Ozark Karst: A Fragile Landform

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Students will become familiar with karst topography in the Ozark Plateau Natural Division, and with the impact that modern humans have had on the sensitive cave ecosystems created by this landform. Presented with a typical commercial development proposal in a mythical North Arkansas town, students will research and assume the roles of community leaders and activists to solve a potential environmental problem. This lesson will take several days to complete.

Grades: 6-8

Arkansas Curriculum Frameworks:
Arkansas History 1.1.6, 1.1.7, 1.1.9, 1.1.12, 1.1.14, 2.1.4, 2.1.7, 4.1.9, 4.1.11, 4.1.13, 6.1.5, 6.1.6, 6.1.8, 6.1.9, 6.1.11, and 6.1.13
Science LS.1.3, LS.2.9, LS. 2.12, ES.2.4, ES.2.5, and ES.3.6

Key Terms:

karst typography	soluble bedrock	spring	sinkhole
cave	limestone / dolomite	carbonic acid	pigment

Key Terms Defined:
karst topography: An area in which the bedrock has been chemically weathered by the groundwater and features caves, sinkholes, and springs; named after the Karst region of Slovenia, along the Adriatic coast in Europe, where the landform was first described.

soluble bedrock: Rock that can be dissolved, including limestone and dolomite.

spring: A natural flow of groundwater, often found in a break in bedrock along a hillside.

sinkhole: A shallow depression or a vertical opening to a cave created when surface limestone erodes. Sinkholes are sometimes referred to as sinks.

cave: An air-filled underground space large enough for human exploration.

limestone: Sedimentary rock made of calcium carbonate. Dolomite is similar to limestone and consists of calcium magnesium carbonate.

carbonic acid: A weak acid formed when carbon dioxide reacts with water.

pigment: A substance, such as chlorophyll or melanin, that produces a characteristic color in plant or animal tissue.

Materials:

- Litmus paper or another acid-base indicator
- A small container to support a ziplock bag
- A small ziplock bag
- Clear plastic cups
- Water
- Straws
- Bromothymol blue indicator or homemade cabbage juice indicator (see instructions in the "Part 1/Experiment #2" section below)
- *Optional for Activity 3:* a small piece of limestone, safety goggles, 20% solution of hydrochloric acid, and a pipette
- A copy of The Dilemma of Sinking Springs for each student (included below)
- *Optional: Pictures of Ozark cave-dwelling animals (not included)*

Background Information:

Karst topography is a type of landform that is characterized by a terrain of soluble bedrock. The name "karst" comes from the area where the landform was first described, in the Karst region of Slovenia along the Adriatic Sea in Europe. Although karst can take many forms, springs, sinkholes, and caves characterize the Ozark Plateau Natural Division. The soluble bedrock typical of the Ozarks of Northwest Arkansas consists of limestone and dolomite.

Ocean waters covered all of Arkansas during the Paleozoic Era, about 300 million years ago. It was during this time that the place that would eventually become the Ozarks was formed. When sea creatures in this ancient ocean died, their shells fell to the ocean floor. Layers after layer of these shells were pressed together over time, eventually forming horizontal layers of a sedimentary rock known as limestone. The shells of marine organisms also formed dolomite, although this rock contains more magnesium than limestone. The horizontal layers of limestone and dolomite are visible along river bluffs and highway cuts.

Karst features are formed when carbon dioxide dissolves in rainwater, creating a weak carbonic acid. As the rainwater percolates through organic material on the surface of the land, it also picks up organic acids produced by decaying leaves and other organic material. The slightly acidic rainwater reacts with limestone and dolomite and slowly dissolves the rock.

Although limestone is not particularly permeable to water, large cracks in the limestone bedrock allow water to move extensively underground. As this groundwater comes in contact with limestone, the water dissolves the rock, widening the cracks to form underground passages and, eventually, caves.

Caves provide a habitat for many unusual species, including bats, a variety of cave invertebrates, salamanders and blind cavefish. All of these organisms are characterized by adaptations that suit them for life in a dark, cool subterranean habitat. A few of these organisms are described below:

A blind crayfish, *Cambarus zophonastes*: This crayfish lacks pigment and has long, thin appendages, reduced body size, and small eyes. It is endangered and found only in Hell Creek Cave (Stone County), owned and protected by the Arkansas Natural

Heritage Commission and the Arkansas Nature Conservancy. This crayfish is *endemic*, meaning it is found only in Arkansas.

Grotto Salamander, *Typhlotriton spelaeus*: This cave-adapted salamander undergoes a complete metamorphosis from a pigmented larva that lives in streams inside or near a cave, to an adult with very little pigment and reduced eyes. The adults do not leave the cave. These salamanders are uncommon. Polluted groundwater is one of the most likely causes of reduction in grotto salamander populations.

Cave Salamander, *Eurycea lucifuga*: This salamander is typically found in the "twilight" region of caves, near the entrance where there is still some light. Unlike the grotto salamander, the cave salamander is bright orange-red with dark spots. While the cave salamander is frequently found in caves, it can also be found in moist, terrestrial habitats. Because it can occupy a wider range of habitats, this salamander is neither rare nor endangered.

Indiana Bat, *Myotis sodalis*: This bat is endangered, primarily because of human disturbance of fragile cave ecosystems.

Gray Bat, *Myotis grisesens*: This bat, like the Indiana Bat, has declined in caves disturbed by amateur cavers and vandals. It is also endangered.

Ozark Cavefish, *Amblyopsis rosae*: This is a small, eyeless, and unpigmented fish found only in Ozark caves in Arkansas, Oklahoma, and Missouri. It is endangered, and groundwater pollution and collectors threaten the remaining populations.

Springs are formed when groundwater flows through a surface crack in the bedrock. The water emerges at about 56° Fahrenheit in the Ozarks, the average annual temperature in that region. Some springs are very large, discharging millions of gallons of water a day. Mammoth Springs, located in Fulton County, is one of those large springs, discharging 234 million gallons of water each day! Most springs are much smaller, with a limited flow of water.

Native Americans and early settlers enjoyed the clear, cold water provided by springs and spring-fed streams in the Ozarks. Perishable foods were often stored in the cold water of the springs and settlers even built stone structures called "spring houses" around springs for the purpose of storing milk and eggs. Many Native Americans and early settlers believed that springs had healing properties; the towns of Eureka Springs and Heber Springs were well known for their "healing waters" and attracted throngs of people who sought cures for their ailments.

Unfortunately, caves and springs are easily polluted by activities taking place on the surface in areas characterized by karst terrain. Surface water enters the groundwater system easily, through cracks in the bedrock and even through sinkholes. Limestone and dolomite are not porous (easily penetrated) and do not filter the runoff, so contaminants are quickly spread throughout the groundwater system. The rapid developments of towns and cities as well as agricultural practices in the Ozarks have contributed pollutants to the groundwater system. Among these pollutants are wastes

from confined animal operations (chickens, hogs, and cattle). When animal wastes are washed off Ozark hillsides during a rain, they can enter a cave system. The process of decomposition of those wastes removes oxygen from the water in the cave, threatening aquatic animals. When rain falls in urban areas, surface runoff carries sediments from construction sites and other pollutants, like gasoline and oil from highways, into the groundwater system. Virtually no springs in the Ozarks are free of bacterial contamination, and sensitive cave organisms are threatened by pollution, particularly in the northwest corner of the state where the human population is increasing rapidly.

Activities:

PART 1: THE SCIENCE OF KARST FORMATION

These simple experiments are easy to perform; however, you might want to consider asking the science teacher on your teaching team to carry out these experiments in his/her science lab.

Experiment #1: Is Normal Rainwater Acidic?

1. Obtain litmus paper or another acid-base indicator from a science classroom.

2. Line a plastic container with a clean ziplock bag and collect at least 10 milliliters (about 1/2 cup) of rain during a normal rainfall. (The rainwater early in a storm is the most acidic. Be sure to seal the ziplock bag after collection to avoid contamination.)

3. During class, use the litmus paper or acid-base indicator to test the rainwater. Normal rainfall should be weakly acidic—about 5.6 on the pH scale.

Note: Students will probably ask about "acid rain." While normal rainfall IS acidic, the "acid rain" associated with airborne pollutants is often at least ten times more acidic and is harmful to the environment. Created when rainfall combines with nitrous and sulfur oxides emitted by industries and automobiles, acid rain has defoliated trees and contaminated lakes and ponds in many areas of the northeastern United States.

Experiment #2: Carbon Dioxide Plus Water Yields What?

1. Discuss the gases exchanged when humans and other animals respire.
   Oxygen is taken in and carbon dioxide is released.

2. Place a known acid, such as lemon juice or vinegar, in a clear plastic cup. Add several drops of bromothymol blue indicator. The blue indicator will turn yellow in the presence of the acid.

Most high schools stock bromothymol blue indicator. Check with a science teacher to obtain this indicator. If bromothymol blue indicator is not available, create your own by barely covering the shredded leaves of purple cabbage in water and heating until the water turns bluish purple. Cook on low heat long enough to concentrate the color so that a few drops will create a color change. Place a few drops of the cabbage pigment/indicator in vinegar and observe the color change. In an acid, cabbage juice indicator turns red; purplish to green in mildly alkaline solutions, and yellow in very alkaline solutions. For complete instructions, go to http://www.science-

house.org/learn/CountertopChem/exp27.html* *or use the keywords "cabbage juice indicator" to locate information on the Web.*

3. Divide students into pairs and give each pair a clear plastic cup of water and a straw. Place several drops of bromothymol blue indicator into their cups of water. Have students take turns gently blowing into the cup. After a few seconds, the bromothymol blue indicator will change from blue to green and finally to yellow, indicating the presence of an acid. (If you use the cabbage juice indicator, it will turn red to indicate the presence of acid.)

4. Explain to students that their experiments prove that carbon dioxide and water combine to form a weak acid, known as carbonic acid.

Experiment #3 *(Optional)*: How Acid Acts on Limestone

1. Obtain a piece of limestone, easily found in the Ozarks.

Limestone is grayish in color and frequently contains recognizable fossils. If you are unsure regarding the type of rock, scrape the surface of the rock with a knife. Limestone will scratch easily, while chert or flint will not. Another abundant rock on Ozark hillsides is sandstone, easily recognized by its rough sandpaper-like surface. Be sure you are not taking rock from private property without the owner's permission, or from a state park or preserved area.

2. Obtain safety goggles and a small amount of 20% solution of hydrochloric acid from a science teacher. Review basic safety procedures with the science teacher. DO NOT let a student conduct this demonstration!

3. Using a pipette, carefully drop a few drops of the hydrochloric acid onto the limestone. Watch for bubbles as the acid reacts with the limestone. (Carefully rinse the rock with water after the demonstration is completed.)

4. Explain to the class that carbonic acid also reacts with limestone in nature, although the natural process takes much more time because carbonic acid is weak compared to the hydrochloric acid.

PART 2: DECISION-MAKING IN KARST AREAS: SHOULD THE MEGA MALL BE BUILT?

1. Explain to your class that they will each be assuming the role of a resident of the mythical town of Sinking Springs, Arkansas. The town is in a karst area of northwest Arkansas, and the Sinking Springs Planning Commission is holding hearings on the proposed construction of the new Mega Mall. In your role you will be either for or against the construction, on the planning commission that will decide whether or not to grant a building permit for the mall, or part of the local media covering the commission's meeting.

* To access links, copy and paste into your browser.

2. Hand out a copy of the The Dilemma of Sinking Springs (included below) to each student. This page also contains some tips for students on how to present their viewpoint effectively. After all of the students have read the page, assign the following 25 roles to students for the upcoming "Town Meeting":

- 5 Planning Commission Members: One chairperson and four members.
- Sinking Springs Mayor, who wants Sinking Springs to grow, grow, grow!
- Sinking Springs Chamber of Commerce Director, who agrees with the Mayor.
- Homeowner in the subdivision next to the Mega Mall site who is concerned about the impact of the development on his quiet neighborhood.
- Contractor who will build the mall and stands to make a lot of money.
- Developer who proposed the mall and who will make even more money.
- Zoology professor at a nearby university who is conducting research on the Ozark cavefish.
- Geologist with the Arkansas Geology Commission who understands the threat to groundwater in this sensitive karst area.
- Ecologist with the Arkansas Natural Heritage Commission who conducts field research to locate rare, special, and endangered species in Arkansas.
- 4 Sinking Springs teenagers (2 for the mall, 2 against).
- 4 Sinking Springs adults (2 for the mall, 2 against).
- Businesswoman who owns a store near the Mega Mall site and who hopes her business will increase once the mall is built.
- President of the local Sinking Springs Environmental Club who opposes the development of the mall so close to Bat Breath Cave.
- Camera operator for the regional TV station (no oral statement).
- News anchor for the regional TV station (no oral statement).

3. Be sure that students understand that oral statements will be made by all of the students playing their assigned roles EXCEPT the Planning Commission members, the news anchor, and the camera operator. The Planning Commission will vote following the hearing, and the chairperson will vote only if there is a tie between the four members of the commission. Also, the camera operator will film the hearing, and the news anchor will report on the event on the "evening news."

4. Give students enough time and guidance to effectively research their roles before they develop their statements. The Missouri Department of Conservation published an excellent article on the karst areas of that state. Access their website at *http://www.conservation.state.mo.us/conmag/2000/03/2.htm*. Any number of good resources can be found on the Internet by using "Arkansas" or "Missouri" with the keyword "karst."

The students who represent those who are against the mall will find ample information to call for a halt in construction. Those who are for the construction might also get some ideas from our neighbor to the north, Missouri. The Missouri Department of Conservation has published a document entitled "Management Recommendations for Construction Projects Affecting Missouri/Karst Habitat." This two-page document will help pro-development students think of ways to build the mall and protect the

environment during the construction process. You or your students can contact the Missouri Department of Conservation for this document. Access their website at *http://www.conservation.state.mo.us/.*

5. Hold the "town meeting" during class. After all of those for or against the mall have made their statements, have the Planning Commission vote and the media report on the events of the day.

Note to teachers: Project WILD is an activity guide developed for science teachers who wish to emphasize the natural environment as they teach scientific concepts. Teachers trained to use Project WILD are reminded that the sometimes-controversial lessons are designed to get students to think. In this lesson, it is a good idea to adopt the Project WILD motto: Teach students HOW to think, not WHAT to think!

Sources:

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The Dilemma of Sinking Springs

Sinking Springs, a thriving community in northwest Arkansas, is named for the large natural spring that once provided water for the town. The spring consists of groundwater that emerges from a large fissure or crack in the limestone bedrock, flows downhill, and "disappears" into a large sinkhole, only to emerge again as a clear, cold spring-fed stream. When the community of Sinking Springs built a pipeline to a nearby reservoir for the community water supply, a park was built at the spring site.

The community of Sinking Springs is growing rapidly, and a developer recently announced plans to build Mega Mall, a shopping center with a number of popular stores on the west side of town. The mall will be built near the region's new interstate highway and is certain to attract shoppers from neighboring communities. Many Sinking Springs teenagers are particularly excited about the new mall, which will include a large movie theater and some of their favorite clothing stores. Community business leaders are also pleased; the new mall is certain to attract new businesses to the area. Real estate prices adjoining the proposed mall site have already doubled!

There is a problem, however, with the proposed Mega Mall development. It will be constructed only two miles from Bat Breath Cave, home for the endangered Ozark Cavefish and the Gray Myotis bat. Because of its location and the potential impact Mega Mall could have on the rare creatures found in Bat Breath Cave, an environmental impact statement must be filed with the Environmental Protection Agency (EPA). In the meantime, citizens of the Sinking Springs community have begun to discuss the controversial mall, and the Sinking Springs Planning Commission is being pressured to reject a building permit for Mega Mall.

A public hearing will be held tomorrow at the Sinking Springs City Hall. Citizen input is encouraged. Statements must be limited to 2 minutes and accompanied by a written copy of the statement.

<u>Tips for presenting your viewpoint effectively</u>:

1. Organize your thoughts and write your statement on a note card. Rank the points that you want to make in order, with the most important ones listed first.
2. Be clear and concise, giving examples if you can so that your listeners will understand your point of view.
3. Keep your statement short and simple!
4. Speak slowly and carefully. You want to be understood!
5. Use visuals to illustrate your point. Posters and pictures help people remember important points.
6. Make eye contact with your audience so that you can keep them focused on what you are saying.