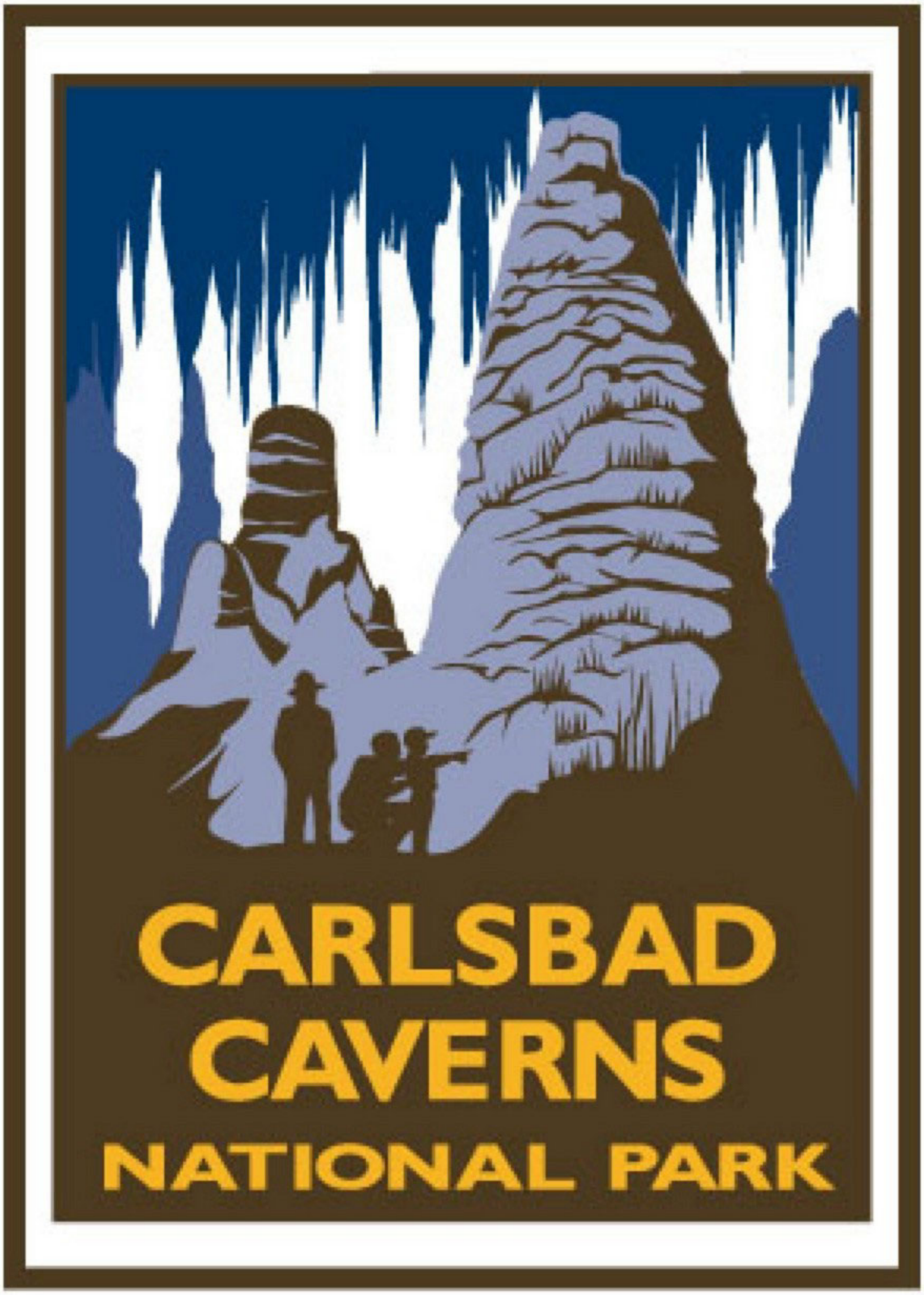
Caves, Canyons, Cactus & Critters

A curriculum and activity guide for Carlsbad Caverns National Park

Middle School Geology



Caves, Canyons, Cactus & Critters

Geology Curriculum

Surf Carlsbad!

As hard as it may be to believe, the southeastern corner of New Mexico was once a shallow inland sea; home to a fascinating barrier reef that is exposed today in the Guadalupe Mountains where Carlsbad Caverns National Park is located. The growth of this reef, as well as the development of thick basin deposits and a series of backreef deposits, has resulted in a world-class geologic classroom. Geologists from around the world come to the Carlsbad Caverns National Park to study backreef-reef-basin sequences, carbonate shelf formation, evaporite basins, and the fascinating caves that form in these soluble rocks.

This unit will focus on the rocks formed in this ancient reef environment. In the first activity, students will study the main reef-forming organisms found in the Capitan Reef. The second activity will provide students the opportunity to study the development of the thick salt deposits found in the Delaware Basin. In the third activity, students will learn to identify the main sedimentary rocks found in Carlsbad Caverns National Park. The last activity will give students the opportunity to explore ancient life through fossils.

The background for these activities is closely tied to the book ***Stories From Stones: The Geology of the Guadalupe Mountains***. It is strongly recommended that you read this book or have a working knowledge of the geology of the Guadalupe Mountains prior to teaching this unit.

A House Made of... Sponge?

What types of organisms would you have seen if you had visited the Permian Reef when it was forming?

Summary: Students will discuss organisms that formed the Permian Reef and will then participate in a game where they are required to recall the information learned.
Duration: 50-minute class period
Setting: Classroom
Vocabulary: calcareous, reef, extinction, Pangea
Standards/Benchmarks Addressed: SC11-E5, SC12-E5

Objectives
Students will:

- name and describe several organisms responsible for forming the Permian Reef.

Background
During the late Permian Period (280-225 million years ago) North America was a part of the super continent *Pangea*. Carlsbad Caverns National Park was located very close to the equator. A shallow inland ocean covered southeastern New Mexico and the area known as the “Permian Basin.” The Hovey Channel to the south-southwest connected this ocean to the larger Permian Ocean. Conditions in the western part of the basin, an area that is called the “Delaware Basin” today, were favorable to the development and growth of many of the organisms living in the ancient ocean. Included in those organisms were a variety of shellfish, fusilinids, algae, echinoderms, trilobites, corals, and colonial organisms such as sponges and bryozoans.

Among the shellfish were organisms such as pelecypods and brachiopods. The shells of these organisms were calcareous, consisting of calcium carbonate ($CaCO_3$). Pelecypods are classified as bivalves and are identified by their hinged, two-halved shell in which the halves are usually symmetrical or the same. Scallops would be an example of modern day bivalves. Brachiopods were similar, but the two-halves of their shells are not symmetrical. They are sometimes referred to as “flying” shellfish due to the “wing-like” appearance of their shells. While brachiopods lived primarily on the reef, pelecypods are believed to have lived more along the reef/backreef boundary, closer to the lagoon area. Both fed by filtering food particles suspended in the water.

Another group of shellfish found in the Permian Sea was the gastropods. Gastropods would be most familiar to us as the common snail. They are recognized by their coiled shell and the way they move about on a wide, flat foot. A gastropod’s primary source of food was algae.

Though they are thought of as the major reef-builders in modern oceans, corals were rare in the Permian Sea. Many of those found are solitary horn corals. Instead, algae were one of the primary reef-building organisms found in the Permian Sea. Several varieties of *calcareous* algae were present in the *reef* area and contributed greatly to the growth of the reef. The other major reef builders were sponges. Sponges were colony creatures forming a calcareous house in which they would live and filter food from the water. Several species of sponge have been found in many shapes and forms.

Bryozoans were another type of colonial organism that lived in the Permian Sea. Bryozoans formed colonies resembling delicate fans along the ocean floor. Like many other organisms along the reef, bryozoans also filtered their food from the water.

Echinoderms were also present. They are easily identified by their five “ray” or five-part symmetry. An echinoderm frequently found among fossils in the reef is the crinoid, a flowerlike organism that filtered food particles suspended in the water.

Many people think of the extinction of the dinosaurs as the greatest *extinction* of all time. However, it pales in comparison to the mass extinction that occurred at the end of the Permian Period. By some estimates, nearly ninety percent of the species on Earth at that time became extinct.

Materials

- One set of ***Reef Builders*** cards per group of students (pre-mounting on cardboard will make the cards more durable)
- Paper for notes during warm-up
- Paper for keeping score

Procedure

Warm Up: Inform students that the information you are about to discuss will be very useful later in the lesson. Suggest that they write down the names and characteristics of the organisms you will be discussing while you write difficult to spell words on the board.

Discuss reefs, how they are formed from the calcareous remains of living organisms, how they form in tropical environments along shallow ocean areas, etc. Use modern-day reefs such as the Great Barrier Reef in Australia or the reefs of Belize as examples in your discussions.

Describe and discuss the organisms responsible for building reefs today. Compare and contrast those to the reef-builders of the Permian Period. Be sure to focus on the environments in which they live, how their shells are formed, and how they feed.

Ask students to list the characteristics found off the coast of Australia or Belize that make ideal environments for reef-building organisms (warm tropical water, shallow water allowing more light, well oxygenated water, etc.). Ask students if they believe conditions near Carlsbad, New Mexico, were different during the Permian Period. Ask them to describe what they think the area near Carlsbad Caverns National Park would have been like 230 million years ago.

Activity

1. Tell students that they are going to use their knowledge of reef-building organisms from the Permian Period in a game. Have students form into groups of three or four.
2. Hand out the Reef Builder cards, face down, to each group of students and instruct them to not look at the cards before being told to do so.
3. Explain that each card lists four characteristics of a reef-building organism from the Permian Period. They will try to guess what the organism is while being given the clues.

4. The person initially given the cards will read the clues, one at a time in order, until someone in the group guesses the organism or until all clues are used without a successful guess.
5. Students begin to read the clues while others in the group attempt to guess the name of the organism. Points are given for successful answers as shown below. The student who successfully answers will be the reader for the next card.
   - One clue - 4 points
   - Two clues - 3 points
   - Three clues - 2 points
   - Four clues - 1 point
6. The game continues until all of the cards have been read. For those students with the highest score, or who score more than a pre-determined number of points, provide a prize or reward.

Wrap Up: Discuss what might happen to the reef if any of the environmental conditions changed (change in water temperature, sea level, available oxygen, etc.). Have students theorize about what might have brought about the eventual end of growth on the Permian Reef.

Discuss current reefs and any conditions that may be threatening their growth (ocean warming, sea level changes, other organisms that feed on reef builders, etc.). Have students describe how studying ancient environments, such as the Permian Reef, can help us better understand our Earth today.

Assessment
Have students:

- name an organism when given a set of its characteristics.
- explain what characteristics make an area of the ocean favorable for reef growth.
- describe why the study of fossils can help us make informed decisions about our Earth today.

Extension
Working in a group of three or four, students select an ecosystem from a given list (desert, rain forest, mountains, etc.). Have them discuss within their group the types of organisms, plants and animals, which would be typical for that ecosystem. They should list the organisms, as well as characteristics we would use to identify that organism.

They will then move forward into the future 230 million years and describe what a person studying fossils from their ecosystem might find. They should also try to predict any misconceptions a future paleontologist might have from misinterpreting the fossils.

Resources
Doyle, Peter. 1996. *Understanding Fossils: An Introduction to Invertebrate Paleontology.* New York, NY: John Wiley & Sons, Inc.

Jagnow, David and Jagnow, Rebecca. 1992. *Stories from Stones: The Geology of the Guadalupe Mountains.* Carlsbad, NM: Carlsbad Caverns Guadalupe Mountains Association.

Reef Builder Cards

A House Made of Sponge?

- I filter my food from the water around me.
- I lived along the boundary between the reef and lagoon.
- My home is formed from two nearly identical shell halves.
- I am similar to modern day scallops.

Answer: pelecypod

- I filter my food from the water around me.
- I wasn't very common in the Permian Sea.
- During the Permian Period, I was often found in the shape of a horn.
- I form many of the reefs found in the world today.

Answer: coral

- I feed on algae growing on the ocean bottom.
- My home is a coiled shell made of calcium carbonate.
- I move around on a wide, flat foot.
- Today, you would refer to me as a common snail.

Answer: gastropod

- I filter my food from the water around me.
- I lived along the top of the reef mound.
- My home is formed from two shell halves that are not the same size or shape.
- My shell sometimes looks like it has wings.

Answer: brachiopod

- I filter my food from the water around me.
- I live in a colony with hundreds of other creatures just like me.
- We were one of the main reef builders in the Permian Sea.
- Today, the remains of my home are often used as an absorbent cleaning device.

Answer: sponge

- I filtered my food from the water around me.
- I lived along the top and front of the reef, firmly attached to the sea bottom.
- One of my varieties looked like a beautiful water flower, but was really an animal.
- My body is identified by its five-part symmetry.

Answer: Echinoderm or crinoid

- I filter my food from the water around me.
- I live in a colony with hundreds of other creatures just like me.
- Our home was often a pretty fan shaped structure attached to the ocean floor.
- My skeletal remains often look like little broken twigs.

Answer: bryozoan

- I am a very important photosynthesizer in the ocean.
- I am one of the oldest organisms on Earth.
- I helped form the reef by growing in great mounds that left large calcium carbonate deposits behind.
- Gastropods feed on me.

Answer: Algae

Old Salts

How did the massive salts beds near Carlsbad Caverns form?

Summary: Students will build their own miniature “evaporite basin” and record observations as salts begin to precipitate out of the water.
Duration: Two or three 50-minute class periods
Setting: Classroom or lab
Vocabulary: evaporite, precipitation, salinity, saturation
Standards/Benchmarks Addressed:SC2-E3, SC5-E2, SC6-E1

Objectives
Students will:

- describe how the massive salt beds near Carlsbad Caverns formed.
- make evaporite basins.

Background

Guess what? The oceans are salty! Ok, that should come as no surprise to anybody. However, the oceans contain more than just sodium chloride, the compound you probably know as table salt. As rivers flow downhill to some ocean, bay, or gulf they dissolve minerals from the land they pass across or through. These dissolved minerals take the form of ions, electrically charged atoms or groups of atoms. The most common of these ions are sodium (Na^{+}), chloride (Cl^{-}), magnesium (Mg^{+2}), sulfate (SO_4^{-2}), calcium (Ca^{+2}), and potassium (K^{+}). Additionally, carbon dioxide (CO_2) dissolved in water can form the carbonate ion (CO_3^{-2}). The combination of electrically negative and positive ions results in a compound called a “salt.” The most common salt is table salt, or sodium chloride. It is composed of a base unit of one sodium ion and one chloride ion.

In the ancient Permian Sea, the salinity of the water would change periodically. Seasonal variations in temperature and freshwater input are thought to have resulted in annual salinity cycles. On a longer scale, the Delaware Basin would periodically be cut off from the Permian Ocean due to changes in sea level or closure of the Hovey Channel to the southwest. This would result in increased *salinity* as the water in the basin began to evaporate. As the water evaporated, the concentration of the less soluble salts would reach the *saturation* point and these salts would begin to *precipitate* out of the water and settle to the bottom, forming the thick deposits of *evaporite* rocks found there today. If the water continued to evaporate and become more saline, the more soluble salts would begin to precipitate. Eventually, as the ancient Permian Sea was isolated from the Permian Ocean for the last time, the most abundant salt, sodium chloride, began to precipitate and the thick salt beds of the Salado Formation were formed. It is in this formation that the WIPP repository is located. At some point during this deposition, potassium chloride was deposited, forming the mineral sylvite. The rock containing this mineral is commonly called potash and is mined near Carlsbad.

Organisms living in the ancient sea used these salts to their advantage. Many of them would extract the calcium and carbonate ions from the water and use them to build shells of calcium carbonate, or what is also referred to as the mineral calcite. This compound is the main component of the rock limestone. Much of the sand along the reef was formed from calcium carbonate precipitated out of the water or from the crushed and ground skeletal remains of organisms. These carbonate sands filled in voids in the reef and were trapped in the massive algal mats that formed along the reef.

Over time, erosion has removed the overlying layers and exposed the reef and the salts deposited in the basin. Calcium carbonate is much less soluble than the other salts. In fact, in the semi-arid environment near the Carlsbad Caverns, the limestone formed from this compound is resistant to weathering and forms the bulk of the Guadalupe Mountains. In the basin to the southeast of the Carlsbad Caverns, deposits of gypsum ($CaSO^4$) are exposed at the surface. Gypsum has a solubility that is about ten times that of limestone. As a result, the gypsum in the basin weathers faster than the limestone in the Guadalupe Mountains. Groundwater moving through cracks in the gypsum beds has formed hundreds of shallow caves near the surface. The largest of these, the Parks Ranch Cave System, is over four miles in length and is located about six miles south of White's City, within sight of the Carlsbad Caverns visitor center. Salt beds do exist on the surface in some very arid parts of the world, such as the region around the Dead Sea in Israel. Near Carlsbad, annual rainfall and groundwater are sufficient to dissolve these salt beds underground, before they are exposed at the surface.

Materials

- measuring cup, 1 cup (250 ml)
- measuring spoon, tablespoon (15 ml)
- glass bowl, 2qt.
- table salt
- Epsom salts
- scissors
- hand lens
- black construction paper
- lid from large jar or shallow, flat bottomed bowl

Procedure

Warm up: Ask the students how many have a parent or other relative who works at a potash mine or at the Waste Isolation Pilot Plant (WIPP). Ask in what kind of rocks the potash mines and the WIPP repository are located. Discuss the thick beds of rock salt found near Carlsbad. Have the students propose what conditions could have created beds of rock salt 2000 feet thick. Point out that rock salt (halite) is not the only evaporite mineral in the basin. Gypsum and limestone are also evaporite rocks forming part of an evaporite sequence a mile thick.

In several places, such as the gypsum plain south of White's City, New Mexico, we find some of the gypsum layers exposed on the surface. Ask the students to brainstorm reasons that we do not find the halite beds exposed at the surface. What happens to them when erosion causes them to be near the surface?

Activity

Halite:

1. In a bowl, dissolve 4 tablespoons (60 ml) table salt in one cup (250 ml) water.

2. Allow the bowl to sit undisturbed until the water evaporates (may take several weeks). If time will not allow for this, expose the bowl to moderate heat, such as an incandescent bulb to speed evaporation.
3. Have the students study the crystals that form in the bottom of the bowl with a hand lens and draw what they observe. Have them compare the crystals in the bottom of the bowl with any they find along the sides of the bowl.

Epsomite:

1. Cut a circle from black construction paper that fits inside a large jar lid or in a flat-bottomed bowl.
2. Dissolve four tablespoons (60 ml) Epsom Salts Mix in one cup (250 ml) water.
3. Pour a thin layer of this solution over the black paper.
4. Allow to stand overnight or longer, if necessary.
5. Have the students study the crystals that form in the bottom of the bowl with a hand lens and draw what they observe.

Have the students compare and contrast the halite and the epsomite crystals.

Wrap Up: Discuss what happens to the salt dissolved in ocean water if the ocean begins to evaporate. Ask which dissolves faster in a glass of cool water, salt, or sugar? Using the students' knowledge that salt dissolves easier, discuss the concept of solubility and the fact that some substances dissolve easier than others. Ask the students if that would mean that some substances would precipitate out, or form crystals, easier than others. Discuss the three main salts found in the Delaware Basin and how they formed at different times as the Permian Sea was cut off from the Permian Ocean and began to evaporate.

Assessment

Have students:

- name the three principal evaporite rocks found in the Delaware Basin.
- explain why the rocks formed in separate layers, even though they all formed from the same evaporating body of water.

Extensions

Given a particular set of objectives or questions, have students design and perform their own experiment related to solubility and salt. Some suggested objectives are:

- Using several salts, find out which one is the most soluble and which will precipitate out of the water first.
- Does mixing two or more salts affect their solubility?
- How does the temperature of water affect solubility?

Resources

Feather, Ralph, et al. 1999. *Glencoe Earth Science.* Westerville, OH: Glencoe/McGraw-Hill.

Hill, Carol. 1996. *Geology of the Delaware Basin, Guadalupe, Apache, and Glass Mountains, New Mexico and West Texas:* Permian Basin Section SEPM, Publication No. 96-39.

Van Cleave, Janice. 1991. *Earth Science For Every Kid.* New York, NY: John Wiley & Sons, Inc.

Is it Limestone, or did I get "Gyped?"

What types of rocks would have formed in the ancient Permian Sea?

Summary: Students identify the primary rock types found in the area around Carlsbad Caverns using properties such as color, grain size, mineral content, and reactivity with acid.
Duration: Two 50-minute class periods
Setting: Classroom or lab
Vocabulary: sediment, sedimentary, texture
Standards/Benchmarks Addressed: SC5-E2, SC6-E1, SC12-E2

Objectives
Students will:

- identify samples of limestone, gypsum, halite, sandstone, and shale using various chemical and physical properties.

Background

The principal rock types found near the Carlsbad Caverns National Park are limestone, gypsum, halite, sandstone, and shale. All of these rocks are sedimentary. They are formed from *sediments* deposited on or near the Capitan Reef during the Permian Period, approximately 230 million years ago. *Sedimentary* rocks fall under three classifications: clastic or detrital, chemical, and organic.

Clastic, or detrital, sedimentary rocks are formed from the broken remnants of other rocks. These broken remains, or sediments, can vary in size from a fraction of a millimeter to several meters. They can be well sorted, with only a narrow size range found within a rock, or they can be a mix of sizes. Chemical cements deposited by groundwater moving through the rock usually hold the sediments together. Sandstone, siltstone, and shale are common clastic sedimentary rocks found in Carlsbad Caverns National Park.

Chemical sedimentary rocks are rocks formed by chemicals precipitating out of water. Most of the chemical sedimentary rocks near Carlsbad precipitated out of the ancient Permian Sea. Gypsum, halite (rock salt), and chemical limestone are examples of chemical sedimentary rocks found in Carlsbad Caverns National Park. Many of the formations seen in the caves of Carlsbad Caverns National Park also formed from minerals left by evaporating water. For more information on the formation of chemical sedimentary rocks, see the activity entitled "Old Salts."

Organic sedimentary rocks are rocks formed from or by living organisms. Fossils are commonly found in organic sedimentary rocks. Organic limestone and coquina limestone are two organic sedimentary rocks found in Carlsbad Caverns National Park.

Identifying sedimentary rocks begins with determining whether the rock is clastic, chemical, or organic. Then the actual rock type is determined by studying the texture of the rock. Rocks made from larger pieces or crystals are said to have a coarse *texture*. Rocks made from smaller pieces or crystals are said to have a fine texture. Other properties used to identify rocks are their color, taste, and reactivity with certain acids. The table provided in the procedure will guide you through the steps needed to identify the sedimentary rocks of Carlsbad Caverns National Park. You will need to provide close assistance to students in the early part of the activity.

Materials

- several samples each of limestone, gypsum, halite, sandstone and shale
- hand lenses
- small sample of dilute HCl for teacher's demonstration
- white vinegar
- copies of data sheets and identification chart

Procedure
Warm up: Divide class into groups of three or four students. Give each group a rock from the materials list. Do not identify the rocks at this time.

As the students to brainstorm a list of as many properties as they can that could be used to describe their rock. Have the students share some of their observations with the class. Write the observations on the board and discuss similarities and differences in their observations.

Display the identification chart on a board or overhead projector.

Describe how the various types of sedimentary rocks are formed. Tell students that they will be using this chart to identify rocks they are given. Have students copy the identification chart.

Activity

1. Give each group one sedimentary rock sample at a time. Do not give a new rock until the students have determined the name of the first one they were given.
2. Have students classify the rock as clastic, chemical, or organic. Most will need assistance on the first rock.
3. Have students determine the texture of the rock (sediment or crystal size, fossils)
4. Have students list any fossils or minerals they see.
5. Have students write any other observations they make. If they believe that they have limestone, they should request your assistance in placing a drop of vinegar on the sample and watching for it to fizz. Dilute HCl can be used, but only under strict supervision with goggles. After, rinse the sample thoroughly.
6. Using the identification table, students determine the name of the rock and show you their data table and rock sample. If they are correct, they continue with another rock until they have tested six rocks.

Wrap Up: On the back of their data table, as a class, or both, have the students answer the following:

- What properties best helped you identify clastic rocks? chemical? organic?
- Describe one environment where sandstone might form.
- If the mineral halite forms by evaporation, would it be clastic, chemical, or organic?

Assessment
Have students:

- submit completed data sheets and answers to questions.

Extensions
Provide students with a cross section drawing of the Capitan Reef similar to that on pages 8-9 in *Stories From Stones.* As a class or in groups, discuss and attempt to determine where the sediments that formed each of the rock samples used in the activity would have been deposited.

Resources
Feather, Ralph, et al. 1999. *Glencoe Earth Science.* Westerville, OH: Glencoe/McGraw-Hill.

Jagnow, David and Jagnow, Rebecca. 1992. *Stories from Stones: The Geology of the Guadalupe Mountains.* Carlsbad, NM: Carlsbad Caverns Guadalupe Mountains Association.

Sedimentary Rock Identification Chart

Is it Limestone, or did I get "Gyped?"

Clastic or Detrital Rocks (made from broken pieces of other rocks)	
Name	**Texture/Composition**
Conglomerate	Rounded mix of sizes larger than 2mm in diameter - gravel
Breccia	Angular mix of sizes larger than 2mm in diameter - gravel
Sandstone	Made from cemented sand (0.06-2mm diameter) - sand
Siltstone	Made from powdered sediments, smaller than sand in size - silt
Shale	Made from microscopic particles of other rocks - clay

Chemical Rocks (appear to be made of crystals)*	
Name	**Identifying Properties**
Limestone	gray/tan/light brown, fizzes in dilute HCl or Acetic Acid (vinegar)
Rock Salt	colorless/white/blue, tastes like salt, dissolves easily in water
Gypsum	white, forms long, slender crystals, or looks like crushed sugar
*Of the sedimentary rocks, limestone is hardest and gypsum is softest.	

Organic Rocks (identified by fossils in them)	
Name	**Identifying Properties**
Limestone	brown to gray crystalline rock with fossils
Coquina	large shell fragments, looks like Rice Krispy Treat

Data and Observations

Is it Limestone, or did I get "Gyped?"

Sample	Observations	Minerals or Fossils Present	Texture	Detrital, Chemical, or Organic	Rock Name
A					
B					
C					
D					
E					
F					

Meet my Pet Fossil, Rocky

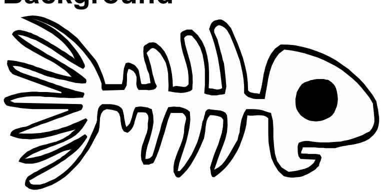
What are fossils and how do they form?

Summary: Students will describe the various ways in which fossils form, make a Plaster-of-Paris fossil, and attempt to describe an organism and the environment in which it lived by studying its fossil.
Duration: Two or three 50-minute class periods
Setting: Classroom or lab
Vocabulary: cast, fossil, mold, paleontologist, petrified, trace fossil
Standards/Benchmarks Addressed: SC2-E3, SC3-E1, SC5-E2, SC6-E1, SC12-E5

Objectives
Students will:

- describe the processes by which fossils form.
- prepare a plaster-of-Paris cast/mold fossil.
- study a fossil and attempt to describe the organism that left it and the environment in which it lived.

Background



Dinosaurs... Sixty-foot-long sharks... Dragonflies the size of a man... Armadillos the size of a Volkswagen beetle...

What do they have in common? They certainly don't exist today. However, all of them did exist at one time and the way we know this is that we have found and studied their remains. The remains, imprints, or traces of living organisms left in rock are called *fossils*. From fossils, we can tell not only what lived and where it lived, but how it lived, what it ate, if it had a social structure, and many other valuable facts.

Most organisms do not create fossils. In fact, certain conditions are necessary if organisms are to have a better chance of being preserved as a fossil. First, a dead organism must be protected from scavengers or decay caused by microorganisms. Organisms that are buried rapidly have a much better chance of being preserved. In fact, many of the best fossils found were deposited in or near swampy areas, where there was a greater chance of rapid burial in non-oxygenated muds.

Jellyfish fossils are hard to find. This isn't due to a lack of jellyfish, but rather it is due to a lack of hard parts in the jellyfish. Hard parts such as bones, shells, or teeth make better fossils. Sharks have been in the Earth's oceans since the Paleozoic Era, but the most common shark fossils we find are teeth. The cartilage skeleton of sharks rarely survives the fossilization process.

Fossils occur in many forms: petrified remains, carbonaceous films, molds and casts, original remains, and trace fossils. *Petrified* remains are turned to stone. As groundwater containing dissolved minerals soaks into and through the buried organism, the minerals replace the original tissues. With the deposition of these minerals, the organism literally "turns to stone."

Carbonaceous films are fossils that can preserve evidence of softer tissues. All organisms are composed of tissues that contain carbon. As the organism is buried, heat and pressure change the structure of the tissue, forcing gases and liquids from the body and leaving behind a carbonaceous film. The resulting fossil shows the outline of the original organism and sometimes details of the body structure as well as the skeletal structure.

Molds and *casts* are formed when a fossil decays, erodes, or dissolves away. The void left behind is called a mold. This void is then filled with sediments washed in through cracks or by minerals that precipitate out of groundwater. This new "replacement" fossil is called a cast. Mold and cast fossils are quite common in the rocks of Carlsbad Caverns National Park. In the activity associated with this lesson, students will make mold and cast fossils.

Sometimes, *paleontologists*, scientists who study fossils, are fortunate enough to find the actual remains of an organism. Any fan of *Jurassic Park* is well aware of the existence of insect remains trapped in amber. Amber is a rock made from sap. In the case of *Jurassic Park,* insect's 175 million years ago were trapped and preserved in a drop of tree sap. This protected the insects' body from decay or petrification and, in the story line, even preserved DNA in the blood the insect had ingested. A more realistic recent story centered on Mammoth remains found frozen in ice. Other actual remains have been found in the La Brea Tar Pit of California.

Trace fossils are evidence that an organism was there without any remains present. Examples of trace fossils are tracks, drag marks, wormholes, and burrows. From these fossils, it is possible to determine such things as an organism's size, lifestyle, hunting behavior, and diet.

Studying fossils provides clues to ancient environments as well. Carlsbad Caverns National Park is located in the semi-arid northern reaches of the Chihuahuan Desert at elevations ranging from around 3000 feet up to around 7500 feet. However, a quick look at the fossils of the park reveals a time when a sea covered the area. Sponges, algae, crinoids, mollusks, and brachiopods were common in this ancient sea and we find their fossils today. Studying these fossils has provided evidence of a massive barrier type reef that most believe was present 230 million years ago. Ongoing studies of the fossils in the park continue to provide insights into the geologic history of the area.

Materials

- paper bowls or butter tubs
- plaster-of-Paris
- leaf, shell, bone, or other materials to turn into fossils
- petroleum jelly
- actual fossils (if none are available, models or photos of fossils can be substituted)
- old vinyl record, any size or artist will do
- old, weathered bone

Procedure

Warm up: Hold up an LP vinyl record for the students to view and ask for them to describe what it is. Have them speculate how old it is and what it would take to make it work. Ask them to describe the person they think first owned it.

Hold up an old, weathered bone. Ask the students to describe the organism that it came from. Ask them to speculate how old it is and what part of the animal it came from.

Hold up a fossil for the class to view. Ask students to describe how it is similar to and different from the two previous items.

Discuss the background material with the class, being sure to focus on how fossils form, types of fossils, and what we can learn from fossils.

Activity

Making a Fossil (Do in groups of three or four):

1. Prepare plaster-of-Paris to that it is smooth and thick
2. Fill bowl or tub with plaster to a depth of about one inch.
3. Coat object to be fossilized (leaf, shell, bone, etc.) with a thin layer of petroleum jelly.
4. Press the object into the plaster, but do not allow the plaster to flow over the top of the object.
5. Allow the plaster to dry at least 24 hours and then remove the object.
6. Coat the top of the plaster with a thin layer of petroleum jelly.
7. Pour more plaster of Paris on top to a depth of about one inch and allow to dry for at least 24 hours.
8. Separate the two halves. The original half represents a mold fossil and the second plaster poured represents a cast fossil.

Amateur Paleontologist Lab

1) Provide each group of students an actual fossil (models or photos can be substituted).
2) Each group must study the fossil and provide their best answers to the following:
    a. What is the name of the fossil?
    b. How, and what, did the fossil eat?
    c. How did the fossil move or how did it attach itself to the ground or ocean bottom?
    d. Find one structure or object on the fossil and explain, in detail, what it was used for.
3) Repeat with two or three other fossils.

Wrap Up: Ask the students how easy it was to answer the paleontologist lab questions. Ask students how they think a professional paleontologist answers those questions. Lead the discussion to focus on the present being the key to the past. In other words, the best information we have to help us learn about the past is what we find on Earth today.

Ask students to list points for and against the statement “the present is the key to the past” and discuss as a class.

Assessment

Have students:

- submit mold/cast fossils and Paleontologist Lab work to teacher.
- Describe the necessary conditions for a fossil to form.
- Describe five types of fossils.
- List five important things that we can determine by studying fossils.

Extensions
Have students hypothesize what fossils would be left behind by today's society. What would a paleontologist 230 million years from now think about the organisms that were alive today? What would they think about our eating habits, social structure, transportation, and entertainment?

Resources
Feather, Ralph, et al. 1999. *Glencoe Earth Science.* Westerville, OH: Glencoe/McGraw-Hill.

Van Cleave, Janice. 1991. *Earth Science For Every Kid.* New York, NY: John Wiley & Sons, Inc.

Carolina Biological Supply Company – www.carolina.com

Fisher Scientific – www1.fishersci.com

Flinn Scientific, Inc. – www.flinnsci.com

Sargent-Welch – www.sargentwelch.com