in this zone must have special adaptations that allow them to survive in dark conditions, such as the adaptations of the non-green plants and blind cave fish. These organisms are called troglobites, and live no where else on earth but in the dark depths of caves.

# Trogloxenes



The word troglaxene comes from the Greek words “troglos” (cave) and “xenos” (guest). They are cave visitors or temporary cave residents, and move freely in and out of caves.

For troglaxenes, caves provide refuge from the elements, a cozy place to spend the winter, or an acceptable environment to bear their young. For example, some troglaxenes, like bears, prefer the constant cave temperatures for hibernation. No matter how much time they spend in caves, troglaxenes never complete their entire life cycle in them.

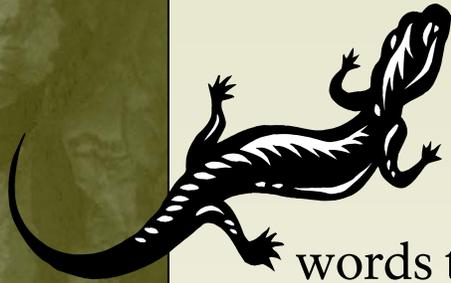


Bats are probably the best known troglaxene.

Skunks, raccoons, packrats, moths, frogs, beetles, some birds, and people are other examples of troglaxenes. Because these animals are not dependent on caves for their survival, they show no special adaptations to cave environments.



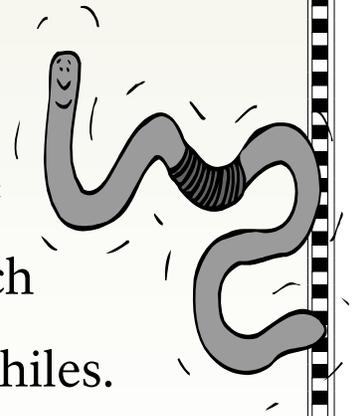
# Troglophiles



Troglophiles *love* caves. The name troglophile itself comes from the Greek words troglos (cave) and phileo (love).

Troglophiles normally live in the dark zones of caves, but they can and do survive outside caves, provided the environment is moist and dark. For example, although some trogliphiles prefer to stay in the cave, sometimes they have to venture out to find food.

Earthworms are a good example; some types of salamanders, crustaceans (such as crayfish), and beetles are also trogliphiles.



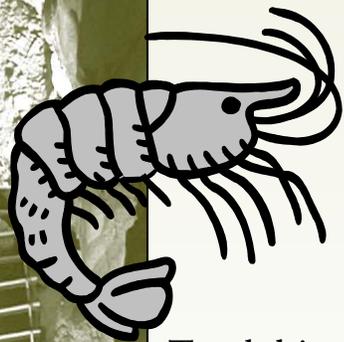
Some individual trogliphiles may spend their entire life cycle in a cave, but other individuals of the same species live outside.

# Troglobites



The word troglobite comes from the Greek words troglos (cave) and bios (life). Troglobites are life forms that live permanently in the dark zones of caves and are found exclusively in caves. Troglobites cannot survive outside of the cave environment, and they have developed special adaptations for living their entire lives in caves.

Because food sources in caves are meager, the sensory organs and physical adaptations of troglobites are devoted to sustaining energy and finding food: those that provide a benefit are enhanced; those not necessary are degenerated.



While some physical structures have been lost, others have been enhanced. Examples include longer legs and antennae, or feelers. These types of adaptations enable them to go for long periods of time with little food.

Troglobites have no eyes or eyes that are poorly developed. Eyes are not necessary because of the lack of light. Most troglobites are white to pinkish in color. They lack pigment (color) because they have no need for protection from the sun's rays or for camouflage to hide them from predators.

In general, existing troglobites have evolved from troglophiles. Examples include cave fish, cave crayfish, cave shrimp, some cave salamanders and insects.



# Cave Life: A Jigsaw Activity

## Student Copy



NPS Photo by Rick Wood

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# CAVE LIFE

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Cave animals fit into three categories: **trogloxenes**, **troglophiles**, and **troglobites**. These categories are based on the amount of time cave animals spend in caves. Are they just visitors? Can they survive outside the cave environment? And what do you call the places in a cave where these animals live?

During this activity you will learn the differences between the 3 categories of cave life, and become familiar with the 4 cave life zones. You will work cooperatively with your group members to learn the material and answer the questions below.

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## The 4 Life Zones of Cave

- **1<sup>st</sup> Zone** = \_\_\_\_\_
  - a. This life zone supports what kind of organisms?
  - b. What are 3 examples of organisms that are found here?
  
- **2<sup>nd</sup> Zone** = \_\_\_\_\_
  - a. Where does this zone start and extend to?
  - b. What are 3 examples of organisms that are found here?
  
- **3<sup>rd</sup> Zone** = \_\_\_\_\_
  
- **4<sup>th</sup> Zone** = \_\_\_\_\_
  - a. What characterizes this zone?
  - b. Describe what organisms in this zone must have in order to survive?

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## Trogloxenes

- 1.) What are the Greek words that “trogloxene” came from and what do the words mean?
- 2.) What are 3 possible reasons for these animals to spend their time in caves?
  - 
  - 
  -
- 3.) What are 3 examples of troglloxenes:
  - 
  - 
  -
- 4.) What are the special adaptations these organisms have that help them survive in caves?

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## Troglophiles

- 1.) What are the Greek words that “troglophile” came from and what do the words mean?
- 2.) How can trogllophiles live outside of a cave?
- 3.) Why do you think a trogllophile would venture outside of the cave?
- 4.) What are 3 examples of trogllophiles:
  - 
  - 
  -
- 5.) If an animal of a particular species is a trogllophile, do all the other animals of the same species also have to be one? Explain.

---

## Troglobites

- 1.) What are the Greek words that “troglobite” came from and what do the words mean?
- 2.) Where are troglobites found?
- 3.) Describe how the physical adaptations of these organisms are devoted to sustaining energy.
- 4.) What are 2 features that these organisms do not have that are adaptations to the lack of sunlight?
- 5.) From which cave animal group have troglobites evolved?

---

### As a group:

Cave animals have developed different adaptations depending on where, and how long, they live in caves. **Give a brief explanation of another group of animals that have developed adaptations specific to where they live.**

# Present a Cave

**Lesson Objective:** After completing this cooperative learning activity students will be able to create an oral and visual presentation on a national park cave and karst resource.

**Key Concepts:** National Park Service cave and karst resources; investigation; cooperative learning.

**Duration:** 3-4 55-minute class periods

- 1-day for introduction and initial investigation;
- 1-2 days for research and project design;
- 1-2 days for class presentations.

**Audience:** Middle school and high school students



NPS Photo by Rick Wood

Present a Cave

Teacher Copy  
and  
Activity Fact Cards



NPS Photo by Rick Wood

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# PRESENT A CAVE: TEACHER COPY

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**Lesson Objective:**

After completing this lesson the students will be able to create an oral and visual presentation on a National Park cave and karst resource.

**Materials:**

1. 1 National Park Service Caves and Karst Facts Sheet for each group (8 total fact sheets available).
2. Present a Cave: Investigation and Planning Worksheet for each student.
3. Peer Evaluation Form for each student.
4. Group Member Evaluation Form for each student.
5. Access to the internet (for additional research).

**Teacher Instructions:**

1. Divide the class into cooperative learning groups of 3 to 4 students.
2. Assign each group one of the fact sheets.
3. Ask the students to read the fact sheet as a group and take notes on important concepts using the Jigsaw Worksheet.
4. Using the worksheet, groups should also plan how they will visually present information about their topic to their classmates.
  - a. Examples might include a poster, a diorama, overheads, a power point presentation, a brochure, or a picture book.
  - b. Encourage students to be creative, but emphasize that they need to present the information in a way that provides their classmates with the key information of the resource.

## TEACHER COPY AND ANSWER KEY

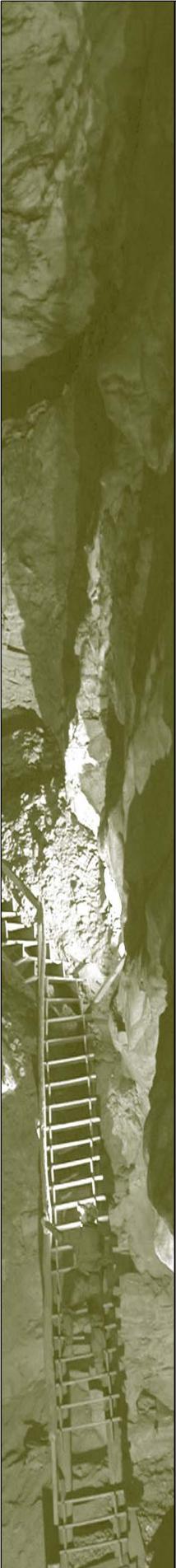
- c. Encourage students to include information on not only the cave formation topics, but also any other cultural or historic information relating to the cave.
5. Give the students adequate time to prepare their presentations.
    - a. Presentations should include:
      - i. General information on their designated cave and karst resource.
      - ii. Information that incorporates their designated topic with what they have learned already about cave and karst formation, fossils, sedimentation, porosity, etc.
      - iii. Pictures and/or illustrations of their cave and karst resource.
    - b. Students will benefit from having a class period to do additional research via the internet.
      - i. The Views of the National Parks website and the National Park Service Caves and Karst Program website can both be invaluable resources for additional information.

The National Park Service Caves and Karst website:  
<http://www2.nature.nps.gov/geology/caves/program.htm>

The Views of the National Parks website is located at:  
<http://www2.nature.nps.gov/views/>
6. At the end of each presentation, students will fill out a:
    - a. **Peer Evaluation Form** for each group.
    - b. **Group Member Evaluation Form** for each of their group members.

Present a Cave

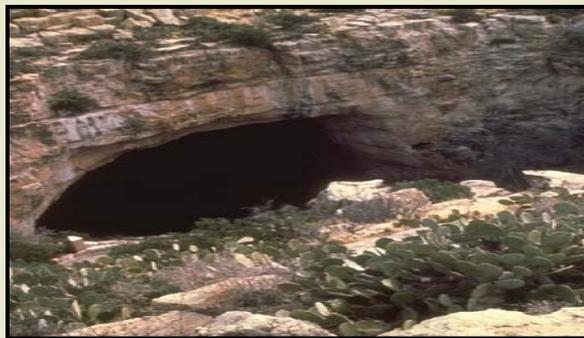
# Activity Fact Cards



NPS Photo by Rick Wood

# Carlsbad Caverns . . .

## New Mexico



### A Journey Underground

Your encounter with Carlsbad Caverns National Park begins near the Chihuahuan Desert of the Guadalupe Mountains. But beyond the somewhat familiar surroundings of rugged mountains and broad plains is another world. Away from the sunlight, away from the flowering cactus, away from the songs of the desert birds and the howl of the coyote, lies the celebrated underground world of Carlsbad Cavern. It is an incomparable realm of gigantic subterranean chambers, fantastic cave formations, and extraordinary features.

### The Formation of the Cavern

The story of the creation of Carlsbad Cavern begins 250 million years ago with the creation of a 400-mile-long reef in an inland sea that covered this region. This horseshoe-shaped reef formed from the remains of sponges, algae, seashells and from calcite that precipitated directly from the water. Cracks developed in the reef as it grew seaward. Eventually the sea evaporated and the reef was buried under deposits of salts and gypsum.

Then, a few million years ago, uplift and erosion of the area began to uncover the buried rock reef. Rainwater, made slightly acidic from the air and soil, seeped down into the cracks in the reef, slowly dissolving the limestone and beginning the process that would form large underground chambers. Many geologists believe that the fresh rainwater mixed with deeper salty water to form sulfuric acid. The added power of this very corrosive substance could explain the tremendous size of the

passageways that formed. The exposed reef became a part of the Guadalupe Mountains and the huge underground chambers far below the surface became the natural wonders of Carlsbad Cavern.

### The Cave is Decorated, Drop by Drop

The decoration of Carlsbad Cavern with stalactites, stalagmites, and an incredible variety of other formations began more than 500,000 years ago after much of the cavern had been carved out. It happened slowly, drop by drop, at a time when a wetter, cooler climate prevailed. The creation of each formation depended on water that dripped or seeped down into the limestone bedrock and into the cave. As a raindrop fell to the ground and percolated downward, it absorbed carbon dioxide gas from the air and soil, and a weak acid was formed. As it continued to move downward the drop dissolved a little limestone, absorbing a bit of the basic ingredient needed to build most cave formations the mineral calcite. Once the drop finally emerged in the cave, the carbon dioxide escaped into the cave air. No longer able to hold the dissolved calcite, the drop deposited its tiny mineral load as a crystal of calcite. Billions and billions of drops later, thousands of cave formations had taken shape.

*And, oh, the shapes they took!*



# Jewel Cave . . .

## South Dakota



### Exploring Jewel Cave

The exploration of Jewel Cave began about 1900 when two South Dakota prospectors, Frank and Albert Michaud, and a friend, Charles Bush, happened to hear wind rushing through a hole in the rocks in Hell Canyon. Enlarging the hole, they found a cave full of sparkling crystals. They filed a mining claim on the "Jewel Lode," but they found no valuable minerals. Therefore, instead of mining the cave they tried turning the cave into a tourist attraction.

The business was never a success, but the cave did attract attention. In 1908 Jewel Cave National Monument was established to protect the small but extraordinary cave. Fifty years later exploration of the cave suddenly intensified.

### Into the Unknown

When Herb and Jan Conn were first persuaded to join a caving expedition in Jewel Cave in 1959, the couple responded without enthusiasm. Their passion was rock climbing, not crawling around in dark, gloomy holes. Little did they know they would spend much of the next 21 years in Jewel Cave, lured by the thrill of discovering the secrets of yet another mile of never before-seen cave.

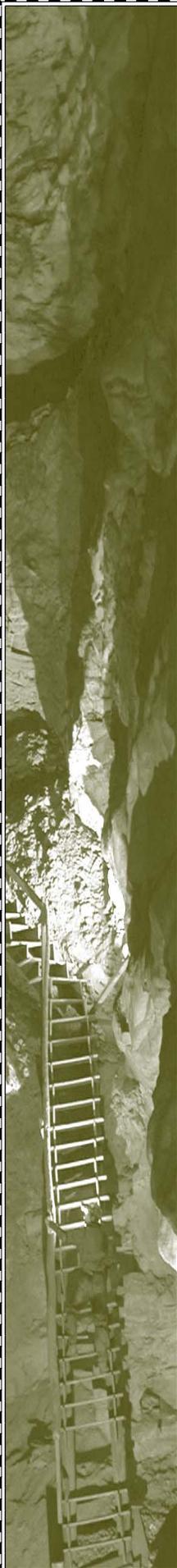
"Our exploration of Jewel Cave, which started out as a mild diversion, quickly mushroomed into an all-absorbing interest," the Conns explain in their book *The Jewel Cave Adventure*. On a typical day, the Conns and their fellow cavers spent 12 to 14 hours underground. Outfitted in hard hats, carbide lamps, gloves, loose fatigues, elbow and knee pads, and boots, the explorers squeezed, crawled, and climbed their way through Jewel Cave's complicated maze. The going was rough. During rest stops they munched on mangled sandwiches and squashed fruit while

massaging sore muscles. Names they gave to some passages, such as Contortionist's Delight and The Miseries, tell the story.

As years passed and more miles of cave were found, it became apparent that Jewel Cave was one of the world's most extensive caves, full of scenic and scientific wonders. The explorers found chambers with exquisite calcite crystals and rare cave formations. One much-decorated room discovered by the Conns - the Formation Room - is a highlight of the Scenic Tour today. They also found rooms as large as 150 by 200 feet, passageways as long as 3,200 feet, and a place where the cave wind blows at speeds of up to 32 miles per hour. The cave, they discovered, is truly a rare and precious jewel.

The caving parties led by this husband-and-wife team would make 708 trips into the cave and log 6,000 hours exploring and mapping. Modern-day cavers have discovered new wonders with more than 80 miles of passages, and today the cave is among the world's longest and is renowned for its variety of formations.

In 1980, after discovering more than 65 miles of cave, the Conns retired. A new generation of cavers has already pushed the known boundaries of the cave to more than 80 miles. But the mystery remains. As the Conns have said, "We are still just standing on the threshold."



NPS Photo by Rick Wood

Jewel Cave photos from the National Park Service Digital Image Archives

# Wind Cave . . .

## South Dakota

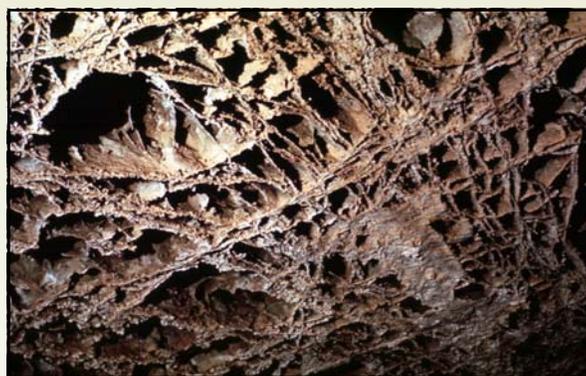
To witness the beginning of the formation of Wind Cave, one of the world's oldest caves, you would have to have been here 320 million years ago. At that time parts of the limestone that constitute the upper levels of Wind Cave were being dissolved into cave passages. As ancient ocean levels fluctuated, these passages were filled with sediments. Beneath the ocean, a thick layer of sediments continued to be deposited above that limestone.

About 60 million years ago, the forces that uplifted the Rocky Mountains also uplifted the modern Black Hills producing large fractures and cracks in the overlying limestone. Over millions of years, water moving slowly through those cracks dissolved the limestone to produce the complex maze of the cave's passages.

Erosion later changed surface drainage patterns and caused subsurface water levels to drop, draining the cave passages. As the modern Wind Cave formed, many of these newer passages intersected the original cave, revealing the red clay and

sandstone sediments from 320 million years ago.

It was after the cave formed that most of the colorful cave formations began to decorate its walls. One of the most prominent features in Wind Cave is **boxwork** (see photo below) - thin, honeycomb-shaped structures of calcite that



protrude from the walls and ceilings. Nowhere else in the world can such a large display be seen. Some of the better known cave formations, such as stalactites and stalagmites, are rare here.

You might wonder if after more than 100 years of exploration there is anything new to discover in Wind Cave. Barometric wind studies estimate that approximately five percent of the total cave has been discovered. In 1891 Alvin McDonald wrote in a diary of his cave trips:

*"Have given up the idea of finding the end of Wind Cave."*

The better equipped cavers of today have not given up. They are continuing to push farther and farther into the cave's cool, black recesses.



# Timpanogos Cave . . .

## Utah

Photo Source: NPS Digital Image Archives



### Underground Delights

Some of the earth's most powerful and most delicate forces combined to create the wonders of Timpanogos cave, beginning when the Wasatch Range was building 65 million years ago.

Many different types of cave formations have been created by water simply dripping or flowing into the caves. Perhaps the most well known of these are stalactites and stalagmites, which can be seen throughout the caves.

Photo Source: NPS Cave and Karst Program



Stalactites, which hang like icicles from the ceiling, form as drop after drop of water slowly trickles down through the cave roof. The smallest stalactites may be hollow and as thin and straight as a soda straw (see photo on left), and so are called soda straw stalactites. Others may be massive: The Great Heart of Timpanogos in Timpanogos Cave -  $5\frac{1}{4}$  feet long, 3 feet wide, 4,000 pounds - is composed of three, or possibly more, tremendous stalactites that have grown together. The many colors of stalactites, and indeed all of the formations in the caves, are caused by traces of iron, nickel, magnesium, and organics.

Stalagmites are formed when mineral-laden water strikes the floor. The tallest stalagmite is about six feet high in Timpanogos Cave; most are smaller. Occasionally stalagmites and stalactites merge, forming a floor-to-ceiling column.

The caves' largest column, 13 feet high, is found in Hansen Cave.

The Cascade of Energy and the Chocolate Fountain, both in Timpanogos Cave, are examples of still a different type of formation - flowstone. As its name implies, the smooth coatings or sculpted terraces of flowstone are created when water flows down a wall or across a floor.

Another common formation - draperies - are created when water trickles down an inclined ceiling. Water, flowing down a sloped surface, can form draperies. If the chemical content of the water changes, staining can cause it to take on the appearance of bacon (see photo on right). A spectacular example of such a formation is the Frozen Sunbeam, a thin translucent sheet of orange-colored calcite in Timpanogos Cave. Draperies in these caves are seldom more than one inch thick.



Photo Source: NPS Cave and Karst Program

Still another, not quite so common type of formation that occurs in the caves is cave popcorn. Popcorn occurs where water seeps slowly through walls or ceilings. These knobby lumps are particularly abundant in Timpanogos Cave, where they occur mixed with helictites.

Today, the caves still are changing: new formations are being created, and existing ones are growing where mineral-laden water continues to enter. As long as water - the master architect and interior decorator - continues to trickle into the caves, creation will continue.

NPS Photo by Rick Wood

# Oregon Caves...

*Oregon Caves may surprise you. Small in size, it is rich in diversity. That richness can be found both underground amidst narrow, winding passageways and above ground where old growth forest harbors a fantastic array of animals and plants found nowhere else. You will discover a land rich in conifers, wildflowers, birds, and amphibians. An active marble cave and underground stream reveal the inside of one of the world's most diverse geologic realms.*

Photos from the National Park Service Cave and Karst Program



## Discovery, Development and Rebirth

As his last match flickered out, 24-year-old hunter Elijah Davidson found himself in the total blackness of the cave. Davidson was chasing after his dog Bruno, who in turn was pursuing a bear. One following the other, the dog and bear entered a dark hole high on the mountainside. Davidson stopped at the mysterious dark entrance. He could see nothing, but an agonizing howl pulled him into the cave to save his dog. Now the matches were gone and Davidson was in total darkness. Fortunately, he was able to wade down a gurgling, ice-cold stream and find his way back into daylight. Bruno soon followed. It was 1874.

Later, other brave souls explored deeper into the cave, returning home to tell of its great beauty and mystery. In 1907, a party of influential men, including Joaquin Miller, the "poet of the Sierras," visited the cave. Charmed by it, Miller wrote of the "Marble Halls of Oregon." The ensuing publicity alerted federal officials to the possibility of preserving the cave. In 1909 President William Howard Taft proclaimed a

## Oregon

area of 480 acres as Oregon Caves National Monument. In 1922 an automobile road reached the park, and 12 years later a six-story hotel, the Chateau, was constructed. The same year, 1934, Oregon Caves National Monument was transferred from the Forest Service to the National Park Service, which still administers it.

Workers blasted tunnels and widened passages in the cave during the 1930s. They put waste rocks in side passages, covering many limestone formations. Changes in air flow patterns altered the growth of formations and caused greater swings in temperature. Freezing water now cracked rock layers. Lights in the cave promoted the growth of algae, which turned portions of the cave green and dissolved some formations. Smoke from torches and lint coming off visitors' clothing blackened other portions.

Since 1985 the National Park Service has removed more than a thousand tons of rubble in its efforts to restore the cave. Transformers, asphalt trails, and cabins were removed to prevent sewage or oils from leaking into the cave from the surface. Thousands of formations buried under rubble were uncovered. Crystal clear water once again cascades over white marble. Some broken formations have been repaired with epoxy and powdered marble. Airlocks have restored natural cave winds by blocking airflow in artificial tunnels. Spraying with bleach keeps the algae under control. The new lighting and trail system will reduce evaporation and unnatural foods, which have attracted surface insects and driven out native species.

Not everything has been or can be restored. For example, the dissolution and formation of cave decorations are in delicate balance with the amount of carbon dioxide in the air and water. A global increase of this gas in the atmosphere, caused largely by deforestation and burning of fossil fuels, is affecting this balance. Still, one can now see a renewed cave, a valuable benchmark against which we can measure human impacts, now and in years to come.



# Great Basin-Lehman Caves

... Nevada

## Great Basin National Park



Great Basin National Park, established in 1986, includes much of the southern Snake Range, a superb example of a desert mountain island. From

the sagebrush at its alluvial base to the 13,063-foot summit of Wheeler Peak, the park includes streams, lakes, alpine plants, abundant wildlife, a variety of forest types including groves of ancient bristlecone pines, and numerous limestone caverns, including beautiful Lehman Caves.

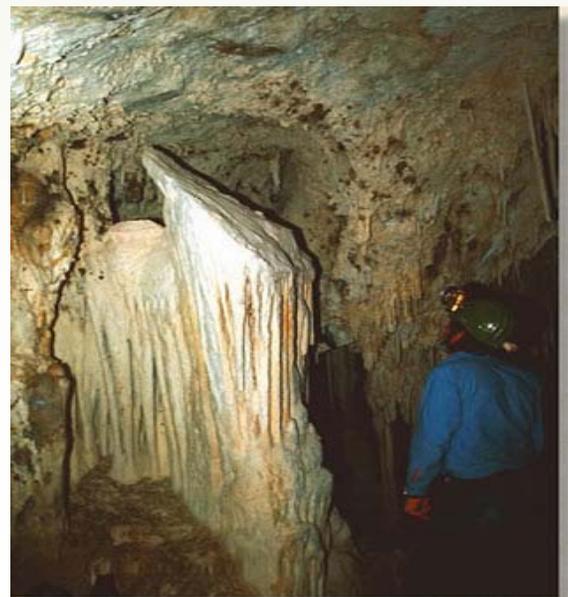
## The Underground World of Lehman Caves

A single cavern, despite the name, extends a quarter-mile into the limestone and low-grade marble that flanks the base of the Snake Range. Discovered in about 1885 by Absalom Lehman, a rancher and miner, this cavern is one of the most richly decorated caves in the country, a small but sparkling gem.

What we see today began millions of years ago. The climate then was much wetter than it is now. Rain water, turned slightly acidic by seeping past surface vegetation and humus, found its way into hairline cracks deep in the native limestone. Trickleing downward, the water dissolved the stone, enlarging the cracks, eventually reaching the water table. There it collected in sufficient quantity to create whole rooms. At one time, an underground stream flowed here, leaving behind tell-tale ripple marks.

Eventually the climate turned drier; water drained from the cave, leaving smooth walls and hollow rooms. Then came the second stage of cave development. Small amounts of water still percolated down from the surface. But now, instead of enlarging the cavern, the mineral-rich fluid began filling it once again. Drop by drop, over centuries, seemingly insignificant trickles worked wonders in stone. The result is a rich display of cave formations, or as scientists call them, speleothems. Lehman Caves contains familiar structures such as stalactites, stalagmites, columns, draperies, and flowstone, along with some interesting and delicate rarities.

Lehman Caves is most famous for the rare and mysterious structures called **shields** (see photo below). Shields consist of two roughly circular halves, almost like flattened clam shells. How they are formed remains a subject of controversy - another of the pleasant mysteries to be found in the underground world.



# Mammoth Cave . . .

## Kentucky



NPS Photo by Gary Berdeaux

### The Longest Cave:

The total surveyed extent of Mammoth Cave currently stands at 580 kilometers (360 miles) with potential for a 1600 kilometer (1000 mile) system. In addition, there are more than 200 caves within the park which are disconnected fragments of the larger system or associated with local drainage features. The geology and geography of the area has resulted in a variety of karst basins, which have become the most thoroughly understood conduit flow aquifer in the world.

### Mammoth Cave Aquifer

Flow through the Mammoth Cave Karst aquifer can be very rapid, on the order of 1000's to 10,000's of feet per day. Contaminants entering the karst aquifer can thus be rapidly transported, unfiltered through the conduit system. The karst aquifer is very dynamic, that is, it responds nearly instantaneously to rainfall. The aquifer stage can rise 10's of feet in a matter of hours, with numerous records showing stage rises of more than 100 feet over the course of one day. Also, chemical and bacteriological properties of the groundwater can change dramatically following rainfall events.

### Cave Entrances

Natural, modified natural, and artificial

cave entrances pose some of the greatest challenges in the management of karst resources. This is because provision must be made for movement of air, water and wildlife within acceptable tolerances while simultaneously providing an adequate deterrent to illegal human entry. United States Fish and Wildlife Service- approved bat gates have been installed on the entrances of caves supporting major bat hibernation areas. Cave gates are designed to accommodate bat movement and natural rates of air exchange, provide greater security, and restore endangered Indiana and gray bat habitat. Airlocks have been installed on man-made entrances to restore cave atmospheric conditions.

### Speleothems

Within the cave, a vast array of subterranean geologic features have developed over millennia, including stalactites, stalagmites, helictites, and travertine dams. There are also several types of gypsum formations, such as the aptly-named "gypsum flowers" (see photo below).



Photo Source: National Park Service Cave and Karst Program



NPS Photo by Rick Wood

# Russell Cave . . .

## Alabama

Photo Source: National Park Service Digital Image Archives



### Indians Find Shelter in the Cave

Thousands of years ago nomadic bands of Indians stumbled upon Russell Cave in the hill country of northern Alabama. We know little about them except that they were few in number, probably less than 15 or 20, and that the only durable possessions they carried with them were a handful of chipped flint points with which they tipped their short hunting spears. These few possessions were found 12 feet below the present floor of the cave.

This evidence, supported by charcoal from their campfires, tells us that about 9,000 years ago these Archaic Period Indians first began to occupy Russell Cave. This is long before the rise of the civilizations of Egypt and the Near East. They could not have lived there earlier, because a stream of water filled the whole cavern until a great rock-fall from the roof shunted the stream to one side and raised the floor of the cave well above its waters. They lived there only during the autumn and winter seasons, maintaining their primitive existence by hunting game and gathering wild plants. Agriculture was probably known, but little used by the Indians of the Archaic Period.

The cave was a great boon to these Indians because it provided ready protection from the elements. This freed them from the need to build a shelter in the forest and gave them more time to find food. Successive bands of hunters with their women and children took shelter in

this cave until A.D. 1000. The records of their seasonal occupations, including several burials of adults and children, have been uncovered by archeological digs. The charcoal from their fires, the bones of the animals they ate, the tools they fashioned from animal bones, their spear and arrow points, and their broken pottery accumulated layer upon layer as thousands of years passed.

The first party of cave dwellers camped on the irregular floor of rock slabs. Archeologists have been able to date the arrival of these people at some time between 6550 and 6145 B.C. by measuring the radioactive carbon remaining in the charcoal of their fires. Russell Cave was a seasonal haven for these early forest-dwelling Indians. They survived by hunting and gathering wild plants in the great hardwood forests of the region. After they had depleted the supply of animals and edible plants in one area, they would move on to another section of the forest.

Probably a number of related families used the cave as a place of shelter and safety mostly in the autumn and winter. The relative warmth of the cave probably prevented the stream from freezing and thus they had a constant supply of water. The forest bore a rich crop of nuts that must have been an important source of food during the worst winter months when game in this mountain-valley country was scarce. In spring and summer, small bands - several families - probably camped along the shore of the Tennessee River only a few miles from the cave. Fish, birds, and small mammals could be obtained in the river environment.

When the last occupants departed, Russell Cave held beneath its surface the record of at least 9,000 years of human life upon this continent.

Studies in historical geology and paleobotany have shown that the plant and animal life of the Eastern Forest Region remained virtually unchanged for thousands of years, until European settlers felled the trees for lumber and opened up extensive acreages for subsistence and commercial farming.

NPS Photo by Rick Wood

Present A Cave

# Student Worksheets



NPS Photo by Rick Wood

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# PRESENT A CAVE

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## Investigation and Planning Worksheet

Group Members:

---

National Park Service Cave and Karst Resource:

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How will you present your information?

Examples might include a poster, a diorama, overheads, a power point presentation, a brochure, or a picture book.

---

Key Facts and Information:

From the Fact Sheet:

Information from additional research:

---

Your presentation should include all members of your team.

Identify at least one part of your presentation for which each group member is responsible.

Group Member	What are they responsible for?

---

# PRESENT A CAVE

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## Group Member Evaluation

Please rate yourself and your team members on the contributions they made in researching, preparing and presenting your project.

*Your ratings will not be disclosed to other students.*  
Be honest in this evaluation!

In rating yourself and your peers, use a one to five point scale:

- 5 = Superior
- 4 = Above Average
- 3 = Average
- 2 = Below average
- 1 = Weak

Insert your name in the first column and your peers' names in the remaining spaces. (One name at the top of each column)

Group Member Names					
Participated in group discussions					
Helped keep the group focused and on the task					
Contributed useful ideas					
<i>Quantity</i> of work done compared to other group members					
<i>Quality</i> of work done					
Enter Total Scores Here					

---

# PRESENT A CAVE

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## Peer Evaluation Form

TOPIC OF PRESENTATION: \_\_\_\_\_

GROUP MEMBERS:

**PLEASE RATE YOUR CLASSMATES ON THEIR PRESENTATIONS:**

- 1 = Superior
- 2 = Above Average
- 3 = Average
- 4 = Below Average
- 5 = Weak

★ You shared important facts:

1                      2                      3                      4                      5

★ You were easy to hear and understand:

1                      2                      3                      4                      5

★ Your visual aid was appropriate to the topic:

1                      2                      3                      4                      5

★ Your visual aid was carefully prepared:

1                      2                      3                      4                      5

**3 THINGS I LEARNED FROM YOUR PRESENTATION:**

1.

2.

3.



# Cave Quiz Game: An Interactive Review Game

**Lesson Objective:** This interactive activity uses the Microsoft PowerPoint program to review key cave concepts presented throughout the Caves and Karst Curriculum Guide.

**Key Concepts:** speleothem formation, types of caves, ways that caves form, fossils, names of speleothems.

**Duration:** 1 55-minute class period

**Audience:** Middle school and high school students

Cave Quiz Game

Teacher Copy  
and  
Answer Key



NPS Photo by Rick Wood

# CAVE QUIZ GAME

## TEACHER INSTRUCTIONS

### Playing the Game:

1. Organize students into small cooperative groups. Depending on the nature of the group, either assign groups or allow students to self-select their groups.
2. Access the game via the internet or a CD. The individual slides can be viewed using Adobe Reader, but open and run the game using the Microsoft PowerPoint program.
3. Start the game by clicking the Slide Show button from the top toolbar and select “View Show”. The review game is now ready to begin.
4. When a question slide is opened, you need to click on the grey background for the question to appear. If you click again the answer will appear. Once the question has been answered, use the button on the bottom left side of the page to return to the main page.
5. Students can select from any of the five categories. Once a selection has been chosen, it will disappear so that it cannot be chosen again.

### Helpful Hints:

1. If you need to exit the game once it is running, use the “Esc” key on your keyboard.
2. If you need to go back, use the arrow on your keyboard that points to the left.

## Cave Quiz Game Questions

Quiz Board Heading	Value	Question	Answer	Location in Curriculum Guide
Speleothems	100	Speleothems are frequently formed when this fluid drips from a cave ceiling.	Water	Making a Cave (page 1); Speleothems-Webquest (page 6)
	200	Speleothems form as these precipitate out of fluids and are deposited onto cave ceilings and walls.	Minerals	Growing Speleothems (page 2); Speleothems-Webquest (page 1)
	300	Speleothems consist mainly of this type of mineral:	Calcite	Growing Speleothems (page 2); Speleothems-Webquest (page 1)
	400	True or False: The term "speleothem" refers to what a cave formation looks like (its morphology), and not its composition.	True	Speleothems-Webquest (page 1)
	500	One thing that all speleothems have in common is that they cannot form until the level of the cave is above this:	Water Table	Interactive Reading Guide #1 (page 4); Speleothems-Webquest (page 1).
Types of Caves	100	These types of caves are produced from the action of waves pounding against rocks that line the shores of oceans and lakes.	Sea Caves	Interactive Reading Guide #1 (page 5); How Caves Form-Webquest (page 4).
	200	This type of cave was commonly used by early people for shelter.	Sandstone Cave	Interactive Reading Guide #1 (page 6); How Caves Form-Webquest (page 5).
	300	This is another name for a lave cave:	Lava Tube	Interactive Reading Guide #1 (page 5); How Caves Form-Webquest (page 3).
	400	The name of this cave is named for the piles of rocks that are produced from rockslides.	Talus Caves	Interactive Reading Guide #1 (page 5); How Caves Form-Webquest (page 4).
	500	Name the 2 types of ice caves: 1.) This type is formed in ice. 2.) This type is formed in rock, but stays frozen year around.	1.) Glacier Cave 2.) Frozen Cave	Interactive Reading Guide #1 (page 6); How Caves Form-Webquest (page 5).

## Cave Quiz Game Questions

The Formation of Caves	100	This type of cave is formed when acidic water dissolves rocks like limestone.	Solution Cave	Interactive Reading Guide #1 (page 3); Making a Cave (page 1).
	200	This type of cave is formed when the action of earthquakes form natural cracks in rock.	Tectonic Cave	Interactive Reading Guide #1 (page 6).
	300	The hard upper crust of lava caves is formed as this touches the flowing lava and cools it down.	Air	Interactive Reading Guide #1 (page 5).
	400	This is the term used when referring to the act or process of dissolving.	Dissolution	Interactive Reading Guide #1 (page 3); How Caves From-Webquest (page 2).
	500	The ceilings of water-filled caves are supported by this type of force:	Buoyant Force	Interactive Reading Guide #1 (page 4); How Caves From-Webquest (page 1).
Cave Life	100	What name is given to the animals that love to spend time in caves?	Troglaphiles	Cave Life ( <i>Troglaphiles</i> Fact Sheet)
	200	What is the name for the cave animal that is only a periodic visitor?	Trogloxene	Cave Life ( <i>Trogloxenes</i> Fact Sheet)
	300	What name is given to those animals that are adapted to spend their entire life in caves?	Troglobites	Cave Life ( <i>Troglobites</i> Fact Sheet)
	400	What factor is used to determine in which category a cave animal is classified?	The amount of TIME an animal spends in the cave.	Cave Life (student worksheet page 1)
	500	Name the 4 life zones in a cave.	4 Life Zones = Entrance Zone; Twilight Zone; Variable Temperature Zone and Total Darkness; and the Dark Zone	Cave Life ( <i>The 4 Life Zones of Caves</i> Fact Sheet)

## Cave Quiz Game Questions

Name That Speleothem	100	What 2 types of speleothems have joined together to make this column? [Picture of a column]	1. Stalactite 2. Stalagmite	Speleothems-Webquest (page 3).
	200	This speleothem sometimes resembles bacon...what is it? [Pictures of draperies]	Drapery	Speleothems-Webquest (page 4).
	300	What type of speleothems are these? [Picture of a cave flower]	Cave Flowers	Speleothems-Webquest (page 2).
	400	This speleothem can eventually grow into a stalactite. What is it? [Picture of a soda straw]	Soda Straw	Speleothems-Webquest (page 6); Present a Cave-Timpanogos Cave Fact Sheet
	500	What type of speleothems are these? [Picture of boxwork]	Boxwork	Speleothems-Webquest (page 2); Present a Cave-Wind Cave Fact Sheet
Fossils and Rocks	100	What are the 3 main rock types?	Igneous, Sedimentary and Metamorphic	The Rock Cycle Review (page 1)
	200	What are the spaces between the soil particles called?	pore spaces	Porosity Mini-Lab (page 1); Porosity of Sediments (page 1)
	300	Of the 3 main rock classifications, nearly all fossils are found in this type:	Sedimentary Rocks	Caves and Fossils Worksheet (page 2); Sediments and Solution Caves: Part 2 (page 1).
	400	This is the term given to the study of forms of life existing in prehistoric or geologic times, especially as represented by fossils.	Paleontology	Caves and Fossils Worksheet (page 1)
	500	The nests of packrats can be considered biological warehouses due to the enormous amounts of fossils they contain. What is the name for these nests?	Middens	Hidden Treasures Fact Sheet