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Inner Space Cavern
Cave Field Activity: Drip Rate Analysis

Subject: Science

Grade level: 6-8, 9-12

Rationale or Purpose: Water plays a major role in cave formation. As rainwater (already acidic with a pH of 6) seeps through leaf litter and decaying matter found in soils, it mixes with carbon dioxide and becomes even more acidic. This water then flows through fractures and faults in limestone and enlarges the passages. Measuring drip rates can provide insight into how large a volume of water is making it down that particular flow path. In this activity, students will compare drip rates at several different locations throughout the cave. They will be able to observe, first hand, the heterogeneity in flow paths present in karst aquifers such as the Edwards aquifer.

Prior Knowledge: This activity assumes students have seen the Virtual Fieldtrip presentation of Inner Space provided at <http://www.esi.utexas.edu/outreach/caves/virtualtours.php> and are familiar with the following:

- Cave rules
- Identifying cave formations

Materials per team (2 students, preferably):

1 timing device (stopwatch or wristwatch with second hand)

1 small flashlight

1 data sheet with cave map of Inner Space Cavern

1 pencil

Lesson Duration: The length of the cave tour plus 10 minutes before and 10 minutes after.

Objectives:

Chapter 112-

Subchapter B-

112.22-

1A- demonstrate safe practices during field and laboratory investigations

2B- collect data by observing and measuring

2D- communicate valid conclusions

4A- collect, analyze, and record information using tools

14B- identify relationships between groundwater and surface water in a watershed

112.23

1A- demonstrate safe practices during field and laboratory investigations

2B- collect data by observing and measuring

2C- organize, analyze, make inferences, and predict trends from direct and indirect evidence

2D- communicate valid conclusions

4A- collect, analyze, and record information to explain a phenomenon using tools

112.24

1A- demonstrate safe practices during field and laboratory investigations

2B- collect data by observing and measuring

- 2C- organize, analyze, make inferences, and predict trends from direct and indirect evidence
- 2D- communicate valid conclusions
- 4A- collect, record, and analyze information using tools
- 14A- predict land features resulting from gradual changes such as mountain building, beach erosion, land subsidence, and continental drift

Subchapter C

112.46

- 1A- demonstrate safe practices during field and laboratory investigations
- 2B- collect data and make measurements with precision
- 2D- organize, analyze, evaluate, make inferences, and predict trends from data
- 2E- communicate valid conclusions
- 5D- evaluate trends in data to determine the factors that impact aquatic ecosystems
- 10A- identify sources and determine the amounts of water in a watershed including groundwater and surface water

112.49

- 1A- demonstrate safe practices during field and laboratory investigations
- 2B- collect data and make measurements using precision
- 2C- organize, analyze, make inferences, and predict trends from direct and indirect evidence
- 2D- communicate valid conclusions
- 8B- identify geologic formations that result from differing weathering processes
- 10A- identify the characteristics of a local watershed such as average annual rainfall, run-off patterns, aquifers, locations of river basins, and surface water reservoirs
- 10B- analyze the impact of floods, droughts, irrigation, and industrialization on a watershed

Activity:

- Step 1: Talk with the cave tour guide and explain your class' experiment (they may already be familiar with the activity).
- Step 2: Group students into teams, hand out data sheets and cave maps. Verify that each team has a watch and a small flashlight.
- Step 3: Explain how to time water drips (2 methods)
 - Method 1 (less time-consuming than the other method)**
 1. Select 1 drip site within the locations listed below.
 2. Start the timer on the first drip.
 3. Count how many drips fall within a 30 second period.
 4. Record your observation in the chart.
 - Method 2**
 1. Select 1 drip site within the locations listed below.
 2. Start timing once the first drop falls (count that as zero).
 3. Count 5 drops and stop timing once the 5th drop falls.
 4. Record your observation in the chart.
- Step 4: When your group enters the cave, find your location on the cave map.
- Step 6: Once you reach the Temptation rock hallway (the only formation you can touch). Mark "1" in the appropriate location on the map. Measure a drip rate together as a class. Record answers.
 - NOTE:** Not all sample sites are labeled on the map. Students need to pay attention to clues in order to know where they are on the map.
- Step 7: Students should record drip rates and site conditions for the 4 other locations selected throughout the course of the tour and record them by filling out the data sheet and map.

Modification: Inner Space Cavern is not wheelchair accessible.

Student Product: Students will fill out a data sheet with the drip rates and general site description and mark sample site locations on the cave map. Data analysis: students will be

asked to graph the drip rates and hypothesize what controls the drip rates and what effect rain events would have.

Closure: Discussion questions for once the cave tour is over:

- In what part of the cave were the drip rates the fastest?
- In what part of the cave were the drip rates the slowest?
- Did the locations with faster drip rates have the same site conditions? What about the areas with slower drip rates?
- Generally, were slow rates clustered together and fast rates clustered together (in the same room)?

Assessment or evaluation: Collect data sheets & maps. Grade the students' work according to the evaluation rubric that follows the Cave Field Trip Activity worksheet.

Extension: See post-visit lesson plan: Is Your Water Clean (comparison of water quality of cave water, tap water, rain water, and river water).

Team members: _____

Expedition date: _____

Inner Space Cavern **Cave Field Activity #1: Drip Rate Analysis**

Goal: To investigate how water enters the Edwards aquifer at Inner Space Cavern. Variations in the rates at which water drips into Inner Space Cavern will provide information on the controls on recharge to the aquifer.

Methods: Each team will locate and time drip rates at 5 different sites in the cave. Use one of the following methods to determine the drip rate. For each sample site, record the location on the map provided, and log the drip rate in the table below.

Method 1

1. Select 1 drip site within the locations listed below.
2. Start the timer on the first drip.
3. Count how many drips fall within a 30 second period.
4. Record your observation in the chart below.

Method 2

1. Select 1 drip site within the locations listed below
2. Start timing once the first drop falls (count that as zero).
3. Count 5 drops and stop timing once the 5th drop falls.
4. Record your observation in the chart below.

What factors might control drip rates? State your hypothesis: _____

Locations (marked on map)	Drip Rate (drips/seconds)	Cave Formations (circle yes or no)			
		Stalactites (on the ceiling)	Soda Straws (on the ceiling)	Stalagmites (on the floor)	Flowstone (on the floor or walls)
1 Temptation Formation		Yes No	Yes No	Yes No	Yes No
2 First Formation Room		Yes No	Yes No	Yes No	Yes No
3 Discovery Room (South End)		Yes No	Yes No	Yes No	Yes No
4 Discovery Room (North End)		Yes No	Yes No	Yes No	Yes No
5 Lake of the Moon		Yes No	Yes No	Yes No	Yes No

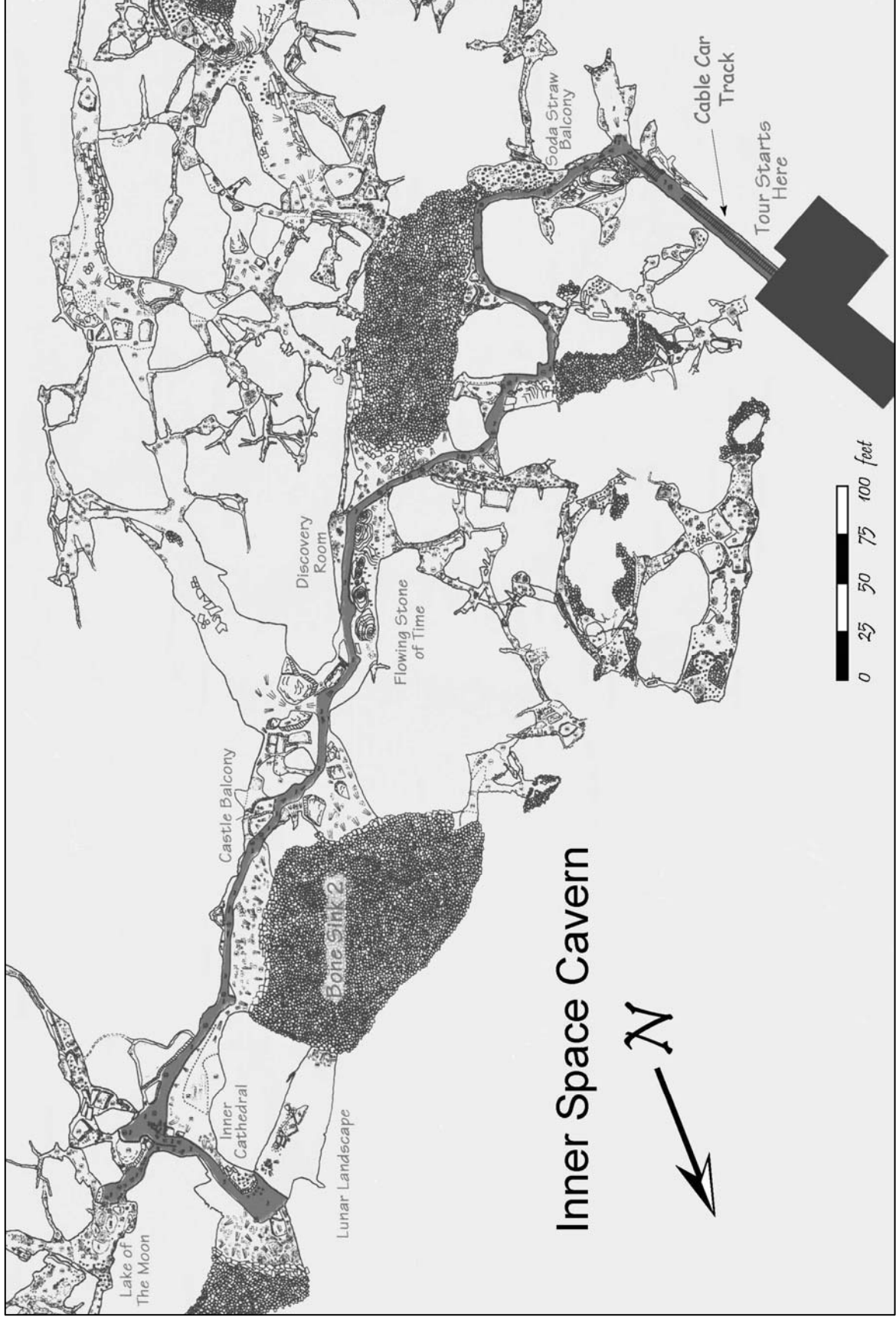
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Data analysis: In the space provided below, graph your results using a bar graph, and answer the following questions in complete sentences.

1. Using the data you collected and your observations during the cave tour, explain why you think drip rates differ (or not) through the cave.
2. Did the locations with faster drip rates have the same site conditions? What about the areas with slower drip rates?
3. Would a rainstorm increase drip rates for all sites you sampled? Explain your answer.
4. Would increases in drip rates (if any) stop as soon as the rain stop? Explain your answer.

Cave Map

Label the locations of each drip site directly on this map.
(Record the site number)



Cave Activity: Drip Rate Analysis Grading Rubric

Circle the appropriate score for each category:

	Not Done	Poor	Average	Good	Excellent
Trip Safety					
Stayed with team and obeyed cave rules	0	4	8	12	15
Points in this section:					
Data Collection					
Worked well with the team to time drip rates	0	1	3	4	5
Recorded sample site locations on the cave map	0	3	5	8	10
Logged appropriate observations on the data sheet	0	5	10	15	20
Points in this section:					
Data Analysis					
Drip Rate Bar Graph	0	5	10	15	20
Questions on observations	0	4	8	12	15
Questions on rain response	0	4	8	12	15
Points in this section:					
Total points:					/100