Caves in Miniature

Design and evaluate a model of groundwater erosion

ESS.2B.7 "Enrichment: Use an engineering design process to design a model to simulate the formation of caves and karst topography by groundwater.*"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline what stands in for rock and cracks, circle the two liquids being compared, and number the cutting, pouring, and measuring steps 1 to 3.

Can a Classroom Model Make a Cave?

1. At the edge of a limestone plateau, rainwater slips through soil and enters tiny cracks. Carbon dioxide in the air and soil dissolves in the water, making it weakly acidic. Over long periods, this groundwater dissolves some limestone, widening cracks into connected passages and caves. If a cave roof fails, the ground above may sink, leaving a sinkhole. A landscape with caves, sinkholes, and other features shaped by dissolving rock is called karst. Engineers cannot wait thousands of years in a classroom, so a model must make the process visible without pretending to reproduce its true timescale.

2. A team proposes a tabletop model with two equal chalk blocks, since chalk contains calcium carbonate, as limestone does. They cut one narrow groove in each block to represent a crack, place the blocks on separate sloped trays, and pour equal amounts of liquid into the grooves at the same rate. One tray gets plain water; the other gets water mixed with household vinegar. The team measures each groove's width before and after several pours. Their goal is to see whether more acidic water widens a pathway more than plain water does. The model treats each groove as a path for groundwater.

3. Before testing, the team sets a criterion: the groove in the vinegar trial should show a larger increase in width. Equal blocks, liquid amounts, slopes, and pour rates keep the comparison fair. If measurements are unclear, the team should revise the procedure and test again while keeping the comparison fair. They must record results even if the prediction fails. Chalk may crumble, while real cave passages usually grow through dissolution over very long periods. A chalk groove also cannot show an underground roof collapsing. A useful model makes one process testable, but its limits matter when explaining real karst.

2 ANSWER WITH EVIDENCE

Use the passage

1. Suppose the vinegar tray is tilted more steeply than the water tray. What would you change before testing, and why?

2. Both grooves widen by the same amount. Has the model met the team's criterion? Explain using the criterion.

3. Neither groove changes enough for the ruler to detect. Propose one change to the procedure that could make the test more useful while keeping the comparison fair.

4. The vinegar groove grows wider. Why does that result alone not show that the model formed a sinkhole?

3 YOUR TURN

Your own words

Design a different tabletop model to investigate how water entering the ground could produce a surface depression. In one paragraph, name your materials and two test setups, state what you would keep the same and measure, give a success criterion, and explain one limit of your model.

ANSWER KEY

Caves in Miniature

HIGH SCHOOL · ESS.2B.7

PART 1 · READ AND MARK

Underline what stands in for rock and cracks, circle the two liquids being compared, and number the cutting, pouring, and measuring steps 1 to 3. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Suppose the vinegar tray is tilted more steeply than the water tray. What would you change before testing, and why?	**Make the tray slopes equal so any difference in groove width can be compared without slope changing the flow.**
2	Both grooves widen by the same amount. Has the model met the team's criterion? Explain using the criterion.	**No. The criterion requires a larger increase in width in the vinegar trial.**
3	Neither groove changes enough for the ruler to detect. Propose one change to the procedure that could make the test more useful while keeping the comparison fair.	**Increase the number of pours in both trays, then measure both grooves again.**
4	The vinegar groove grows wider. Why does that result alone not show that the model formed a sinkhole?	**A sinkhole involves the ground surface sinking, often after an underground roof fails. A wider groove does not show either event.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would place equal groups of sugar cubes beneath equal layers of dry sand in two shallow trays. I would slowly pour 50 mL of water into a small hole above the cubes in one tray and add no water to the other. I would keep the sand depth and cube arrangement the same. After ten minutes, I would measure the deepest surface depression in each tray. My model succeeds if the watered tray has a deeper depression. Sugar dissolves much faster than limestone, and sinking sand is not the same as a cave roof breaking.

Accept other fair revisions for question 3 if both trials receive the same change. For the open task, look for two comparable setups, a measurable surface change, a stated success criterion, and a realistic limitation.