“LIVING IN CAVE COUNTRY”

Learning about Caves and Karst

The southern half of Missouri is cave country. Water has carved into the surface and through the subsurface to create our rugged Ozarks terrain ... a land of ridges and hollows laced with thousands of sinkholes, springs and caves. Karst is another name for cave country. Specifically, we’ll look into:

1. Natural History: The Nature of Cave Country.
How do caves and karst show geological and biological process at work?

2. History: Man in Cave Country.
How are people living in karst areas affected by the unique geography?

3. Conservation: Protecting Cave Country.
How do we take care of the land, water, wildlife, and ourselves?

THE NATURE OF CAVE COUNTRY

Much of the significance of caves is due to their unique natural histories. We can actually enter the earth and watch geology at work: water first carries off soluble rock to hollow out a cave and then brings in minerals to build formations. And small, white, blind cave animals are living examples of adaptation to total darkness.

DEFINITIONS

A **cave** is a natural underground cavity large enough for people to enter. Here in Missouri, we only add caves to the state list which are at least 20 feet long. A mine is not naturally formed, and so is not a cave. Folks generally use the word **cavern** as a synonym for cave. A **cave system** includes all passages that interconnect. Some of these may be very small or water-filled.

TYPES OF CAVES

1. Most caves are in rocks that can be dissolved by a weak natural acid (usually carbonic acid). This acid forms when rainwater mixes with carbon dioxide in the upper layers of the soil. Soluble rocks include limestone, dolomite, gypsum and marble. Caves formed in the rocks are **solutional caves**. Ozark caves are solutional.

2. Caves form inside lava flows during cooling. First a crust hardens on the lava. A break in this crust allows molten lava to flow out leaving tunnel-like passages hundreds or even thousands of feet long called **lava caves** or lava tubes. Ice Cave at Grants, New Mexico, is a lava tube open

to the public. Others are found in Hawaii, California, Idaho, Oregon and Arizona.

3. Waves create **sea caves**. The waves force water into cracks in the rock, breaking of the rock and forming caves. Sea Lion Cave in Oregon is open to the public.

4. Huge rockfalls from cliffs can create large spacious chambers within the resulting boulder piles. Such **talus** (ta' les) **caves** are found in the northeastern United States. One cave contains over 12,000 feet of walking and crawling passage. Polar Cave in New Hampshire is a talus cave open to the public. Others are found in Pinnacles National Monument in California.

5. Melting water moving through glaciers creates **glacier caves** in places such as Canada, Alaska, and high on Mt. Rainier in Washington.

6. The movement of rock along a fault can make an **earthquake cave**. Sipapu Caverns in Wupatki National Monument in northern Arizona is one such cave. Explorers have descended about 500 feet into this natural crack in the rock. The bottom is plugged with debris washed down from the surface. Seneca Caverns in Ohio is an earthquake cave open to the public.

7. In desert areas, flash floods can move through the soil and hollow out openings. This commonly occurs near the edge of terraces that have been cut by gullies. Caves of this type are found in the Mojave Desert in California and are called **soil tubes**.

The most common kind of cave by far is the solutional cave. All the caves in Missouri are of this type. With more than 5500 known caves, Missouri is known as the "cave state".

THE OZARKS

The Ozarks, called by geologists the Ozark uplift or Ozark dome, is the result of repeated episodes of submergence, deposition, uplift, and erosion.

During times when the area was submerged under the ocean, creatures took lime from the seawater to make their shells. As they died these shells, together with limey mud, settle to the ocean floor and built up in layers. After millions of years of accumulation, the weight of seawater and overlying sediments pressed these layers into rock. So most of the rocks in the Ozarks are old ocean floor - limestone and dolomite. The limestone, in particular, contains a lot of fossils.

More recently (geologically speaking), during the last couple of hundred million years, the area has been mainly in an uplift and erosion mode. The geologic center of the uplift is the St. Francois Mountains in southeast Missouri. These are the oldest rocks in the Ozarks. Like a huge dartboard, the rocks get younger in irregular bands moving outward from the St. Francois Mountains.

As the area lifted in a broad plateau, agents of erosion (mainly water) worked to carry off the rock. Rivers cut their channels, creating the rugged Ozark topography. At the same time, subsurface water made caves.

SOLUTIONAL CAVE PATTERNS

Solutional caves can be divided into two patterns - maze and branch-work. Which pattern a particular cave becomes depends mainly on how water moves into and through the subsurface (type of recharge).

Maze caves form in several ways: by flood water pouring down through sinking streams, by water percolating through the rock (diffuse recharge), or by rising deep-seated water. Any of these conditions causes the simultaneous enlargement of many openings, forming a pattern of many interconnecting passages and closed loops. The maze pattern can vary greatly - from a regular crisscrossing network of passages (Mark Twain Cave near Hannibal, Missouri) to a giant 3-dimensional inkblot pattern with irregular rooms and passages wandering away from the areas of main development (Carlsbad Caverns, New Mexico).

But the largest number of solutional caves form when water moves underground via sinkholes. The water simply moves down through these point sources into a system of conduits. The overall pattern is a branching system of joining tributaries, much like a river system, and thus is called **branch-work caves**.

CAVES ARE DRAINED SPRING SYSTEMS

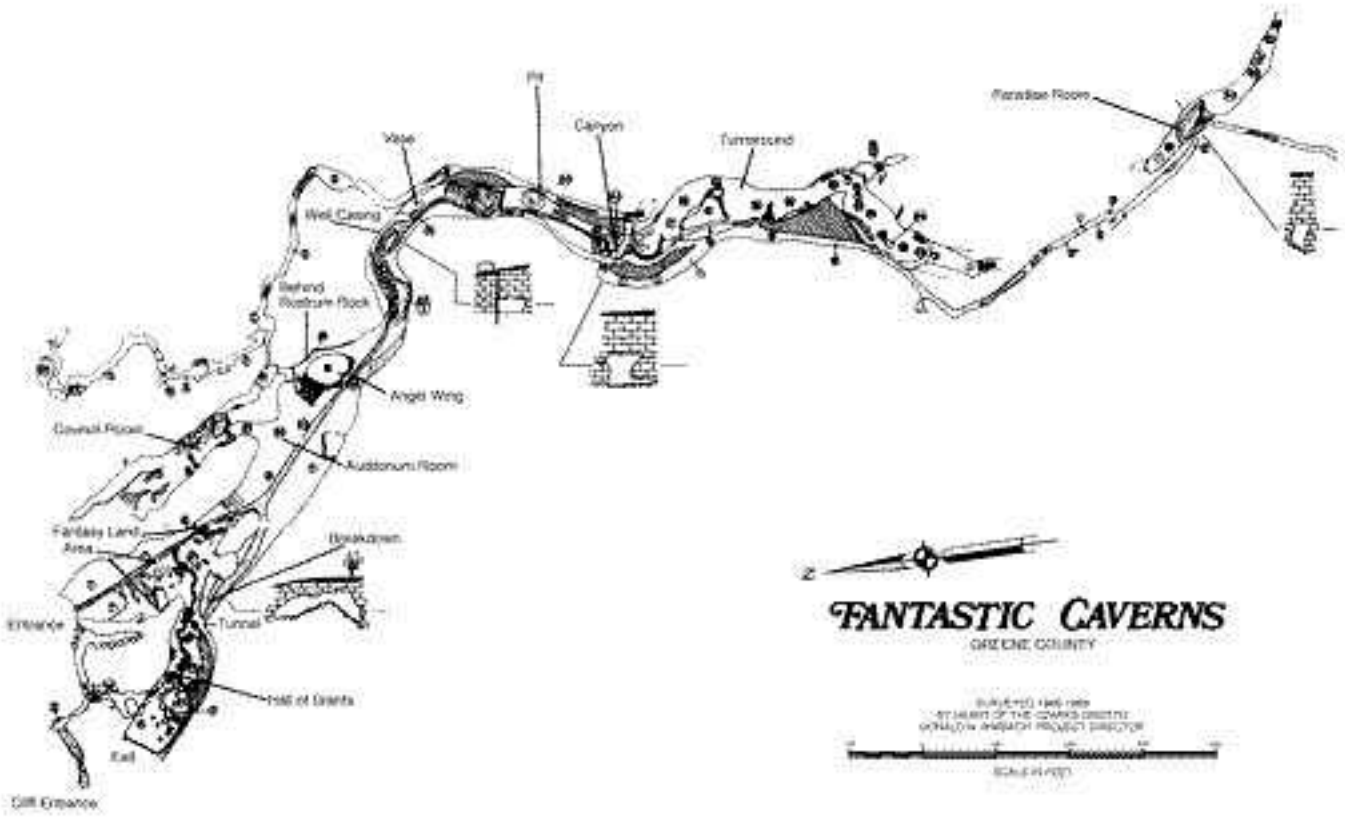
About 90% of solutional caves, both branch-work and maze, form by the movement of water from overlying recharge areas to springs in nearby valleys. The process of forming such a cave in soluble rock (usually dolomite or limestone) begins with rain. As rain falls through the air and seeps into the soil, it absorbs a small amount of carbon dioxide. Water mixed with carbon dioxide forms a weak carbonic acid solution that dissolves the rock.

The openings forming below grow larger and join creating an underground river as part of a spring system. Water hollows out and enlarges the passages as it enters this system (often through sinkholes), moves below ground, and surfaces at a spring. Finally, in response to surface rivers eroding ever deeper, the subsurface water drains away ... leaving behind a cave. Often the draining is incomplete, and a stream still flows through part of the cave. This stream can flood during heavy rains.

Three-fourths of the runoff in the Ozarks moves underground through caves. Rivers here not only flow on the surface, they flow **below** the surface. Springs are the drainage points for caves: caves are really drained spring systems. A large Ozark spring, such as Big Spring near Van Buren, discharges millions of gallons per day and each 1000 gallons contains about one pound of dissolved rock. Indian Spring, which flows from Fantastic Caverns, discharges 9000 gallons per minute during peak flow. Imagine the enormous volumes of water and long lengths of time to form caves. And with thousands of springs, you can think of Missouri as a “cave factory”.

FANTASTIC CAVERNS

Fantastic Caverns is a two level branch-work cave. Each was at one time full of water, but over a very long period of time this changed. The jeep tours run on the dry upper level. The lower level is a wet weather stream, carrying water during the rainy season through the cave to the discharge point at Indian Spring. Rarely, big rains will back up water from the lower level into the upper level, flooding it. Below the cave, all openings in the rock are water filled - that is, below the water table. This water supplies wells in the area.



The Little Sac River runs along the northeast side of the cave property, flowing through a deep valley. Once the valley was not as deep, and the river level corresponded with the upper level of the cave. During this period, the upper level of the cave was an active spring system. But as the river eroded deeper into the valley, the water level in the cave lowered. Figure 1 is a map of Fantastic Caverns, showing portions of both levels.

CAVE FORMATIONS

Dripping water can enter a cave and deposit mineral decoration. The most common mineral is calcite (often called lime), but others such as aragonite and gypsum are found in caves. This

process is similar to the buildup of minerals in a tea kettle.

The water begins as rain or snow falling on the ground. As it seeps through the soil and through cracks in the rock, it dissolves out minerals that it carries in and deposits in the cave.

Chemically speaking the process is as follows: Rainwater absorbs carbon dioxide from air and from decaying plants in the soil (the microorganisms which decay plants work the same way we do - they take in oxygen and give off carbon dioxide). This turns the water into mild carbonic acid - kind of a weak soda water - that dissolves calcite from the limestone as it seeps down. When the water enters the cave, it looses some of its carbon dioxide to the air, becoming a weaker acid not able to hold as much. This forces the water to deposit calcite.

Common cave formations include stalactites which grow from the ceiling (stick “tite” to the ceiling), stalagmites which grow from the floor (“mite” grow to the ceiling), and columns which join the floor and ceiling. These formations grow from **dripping water** - and are collectively called dripstone. Thin sheets of water flowing down a wall or out across the floor creates flowstone.

FAMOUS CAVES

Long Caves. Some of the longest cave systems in the world are found below the United States. The Mammoth-Flint Ridge Cave System of Kentucky has over 340 miles of interconnecting passages, making it by far the world’s longest known cave.
Some other long U.S. caves: Jewell Cave in South Dakota over 80 miles, Wind Cave in South Dakota over 60 miles, Lechuguilla Cave in New Mexico over 60 miles. The longest known cave in Missouri is Crevice Cave, south of St. Louis and not open to the public, at about 28 miles.

Deep caves. Lechuguilla Cave in New Mexico is over 1500 feet deep, making it the deepest known cave in the U.S. But unlike the long caves, the U.S. does not have the world’s deepest caves. Europe has some caves over 4000 feet deep.

Unique Caves. Carlsbad Caverns has several hundred thousand Mexican Freetail Bats, which storm out of the cave at dusk in the summer. Waitoma Cave in New Zealand contains glow worms. Some caves are toured by boat (Spook Cave in Iowa, Penn’s Cave in Pennsylvania, and Blue Springs Caverns in Indiana), by rail (Postojna Cave in Yugoslavia), and by jeep drawn tram (Fantastic Caverns in Missouri, Harrison Cave in Barbados). Cave explorers often tour caves on their hands and knees or even on their stomachs!

CAVE PLANTS AND ANIMALS

There is no natural light in caves. Without light, no green plants can grow. Algae, moss, and sometimes-even ferns grow around lights in cave attractions, but they can grow there only because of the artificial lights.

Without green plants, what can grow in a cave? Only non-green plants such as fungi, plus bacteria, grow in the dark interior of caves. They depend upon organic material rather than

photosynthesis for food. Occasionally mushrooms grow on wood washed into caves, but bat guano generally will not support them. Mushrooms have been grown commercially in caves by hauling in horse manure or other organics.

Fungus and bacteria are crucially important to animal life in caves. Because there is no light to grow green plants for the animals to eat, the cave food chain is based upon detritus. Detritus consists of bat guano, cricket guano, sticks, leaves, dead bats, and any other dead organic material. However, most cave animals cannot digest this detritus. Instead, they eat bacteria and fungus that can consume the organic detritus. Some cave animals are predators and eat other cave animals. Bats do all their feeding outside where they eat insects. Figure 3 illustrates the cave food chain.

Animals that spend their entire lives in caves are tiny, white and blind. The predators, such as the Ozark cavefish, the cave crayfish, and the grotto salamander, are still only a few inches long. Other cave animals are even smaller. Several hundred kinds of animals inhabit underground Missouri.

Cave animals are sparse and small because there is so little food in caves. In most Missouri caves, the amount of food is perhaps only 1/2000th of the food on the surface. Even in caves with large bat colonies, where there is more food because of bat guano, the cave has only 1/200th as much food as the surface.

Why are cave animals white and blind? Beyond the entrance area, caves have no light, so animals living there have adapted. True cave dwelling species lack skin pigment since they need neither sun protection nor camouflage. They are albino, permanently white. In addition, some animals (such as surface fish) with skin pigment will sometimes enter caves. These animals get very light colored because their skin pigment requires sunlight to make it work.

Like pigment, eyes have no value in the total darkness of a cave, so there is no evolutionary pressure to maintain them. In fact, an animal with eyes might injure them; eyes in a cave become a liability. But cave animals have their other senses more keenly developed. The Ozark cavefish, for example, has receptors along the lateral line of its head and body. These receptors pick up movement in the water.

At least eight kinds of bats inhabit Missouri caves. Two kinds (or species) are the eastern pipistrelle and the gray bat. Pipistrelles are tiny bats with wings spanning only 5-6 inches and weighting five grams (the weight of a nickel). No vampire bats live in the United States. They do, however, live in Mexico and Central America.

Bats are **not** blind. But they do have a sophisticated sonar - if you make your living snaring mosquitoes in the dark you need to go high tech. The sonar works like this; the bat makes a high pitched sound, and then uses the echo to “see” his surroundings.

Bats typically eat about half their body weight in bugs each night. They do the job of birds, only they work at night. Many of these bugs damage crops and forest trees. Bats also eat mosquitoes. They supply guano (bat manure) essential for the animal life in many caves. Bats

are beneficial to man; they are not to be feared or disturbed. Four species of bats in Missouri are near extinction.

Why do bats hang upside down? Probably for three reasons. One, when bats sleep and especially when they hibernate, they lower their body temperature and slow down their respiration and all body activities. Body temperature lowers to near the cave temperature, which here in the Ozarks is about 56-60 degrees F. When they are flying, their temperature is near 100 degrees. They could not balance like a bird under such conditions; it's easier to hang upside down. Two, by hanging from the cave ceiling, bats are out of reach of predators. Three, because they fly, bats are true lightweights. Their bones are thin and light for flight. In fact, engineering studies show that the femur (upper leg) won't support the bat upright. But by hanging, the weight is transferred from the bones as compression to the ligaments as tension. The ligaments easily hold the weight.

Are there snakes in caves? Only at the entrances. Caves are too cool for snakes; their metabolism slows down and they get sluggish. Besides, food is scarce and difficult to find in total darkness.

ENDANGERED SPECIES IN MISSOURI CAVES

Several endangered species live in Missouri's caves: including snails, millipedes, crayfish, fish and bats.

One endangered species is the **gray bat.** It weights about ¼ ounce, and eats about half its weight in insects every night. It has a life span of 15 to 20 years. It is endangered because of habitat loss - the bats are being bothered too much in the caves that are essential to them. Less than 1% of the caves in Missouri are suitable for major bat colonies; the bats are very specific in their needs. Pesticides used on the insects they eat also threaten bats. These pesticides build up in the bats, and can kill them or their young.

The Ozark cavefish, found in Fantastic Caverns, is a very rare animal found only in the western part of the Ozarks. The fish lives only in underground water. It is the most highly cave-adapted fish in the United States. Fewer than 500 of these fish are known to exist. Underground water contamination is probably their biggest threat.

GLOSSARY OF COMMON CAVE TERMS

Cave Attraction/Show Cave- cave open to the public with guided tours for a fee.
Cave coral (or popcorn) - irregular clusters of calcium carbonate (the mineral calcite) which builds up on walls and existing formations as water slowly seeps out.
Cave formation - a crystalline deposit of calcite found in a cave, includes cave coral, columns, draperies, flowstone, soda straws, stalactites and stalagmites.
Column - a cave formation connecting the floor and the ceiling, created when stalactites and stalagmites grow together or when one of them grows all the way to the floor or ceiling.

Drapery - forms where drops of mineral-laden water trickle down the underside of an inclined ceiling, leaving a deposit which folds and curls like a curtain.
Flowstone - forms where a film of water flows over walls, floors or formations depositing sheets of calcite (resembles icing).
Soda straw - thin-walled hollow tubes about ¼ inch in diameter. It forms as water runs through the center and deposits rings of calcite around the tip.
Stalactite - grows down from the ceiling as water deposits mineral layers over the outside of a plugged soda straw.
Stalagmite - grows up from the floor as water drips from above, often (but not always) grows beneath a stalactite. It has a rounded top, compared to the carrot shaped stalactite.
Wild cave - an undeveloped cave, often located in a secluded area. Only experienced cavers should enter a wild cave. No fee is usually charged, and there are no lights or pathways.

MAN IN CAVE COUNTRY

Caves have important histories and whether we know it or not, they have affected everyone. One prime example is saltpeter production - used to make gunpowder essential to the survival of the young United States. Primitive people living in cave country - including Indians here in North America - used them for housing, art galleries, and as sources of raw materials.

MAN'S ANCESTORS

Two million-year-old skeletal remains of Australopithecus africanus have been found in shelter caves in Africa. They didn't live in the dark zone; rather they used the twilight zone for shelter and meals. Archeological excavations beyond the twilight zone of hundreds of caves have never found a major accumulation of artifacts.

CAVE ART

Cro-Magnon man was active as a cave artist during the waning phases of the last glacial state. Using the wall in the dark zone as a canvas, he painted thousands of animal figures, many of them extremely realistic in pose and vivid in color. For light Cro-Magnon used a wooden torch or a stone lamp, with marrow or fat for fuel. The lamp had a wick, perhaps of moss, and could produce a fairly bright light for several hours. The pigments were red and yellow ochre, mixed with animal fat, and black from burned bones and manganese coatings on cave walls.

Possibly the animal figures were made in the hope of ensnaring game by magic: many portray nets, spears, and traps. One remarkable fact is that cave art rarely shows a human figure, and those that are shown are little more than stick figures. The artists may have believed what many primitive people still believe - that a man can be hurt by mutilating a picture or figure of him.

IN AMERICA

Excavations at Sandia Cave in New Mexico reveal two different cultures. The older is recorded by distinctive spearheads. A two-foot layer of silt, without artifacts, covers the spearheads. This

layer contains pollen from spruce and fir trees, showing that the southwest had a cooler and moister climate than now.

The younger culture is represented by beautiful spearheads found above the pollen-bearing soil and under flowstone. Each of these spearheads has a smooth, shallow groove: the first points made by flaking with firm pressure rather than chipping with sharp blows. The men who used these fluted points lived about 10,000 years ago, and hunted now extinct species of wooly mammoth, peccacary, bison, and camel.

Here in Missouri, Graham Cave State Park (off I-70 between Columbia and St. Louis) is a sandstone shelter with layers of Indian artifacts. Archeologists have cut down into the layers, exposing the remains of older Indian cultures as they dig deeper. Indians used that cave as much as 8000 years ago.

In Mammoth Cave, Kentucky, an Indian skeleton was found lying beneath a giant rock, his bundle of reeds used for light lying beside him. He was digging out a pocket of gypsum crystals, and apparently didn't notice he was also undercutting the rock.

SALTPETER

Saltpeter is a nitrate found in some dry cave soils - apparently left in the soil by nitrogen fixing bacteria. The mining and processing were ingenious. The miners piled the cave soil into giant hoppers, and then ran water through to dissolve and carry out the nitrates. They then boiled off this water to leave the saltpeter crystals behind. Saltpeter is the major ingredient in gunpowder, along with smaller amounts of charcoal and sulfur.

The mining of saltpeter for gunpowder during the War of 1812 was of vital importance to the survival of our young nation. During the Civil War, the Confederates resumed the operation of these natural mines when the Union blockade cut off foreign sources of power.

CAVERS

New caves are found often. In Missouri we find new caves at the rate of about 80-100 per year. Recently discovered Lechuguilla Cave in New Mexico is pristine and huge - the deepest cave in the United States and surveyed at over 60 miles long. Cavers love to visit all kinds of caves, drawn by the beauty and adventure. Caves are a last frontier: where else can you still go where no one has ever been?

Cavers follow some basic safety rules:

1. Never go alone. Go with folks familiar with caves.

2. Take at least three sources of light per person (flashlight, carbide lamp, etc). Also, take extra batteries, bulbs, fuel, etc.

3. Dress in rugged, protective clothes: coveralls, boots, helmet, gloves, etc.

4. Make sure people know where you are, and when you expect to return.

5. Get the cave-owner's permission before visiting.

6. Don't go into a cave when it's raining or when it might rain. Caves can flood in a short time.

7. Realize that caves are fragile and easily damaged. Follow the Caver's Motto: take nothing but pictures; leave nothing but footprints; kill nothing but time.

SCIENCE

The simplicity of the cave environment, with no sunlight and constant temperature, makes a unique laboratory to study the end products of a geological and biological "experiment" running thousands of years. We also can study underground water from a unique perspective - from within the ground.

OTHER USES

The list is long: mushroom growing (Fantastic Caverns), cheese-aging and storage (below Springfield), mining bat guano for fertilizer (Bat Cave in Arizona), using cave air for air-conditioning buildings (a theater below Stockton), fallout shelter (Fantastic Caverns in the 1960's). But the biggest business now for caves is tourism - cave attractions provide a comfortable and informative way for folks to enjoy caves.

AGRICULTURE AND KARST

Early settlers came to the Ozarks to make their living on the land. But in many cases, the land wouldn't support them. Karst areas are scenic places, but the things that often make the land beautiful make farming difficult.

To understand why, look at the terrain. The topography generally is steep, with rivers cutting deep into channels leaving ridges in between. Think of the problems for farmers: steep slopes, thin rocky soil, a rather deep water table (which make wells expensive), and a constant threat of subsurface water contamination (given all the cave and sinkhole openings).

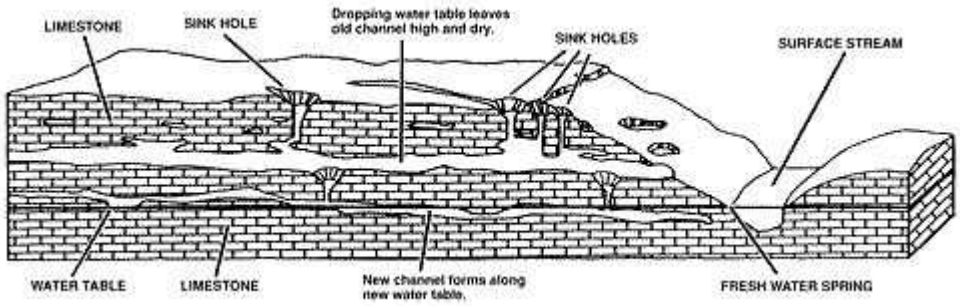
PROTECTING CAVE COUNTRY

KARST - The movement of rainwater down from the surface and through a cave shows the surface-subsurface connection. This water brings in nutrients for the cave animals. But it also can bring in contaminants. If we pollute the surface, we also pollute the subsurface. One way to put it: "what goes down comes up". To understand how this works, you first need to know something about karst and its problems.

Karst is where the dissolving of soluble rocks - limestone, dolomite, gypsum, or marble - plays the major role in land erosion. Karst areas have caves, springs, sinkholes and sinking streams (which flow into the ground and disappear) - making the whole area resemble Swiss cheese coated with soil.

Water creates these features in soluble rock. It also uses them as conduits: entering through sinkholes, flowing underground through caves, and surfacing again at springs. A spring is the drainage point for a cave; a cave is a drained spring system. Southern Missouri contains these features and the unique environmental problems associated with them.

There are two basic ways in which water from the surface recharges groundwater in Karst areas: discrete recharge and diffuse recharge. Discrete recharge is very localized, and often involves large quantities of water that move rapidly into groundwater supplies. A storm water stream disappearing into a sinkhole is an example. Discrete recharge typically provides ineffective natural filtration and cleansing for water. In contrast, diffuse recharge involves slower moving water that seeps through soil and rock units in route to groundwater supplies.



SINKHOLES

Understanding sinkholes is another way to understand the surface-subsurface relationship in cave country. A sinkhole is a depression in the earth's surface with subsurface drainage, where water has dissolved out a drainage network through the rock.
Sinkholes are the entry points for water into spring systems. Soil, organic debris, and sometimes pollutants move down through sinkholes during rainstorms. These materials are transported through underground streams, and finally resurface at springs. That's why we say in the Ozarks that whatever goes down comes back up.

To trace the movement of underground water, a harmless dye (such as fluorescein) is poured into water flowing into a sinkhole. Charcoal packets placed at springs can remove some of the dye from the water. If the dye is detected, then that sinkhole is one of the sources for that spring. The process is simple and direct.

A sinkhole relates to an underground stream in much the same way a surface gully relates to a surface stream. To protect the quality of water in surface streams, we must protect the quality of

water in gullies. Similarly, if we are to protect the quality of water in underground streams and springs, we must protect the quality of water entering sinkholes. Figure 2 shows how a typical sinkhole plain relates to the surface in karst terrain. There are many sinkhole areas in Missouri. One large area includes Springfield.

SURFACE TO SUBSURFACE POLLUTION

Caves and the land in which they are located are closely tied together. What happens on the surface can affect caves. Therefore, groundwater pollution in cave country is a serious problem. It's often more serious than surface water pollution. Several types of groundwater pollution occur frequently. The most common is human waste (sewage), followed by industrial and hazardous waste.

SEWAGE POLLUTION

All too often, poorly planned sewage systems (such as septic field systems) contaminate nearby wells and springs. Entire towns may contaminate karst groundwater systems if they discharge wastewater to surface streams that sink into the ground and feed groundwater supplies. The key to preventing these problems is sound planning with emphasis on groundwater protection. If sewage enters karst groundwater, it can seriously deplete the amount of oxygen dissolved in the water. Aquatic life suffocates without oxygen, and the water exudes offensive odors.

A case history may be helpful in understanding the sensitivity of underground streams to oxygen depletion. Hidden River Cave is a large stream cave system located in Horse Cave, Kentucky. The cave's drainage basin is a large sinkhole plain in karst terrain. The community discharged large quantities of poorly treated sewage directly into the cave stream. During the summer, terrible odors came out of the cave entrance that was in the business district of Horse Cave. The odors substantially detracted from the entire area. In addition, the cave was both a major tourist attraction and the water supply for the city of Horse Cave: neither of these uses was possible (Aley, 1981). A project costing millions of dollars was necessary to restore the groundwater quality of the region. Perhaps this historic disaster will help us prevent similar situations in Missouri karst areas.

City sewers can cause problems for groundwater in karst areas if the sewers leak. And they often do leak. Sinkhole development and land subsidence are common process in karst areas, and the processes can crack sewer lines or separate connections in the lines. Much of the sewage lost from sewer lines discharges from springs.

Many of our city sewers are old and have serious leakage problems. Some need to be replaced. Sometimes old sewers can be repaired by inserting new plastic pipes inside the old lines. New sewers need to be constructed of materials that can better withstand the effects of sinkhole collapse and land subsidence. A new sewer line crossing a sinkhole area near Horse Cave is made of a plastic pipe that has a great ability to stretch. When new sinkholes develop along this sewer line, this new pipe will stretch across the holes rather than break and dump sewage into the groundwater system.

INDUSTRIAL AND HAZARDOUS WASTES

This category includes everything from chemical and gasoline spills to landfills to the disposal of hazardous and radioactive wastes. The location of industrial plants is important since many factories use chemicals and other materials that can seriously degrade water quality.

Factories must have good waste disposal facilities. Where city sewers don't exist, factories sometimes use lagoons for waste disposal. Sometimes the lagoons leak into groundwater supplies and damage water quality in the region. Leaky industrial lagoons have caused serious groundwater problems near Springfield, Missouri.

Gasoline and other petroleum products are familiar to all of us. Many of these products however, are serious water pollutants. Leaking underground fuel storage tanks have ruined thousands of wells in the United States. Gasoline can readily follow the same underground routes as water. Imagine what happens when gasoline is spilled in a sinkhole. Unfortunately, it's almost impossible to remove all the gasoline once it enters the groundwater.

Even the disposal of common trash and garbage creates serious problems in karst areas. In the United States, we generate about 3.5 pounds of solid waste per person per day. At present, much of this waste goes to landfills. In karst areas, substantial volumes of water commonly move through the trash and create a liquid called landfill leachate, which routinely contains heavy metals, chemicals, and other toxic materials. Furthermore, landfill leachate has a tremendous demand for oxygen. When it mixes with clean groundwater supplies, the end product often is a septic spring or well which kills aquatic life and causes terrible odors.
What can we do about these problems? First, everyone needs to understand that wastes from our use of the surface can easily enter karst groundwater systems. Creating pollution benefits no one. Factories must not be located where they are likely to cause groundwater pollution - such as in areas with numerous sinkholes. Fuel storage tanks should be designed so that they don't leak. Sometimes in karst areas incinerators are a better solution for trash disposal than landfills. Groundwater pollution always results from landfills in karst areas.

In 1978 Fantastic Caverns began monitoring the quality of groundwater in its underground system. The water is of high natural quality now. These conditions must be preserved for several reasons. First, the cave is a natural wonder and a major recreational and educational resource for the region. Second, the cave provides critically important habitant for cave animals - such as the Ozark cavefish and the briskly cave crayfish - which are threatened with extinction. Finally, the water in the cave stream is an indicator of the quality of water in hundreds of area wells.

As part of our science research program, Fantastic Caverns is sponsoring a major groundwater study in the area. The study includes groundwater traces to delineate the recharge area for Fantastic Caverns and nearby springs. Protecting groundwater is a major part of protecting caves, and an important part of living in cave country. For Fantastic Caverns, conservation is just good business.

HISTORY STUDY QUESTIONS

1. People who explore caves are called _____.
2. Why would someone want to explore a cave? _____
   _____
   _____
3. Ancient cave artists in Europe drew pictures of _____on cave walls.
4. _____ was mined and used to make gunpowder during _____
   _____.
5. Name three rules of safe caving.

   1. _____
   2. _____
   3. _____

6. What is the Caver's Motto? _____
   _____
   _____
7. Here in Missouri Indians used _____Cave. Artifacts in the soil of that cave have been dated to_____ years ago.
8. What is one problem with farming in cave country? _____
   _____
   _____
9. Name three uses for caves?

   1. _____
   2. _____
   3. _____

CONSERVATION STUDY QUESTIONS

1. Caves, sinkholes, springs, and underground streams are all features of _____ terrain.
2. When rainwater recharges the groundwater system, it gets there by two different methods. _____ Recharge takes place when rainwater percolates through deep layers of topsoil causing natural filtration. _____ recharge, common in karst terrain, happens when rainwater rapidly makes its way into the underground by flowing into sinkholes, sinking streams, and other conduits with little or no natural filtration.
3. Sewer lines need to be monitored regularly because they may _____.
4. _____ pollution is common in karst areas.
5. One common pollutant that is nearly impossible to clean up is _____.
6. Limestone contributes to water movement in the ground because it is _____ and permits the formation of openings.
7. Explain a sinkhole and how it works._____ _____ _____
8. Flourescein _____ is used to trace groundwater movement.
9. Of the types of groundwater pollution in karst terrain, _____ waste is the most common. A cause of this is leaky _____ systems.
10. Depletion of the dissolved oxygen in water causes it to _____ and kill aquatic life.

NATURAL HISTORY STUDY QUESTIONS

1. Hollow underground spaces are called _____.
2. There are several types of caves. Two of these are _____ caves and _____ caves.
3. Most caves are formed in _____.
4. Rainwater picks up carbon dioxide from soil, forming _____, which dissolves some rocks.
5. Green plants do not live in caves because there is no _____.
6. Name two rare or threatened Missouri cave animals: _____ and _____.
7. There over _____ caves in Missouri making it the “Cave State”.
8. Explain briefly the development of cave formations._____ _____ _____
9. What do cave animals eat? _____ _____
10. What do bats eat? _____ _____
11. Cave formations that grow down from the ceiling are called _____, while those that grow up from the floor are called _____.
12. The remains of animals found in rock are called _____.
13. Caves are drained _____ _____.
14. _____ is the world’s longest known cave.
15. Southwest Missouri is part of what geologists call the Ozark _____.
16. Some caves form a confusing pattern of intersecting passages and are called _____ caves.
17. Most Missouri caves show branching drainage patterns. These caves are called _____ caves.

TEST KEYS

History

1. caver,

2. adventure, beauty, discovery,

3. mostly animals,

4. saltpeter, Civil War, War of 1812,

5. never go along, take three lights, tell others where you are going, wear old clothes, get permission, don't go in the rain,

6. take nothing but pictures; leave nothing but footprints; kill nothing but time,

7. Graham Cave, 8000 years ago.

8. hilly, rocky, thin-soiled, steep, deep wells, easily contaminated ground water,

9. caving, science, tours, mushroom growing, cheese aging, air conditioning,

Conservation

1. karst,

2. diffuse, discrete,

3. leak,

4. groundwater,

5. gasoline,

6. soluble,

7. (from information),

8. dye,

9. human, septic or sewer,

10. smell bad,

Natural History

1. caves,

2. solutional, lava, sea, talus, glacier, earthquake, soil tubes,

3. limestone,

4. carbonic acid,

5. sunlight,

6. gray bat, Ozark cavefish, cave crayfish,

7. 5500,

8. (from information),

9. organic material (bacteria, fungi, other cave animals),

10. insects from outside the cave,

11. stalactites; stalagmites,

12. fossils,

13. spring systems,

14. Mammoth Cave, Kentucky,

15. uplift or dome,

16. maze,

17. branch-work