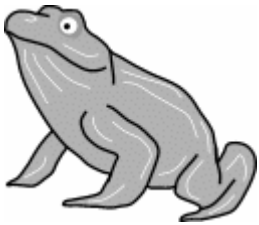
Teacher's Guide to:

The Mystery of Black Water Cave



by
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Caves & Karst

Caves are natural openings in the ground surface which may be formed in a variety of ways. Dissolution of soluble rock is the most common mechanism for cave development (*i.e.* solutional caves), as water passes through the ground. Other mechanisms of cave formation include voids created by tectonism in hard rock (*i.e.* tectonic caves), voids created in unconsolidated sediments by weathering (*i.e.* suffosion caves), voids created in volcanic settings by flowing lava (i.e. lava tubes), voids created by mechanical abrasion along coastlines (*i.e.* sea caves) and voids created by the melting of ice in glaciers (*i.e.* ice caves).

The cave depicted in *The Mystery of Black Water Cave* is a solutional cave because this is the most common type of cave. Black Water Cave was formed by water flowing through the subsurface and dissolving rock. In this case, the soluble rock is limestone (*i.e.* calcium carbonate – $CaCO_3$), but other common types of soluble rock included dolomite (*i.e.* calcium-magnesium carbonate – $CaMg(CO_3)_2$) and gypsum (*i.e.* calcium sulfate – $CaSO_4 \cdot 2H_20$). As water passes through soluble rock, minor amounts of rock are dissolved and transported away in solution, which may create large voids and complex cave systems over time. On the scale of a human lifetime, this is a very slow process, but in the context of geologic time a cave can develop very rapidly.

Various factors can influence the rate of rock dissolution. In carbonate rocks (*e.g.* limestone and dolomite) the addition of acids to water can accelerate the rate of dissolution. Rain (meteoric water) picks up carbon dioxide from the atmosphere and forms a weak carbonic acid. Additional carbon dioxide is absorbed in water as it passes through soils where organic plant material is decomposing, strengthening the carbonic acid solution. This addition of carbonic acid significantly increases the rate of rock dissolution. Other factors that affect the rates of rock dissolution include water salinity and temperature.

Throughout the book, speleothems are shown hanging from the ceiling, growing from the floor, or associated with flowing water. Although speleothems form from a wide variety of minerals, they are most often calcite ($CaCO_3$). As water passes through carbonate rocks, it becomes saturated with dissolved minerals. When this saturated fluid passes into an open void, it begins to degas carbon dioxide and evaporate water. Therefore, the dissolved minerals precipitate to form speleothems, because the same mechanisms that enhance dissolution of carbonate rock (*e.g.* addition of carbon dioxide) also enable the precipitation of calcite when they are removed from the system.

In *The Mystery of Black Water Cave*, cave passages are developed along geologic structures. Carbonate rocks are deposited in horizontal layers in marine settings by the accumulation of the calcite shells of marine organisms. Changes in deposition of layers of marine sediment are often preserved and exhibit variations in composition, which affect the rate at which different layers dissolve; some layers will dissolve faster than others.

In addition to compositional variations, rocks are often deformed by tectonism. Rocks can become folded or fractured as portions of the earth's crust are pushed together or pulled apart by plate tectonic movement. The folds and fractures commonly control the routes through which water will flow through the subsurface. Therefore, the combination of variations in rock composition and tectonic deformation controls the overall pattern of cave development.

Abundant information can be found on-line that details the formation of caves. Some of the most useful websites are listed at the end of this book, which provide more detailed information that could be incorporated into educational programs.

Geomorphic Cave & Karst Features

The following terms and definitions are typical features associated with caves. Examples of these can be found throughout *The Mystery of Black Water Cave*. Images throughout the story can be used to introduce these terms to students and familiarize them with common features in caves. The first occurrence of an illustration of each specific feature is referenced by page number at the end of each definition. Numerous other examples occur throughout the story. The profile view of the entire map (pg. 49-50) shows the relationship between many of these features.

Breakdown: large blocks of rock often found within caves that results from the partial collapse of cave ceilings and walls (pg.2).

Cave: a natural hole in the ground that is large enough for human entry (pg.2).

Column: a speleothem that is formed when a stalactite and stalagmite grow together to form a continuous speleothem that is connected at both the ceiling and floor of a cave passage (pg. 11).

Dome: a section of cave passage that is substantially taller than its length or width; domes often form above pits (pg. 31).

Entrance: a general term used to describe the location where a cave intersects the land surface and can be entered by humans (pg.2).

Epikarst: the uppermost zone of a cave system where dissolution of bedrock forms an irregular surface that is often covered by soil (pg. 35).

Flowstone: a type of speleothem that forms by sheets of flowing water depositing thin mineral layers (pg. 17).

Karst: a landscape created by dissolution of rock with an underground drainage system, and usually characterized by the presence of sinkholes and caves (pg. 2).

Passage: broadly defined, a cave passage is any negotiable portion of a cave, but generally refers to sections of cave that are horizontal or slightly inclined (pg. 3).

Pit: a vertical cave passage that may connect two or more horizontal levels of passages within a cave (inside cover).

Room: an enlarged cave passage relative to other portions of a cave, often formed at the junction of two or more passages (pg. 25).

Sinkhole: a closed-depression on the surface in karst terrains that commonly connects to caves, typically formed by rock dissolution or collapse of an underlying cave passage (pg. 35).

Speleothem: a general term for any type of secondary mineral deposit within a cave; most commonly calcite (pg. 5).

Stalactite: a type of speleothem that hangs from a cave ceiling and is formed by dripping water (pg. 5).

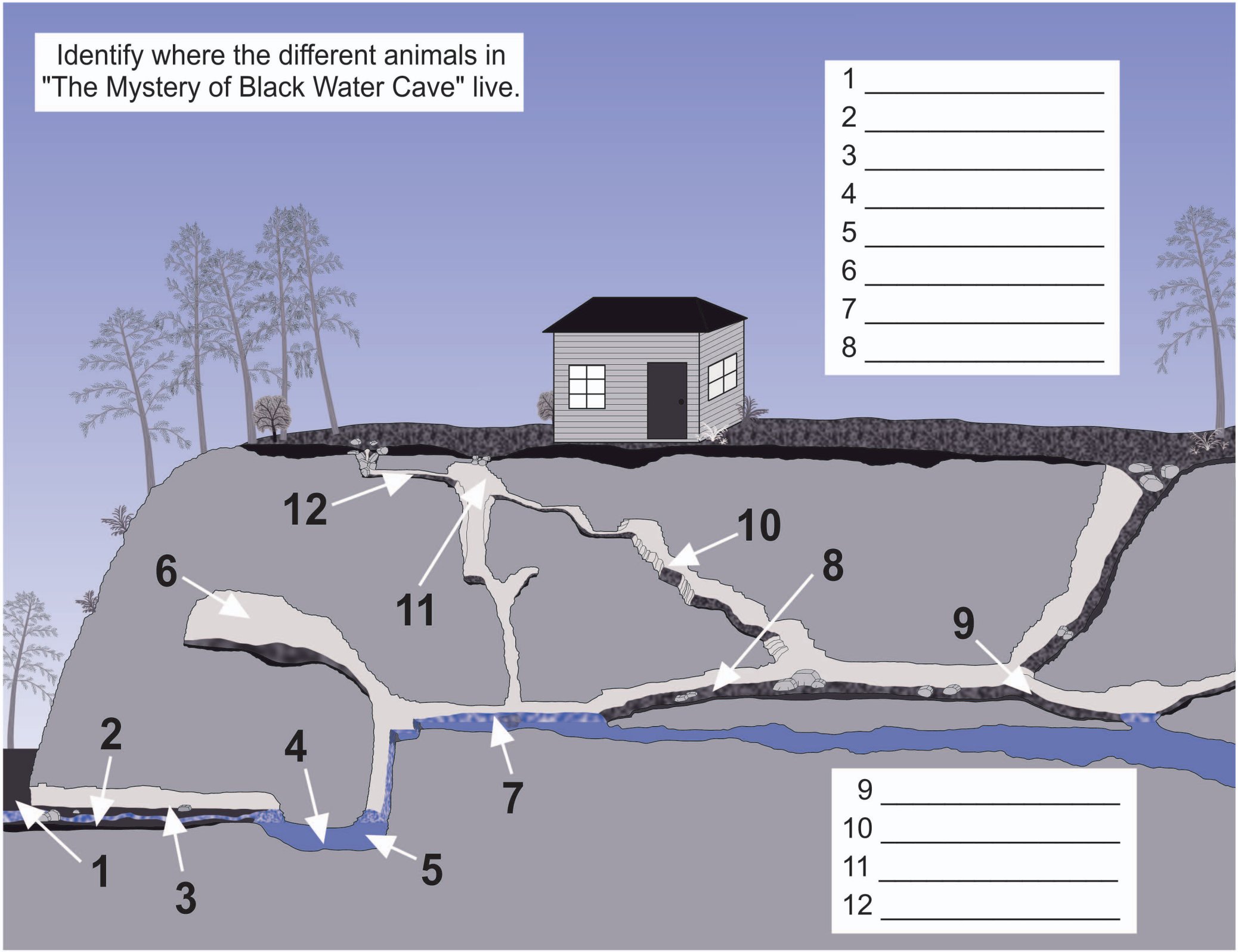
Stalagmite: a type of speleothem that is formed by growing upward from a cave floor by the dripping of water from above (pg. 6).

Sump: a portion of cave passage that is completely filled with water (pg. 12).

Suggested Student Project:

Review the above terms with students as they are illustrated in the book. Have each student draw a segment of cave passage in which they must clearly depict several of these geomorphic features. Have students compare their drawings and discuss the variability in their pictures.

Identify where the different animals in "The Mystery of Black Water Cave" live.



Human Uses of Caves: Ancient

Humans have used caves for a variety of purposes over the ages, from living spaces to commercial guano mining. Prehistoric people took advantage of caves for temporary or permanent shelter from the elements and enemies. Caves provided a natural enclosure offering protection from rain, snow, and even heat. Small cave entrances provided a defensible opening to the outside world. Additionally, some prehistoric cultures reserved some caves for religious ceremonies and did not live in them.

How do we know so much about the prehistoric use of caves? The cave dwellers left their mark in caves with rock art, fire pits, and discarded clothing, tools, cooking implements, and bones. Caves typically have a very stable environment with relatively constant temperature and humidity. Poor accessibility to the outside protects artifacts and remains from scavengers, both animal and human. This type of environment is ideal for the preservation of fossils and artifacts.

Two well-known examples of prehistoric cave use are:

Cave Art – The Cave at Lascaux, France :
www.culture.gouv.fr/culture/arcnat/lascaux/en/

Ceremonial Use – Ceremonial Cave, Texas :
http://www.texasbeyondhistory.net/ceremonial/index.html

Suggested Student Project:

Have the class search the internet for examples of fossils found in caves. (Internet keywords could include: cave, karst, sinkhole, fossil, paleontology).

Have students expand their search and look for caves that were used by prehistoric humans. (Internet keywords could include: cave, karst, sinkhole, fossil, archeology, anthropology, Neanderthal, artifacts, cave art, mummy, paleoindian).

Human Uses of Caves: Modern

Human cave use continues today. There are many modern uses for caves. In the early part of American history, people took advantage of a byproduct of one of the animals that live in caves – bats. Guano (bat feces) was used during the Civil War and World War I in the production of ammunition. Nitrates from guano were used in making gunpowder. Guano was also was used as a fertilizer in the early 20th century. Guano mining was active in the United States until chemical fertilizers became more cost-effective. Caves were used as natural storage vaults for everything from equipment to art work. During the 1950s, several municipalities designated local caves as fallout shelters in case of nuclear attack.

Throughout human history, many caves have been sites of military importance. Castles were sometimes built into entrances during medieval times, utilizing caves as part of the castle's construction. During World War II, caves were used as defensive positions and storage facilities throughout the Pacific islands. Today, caves continue to be used by people as natural defensive positions in military campaigns.

More modern uses of caves include food production. The constant temperature and humidity conditions within caves makes them an ideal location for raising mushrooms, and fermenting and storing cheese and wines. Caves are used for scientific research including geology, hydrology and biology. Many people enjoy the recreational aspect of caves. Adventurous cavers explore wild caves. Cave divers explore caves that are completed submerged. Caves that are open to the public and have been augmented with artificial light and paved walkways are known as show caves.

Suggested Student Project:

Have students find local show caves on the Internet. Have the class collect materials on the different show caves in your area. As a class, vote on the favorite show cave and plan a class field trip.

Pollution of Cave & Karst Systems

Karst terrains are extremely susceptible to pollution and environmental contamination. Sinkholes and cave entrances provide direct connections to the Earth's surface for the introduction of pollution. Sinkholes. cave entrances, and epikarst features are conduits that allow the rapid transfer of contaminants into and throughout the subsurface, similar to the way water flows rapidly through pipes but much more slowly when poured on the ground surface. Effectively no filtration occurs when polluted water moves through karst conduits.

Pollution of karst systems can be in the form of solids, liquids, or gases. Solid waste is often introduced by the dumping of trash in sinkholes and cave entrances. Liquid contaminants are transported rapidly through the subsurface by mixing with cave streams. Liquid contaminants can be many things, but are most often associated with waste water disposal, underground storage / gas tanks, fertilizers, pesticides, and other liquids that humans readily dump onto the ground. Gaseous contaminants can also be introduced into cave systems, often as vapor from leaky underground storage / gas tanks. Solid, liquid and gaseous pollution all harm caves and animals living within caves. However, contamination of karst systems also hurts humans because most people living in karst terrains extract groundwater for daily use.

Karst systems are fragile ecosystems that are easily impacted by pollution. Many species of cave animals have become threatened or even endangered by the introduction of pollution into karst groundwater systems.

Suggested Student Project:

As a class, make a list of possible contaminants that may pollute cave systems. Identify which types of pollution must enter through a cave entrance (*e.g.* car tire) versus those which can be transported through epikarst (*e.g.* gasoline).

Cave Animals

Many animals take advantage of caves as either a permanent home or a temporary shelter. There are three main categories of cave animals:

Trogloxenes (trog-lo-zeens) are animals that live on the surface but spend some time within caves. This is primarily for shelter. Trogloxenes need to leave the cave to survive, either to find food or to mate. Examples of trogloxenes include mammals such as bats, bears, raccoons, packrats, foxes and ringtails, birds such as swallows, owls and vultures, as well as some reptiles, amphibians, fish, and invertebrates.

Troglophiles (trog-lo-files) are animals that can live on either the surface or within a cave. Troglophiles can potentially live their entire lives in a cave but they retain the ability to live on the surface. Examples of troglophiles include many insects such as beetles, millipedes, and centipedes, plus some species of crayfish and salamanders.

Troglobites (trog-lo-bites) have evolved special physical adaptation to spend their entire lives within a cave. Troglobites cannot survive outside of a cave. These adaptations include the loss of eyes and skin pigment, elongated limbs and feelers, and an enhanced sense of smell and vibration. Examples of troglobites include cave insects (cave millipedes and cave spiders), amphibians (cave salamanders), crustaceans (cave crayfish and cave shrimp) and cave fish.

Suggested Student Project:

Have the class discuss why troglobites have evolved to be physically different than their surface-dwelling relatives. Why are troglobites white / albino? Why do troglobites have decreased eye size or no eyes at all?

For More Information:

http://www.batcon.org/ Bat Conservation International. Detailed information on bats, including teaching materials and articles.

http://www.caves.org/ National Speleological Society. Detailed information on cave conservation and links to cave related topics.

http://www.goodearthgraphics.com/virtcave/ The Virtual Cave. Interactive website with virtual tours of different types of caves.

http://www.nckri.org/ National Cave and Karst Research Institute. U.S. organization dedicated to research, education, conservation and management of caves and karst systems.

http://www.projectunderground.org/ Project Underground, Inc. An environmental education program to improve the understanding of cave and karst systems.

http://www.karstportal.org/ Karst Information Portal. An on-line cave and karst science resource with numerous links to cave related topics, journals, and databases.

http://www.uis-speleo.org/ International Union of Speleology. The international organization for cave exploration and research.

http://www.usgs.gov.education.index/ U.S. Geological Survey (USGS) Learning Web. Numerous teaching and educational materials on geology and maps.

For more information about *The Mystery of Black Water Cave* and other educational materials and programs of the National Cave and Karst Research Institute, please contact:

info@nckri.org