Comparing Surface and Subterranean Environments

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Introduction

The GLOBE Program provides a framework for students and teachers to inquire about their local and global environment. GLOBE protocols are used to collect data about land cover, the atmosphere, soils and water quality. GLOBE data can also assist scientists in validating remote sensing satellites. However, there are environments that satellites cannot investigate. This field guide utilizes existing GLOBE protocols to explore an extreme environment. Caves provide an opportunity to utilize GLOBE protocols to investigate underground environments and compare them to surface environments.

What is a cave?

A **cave** is a natural opening in the ground. For an opening to be a cave, it must extend beyond the zone of light and be large enough for a person to enter. Caves can be found in a variety of rock types and are caused by different geological processes. Caves can be found in various sizes, from single rooms to interconnecting passages many kilometers in length.

The scientific study of caves is called speleology. It is an interdisciplinary Earth system science based on geology, hydrology, biology and archaeology. Exploring a cave for recreational or scientific purposes is often referred to as "caving" or "spelunking."

Types of Caves

According to the United States Geological Survey (USGS) there are four main types of caves:

- Solution caves are formed in carbonate and sulfate rocks such as limestone, dolomite, marble, and gypsum by the action of slowly moving ground water that dissolves the rock to form tunnels, irregular passages, and even large caverns along joints and bedding planes. Most of the caves in the world, as well as the largest, are solution caves.
- Lava caves are tunnels or tubes in lava formed when the outer surface of a lava flow cools and hardens while the molten lava within continues to flow and eventually drains out through the newly formed tube.
- Sea caves are formed by the constant action of waves which attack the weaker portions of rocks lining the shores of oceans and large lakes.
- Glacier caves are formed by melt water which excavates drainage tunnels through the ice.

Natural Bridge Cavern Formation

One of the 11th Annual GLOBE Conference Field Day Studies focused on the exploration of a *solution cave.* Discovered in 1960, this 60-foot limestone rock span forms a natural bridge over a large sink hole in New Braunfels, Texas.

How do the extensive and complex passageways of solution caves develop?

Solution caves are formed when limestone or similar type rocks are exposed to the physical and chemical weathering action of water. Rainwater seeps through the surface of the earth, moving through soil and decaying plants absorbing carbon dioxide. The combination of carbon dioxide and water makes carbonic acid which is a weak acid. As this slightly acidic water moves through the cracks in the rock and spaces beneath the earth, is slowly dissolves calcite forming larger cavities and caves. The resulting solution of calcium bicarbonate is carried off through the underground water system.

When this solution reaches open spaces, the deposition of calcite can occur. This happens as the result of carbon dioxide gases escaping as the solution is allowed to expand. The carbon dioxide gas escapes from the water. This is analogous to carbon dioxide escaping from an opened can of soda pop. The acidity of the water is thereby reduced, the calcium bicarbonate cannot remain in solution, and calcite is deposited as dripstone.

Cave Features

Natural Bridge Caverns is host to a number of cave features. Most of these are drip stone features, caused by water dripping throughout the caves.

Although there are many cave features, the most familiar cave features are stalactites and stalagmites. Stalactites hang on the ceiling of caves. They are formed as water drips from the ceilings of caves, leaving a small amount of dissolved solids behind. Some stalactites are very thin and hollow. These are called soda straws. Stalagmites form on the floors of caves usually beneath a stalactite. An easy way to remember the difference is stalactites form on ceilings while stalagmites grow on the ground. Sometimes, stalactites and stalagmites connect to form impressive columns.

Another feature in caves is the rock material produced by the collapse of the ceiling or walls of a cave. These can vary in size from small rocks to massive blocks.

Caves as Extreme Environments

Caves are interesting in terms of how they demonstrate the concept of Earth as a system. The intersection of rock, water, air, and life found in caves tell us much about the conditions under which life can begin, evolve, and survive as well as what kinds of life we might expect to find on other worlds. Scientists are very interested in caves due to the presence in some of extreme life. Extremophiles, or extreme loving organisms, is a term used to define life found in conditions that would be challenging to most of the life we think about on Earth. In particular, conditions we find inhospitable to us! This includes extremes in pH, pressure, light, temperature, and radiation.

Extremophiles in caves include microbes that can satisfy their energy and nutrient needs with the simplest of chemicals under the harshest of conditions. Some extreme life in caves, like Kane's Cave in Wyoming and Lechuguilla Cave in New Mexico, use hydrogen sulfide as a source of energy and survive in conditions where the pH is between 1 to 5. In the process they produce sulfuric acid and other byproducts. The sulfuric acid can contribute to the breakdown of rock in a cave while the byproducts may serve as nutrients or an energy source for other life.

Scientists have found that some of the extremophiles in caves are similar to those found at hydrothermal vents, another extreme environment. The vent ecosystem depends on these microbes as they reside at the base of the food chain, helping to provide energy and nutrients through chemosynthesis, a process like photosynthesis, but dependent on energy derived from chemicals, not sunlight. Some of these microbes form symbiotic relationships with the animal life found at deep-sea vents—tubeworms, mussels, and clams—that, without this relationship, would not be possible.

Scientists studying extreme life on Earth believe that the ability of life on Earth to survive under extreme conditions, with the simplest of chemicals as an energy source, provides evidence that life may have evolved on other worlds under equally limiting conditions. They hold out the possibility of our discovering life on other worlds, living in subsurface environments, like caves on Mars, or hydrothermal vents on Jupiter's moon Europa.

As you explore and study caves, keep in mind what they can tell you about the ability of life to survive, even under the most inhospitable (to us!) conditions.

Cave Safety

Responsible caving is essential. Never enter a cave alone or without a guide and the recommended equipment and materials needed for the area. Consult with the National Speleological Society Web site for information about safe caving.

GLOBE Cave Investigation

Materials

❏ GPS

❏ Thermometer

❏ Digital Hygrometer

❏ Digital Barometer

❏ Flash Light

GLOBE Cave Protocols

Outside Cave:

Cave Entrance:

❏ Site ID

❏ Site Description

❏ Air Temperature

❏ Relative Humidity

❏ MUC

❏ Air Pressure

Inside Cave:

Collect Data in the Top Room, Bottom Room, and any other Major Rooms

❏ Room ID or Name	❏ Room Description	❏ Air Temperature
❏ Relative Humidity	❏ Air Pressure	
(optional, if allowed)	❏ Water Temperature	❏ Water pH

Enter Data on the GLOBE Cave Data Sheet (next page)

Cave Investigation

Data Collection Sheet

School/Group Name: ____

Class or Group Number: ____

Name(s) of caver(s) or spelunker(s) completing Site Definition Sheet:

____

Date: _________________________ Check one: ❒ New Site ❒ Metadata Update

Site name (give your site a unique name):

____

Outside the Cave

Cave Entrance Location: Elevation: ________ meters

MUC ________

Latitude: _________________________________ ˚ ❒ N or ❒ S

Longitude: ________________________________ ˚ ❒ E or ❒ W

Source of Location Data (check one): ❒ GPS ❒ Other

Cave Entrance Description:____

____

____

Air Temperature _________ Relative Humidity ______

Inside the Cave

First Uppermost Large Room Encountered (Required) Identifying Name:_____________

Air Temperature: _________ Relative Humidity: _________ Air Pressure: _____________

Description of First Room ____

____

Is water present? Yes No Are you allowed to sample the water? Yes No

Describe the source: (Dripping from ceiling, stream, etc.) ________________________________

____

Water Temperature: ________ Water pH: _________

Cave Features Observed:

❑ Soda Straws ❑ Stalactites ❑ Stalagmites ❑ Columns ❑ Flow Stone ❑ Other ___________

Evidence of Biological Activity

❑ Fluorescence ❑ Animal Scat ❑ Insects ❑ Bones ❑ Bacteria ❑ Fungus ❑ Other _________

Evidence of Human Impact

❑ Graffiti (ancient and recent) ❑ Paths ❑ Stairs ❑ Bridges ❑ Other ___________

Deepest Large Room Encountered (Required) Identifying Name:___________________

Air Temperature: _________ Relative Humidity: _________ Air Pressure: _____________

Description of First Room ____

____

Is water present? Yes No Are you allowed to sample the water? Yes No

Describe the source: (Dripping from ceiling, stream, etc.) ________________________________

____

Water Temperature: ________ Water pH: _________

Cave Features Observed:

❑ Soda Straws ❑ Stalactites ❑ Stalagmites ❑ Columns ❑…Flow Stone ❑ Other ______

Evidence of Biological Activity

❑ Fluorescence ❑ Animal Scat ❑ Insects ❑ Bones ❑ Bacteria ❑ Fungus ❑ Other _________

Evidence of Human Impact

❑ Graffiti (ancient and recent) ❑ Paths ❑ Stairs ❑ Bridges ❑ Other ____________

ADDITIONAL CAVE ROOMS

Identifying Name:_________________

Air Temperature: _________ Relative Humidity: _________ Air Pressure: _____________

Description of First Room ____

____

Is water present? Yes No Are you allowed to sample the water? Yes No

Describe the source: (Dripping from ceiling, stream, etc.) ________________________________

____

Water Temperature: ________ Water pH: _________

Cave Features Observed:

❑Soda Straws ❑Stalactites ❑ Stalagmites ❑Columns ❑ Flow Stone ❑ Other ____________

Evidence of Biological Activity

❑ Fluorescence ❑ Animal Scat ❑ Insects ❑ Bones ❑ Bacteria ❑ Fungus ❑ Other ________

Evidence of Human Impact

❑ Graffiti (ancient and recent) ❑ Paths ❑ Stairs ❑ Bridges ❑ Other ____________

Identifying Name:_________________

Air Temperature: _________ Relative Humidity: _________ Air Pressure: _____________

Description of First Room ____

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Is water present? Yes No Are you allowed to sample the water? Yes No

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ADDITIONAL CAVE ROOMS

Identifying Name:__________________

Air Temperature: _________ Relative Humidity: _________ Air Pressure: _____________

Description of First Room ____

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Describe the source: (Dripping from ceiling, stream, etc.) _______________________________

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Water Temperature: ________ Water pH: _________

Cave Features Observed:

❏Soda Straws ❏Stalactites ❏ Stalagmites ❏ Columns ❏ Flow Stone ❏ Other ________

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Evidence of Human Impact

❏ Graffiti (ancient and recent) ❏ Paths ❏ Stairs ❏ Bridges ❏ Other ____________

Identifying Name:__________________

Air Temperature: _________ Relative Humidity: _________ Air Pressure: _____________

Description of First Room ____

____

Is water present? Yes No Are you allowed to sample the water? Yes No

Describe the source: (Dripping from ceiling, stream, etc.) _______________________________

____

Water Temperature: ________ Water pH: _________

Cave Features Observed:

❏Soda Straws ❏Stalactites ❏ Stalagmites ❏Columns ❏Flow Stone ❏ Other __________

Evidence of Biological Activity

❏ Fluorescence ❏ Animal Scat ❏ Insects ❏ Bones ❏ Bacteria ❏ Fungus ❏ Other ________

Evidence of Human Impact

❏ Graffiti (ancient and recent) ❏ Paths ❏ Stairs ❏ Bridges ❏ Other ____________

Follow-up questions:

1. Describe the chemical processes involved in cave formation.

2. Explain the chemistry behind the development of at least two of the features that you have found in this cave.

3. Can you use a chemical equation to describe these processes?

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