

Lab #3: *Determining Pore Space and Measuring Permeability*

Questions

What is porosity? What is permeability? How are porosity and permeability related? How can they be measured? Do ice and snow have pore spaces? Are they permeable? How can air bubbles in ice help scientists understand ancient climates?

Overview

Students will understand porosity and how gases/liquids can move through permeable materials (permeability). Also, students will repeat a valuable scientific experiment performed on the ITASE expedition by expedition members and Dr. Mary Albert at the USA Cold Regions Research and Engineering Laboratory, Hanover, NH. During the experiment, snow from Antarctica was recovered in plastic bowls, filled with dimethylphalate which filled the pore spaces around snow and froze. Students will repeat these experiments with pieces of ice. Permeability can be demonstrated using cello and natural sponges. The pore spaces in cello sponges are not connected through the sponge but the pore spaces in natural sponge is connected through the sponge. If two sponges, one natural and one cello, had the same volume of pore space the natural sponge would be more permeable.

Rationale

Diffusion and preservation of gases through snow is fundamental to the theory that paleo-atmospheric gas can be collected from ice and snow for use in understanding paleo-environments.

Grade Level

5th – 8th

Objectives

In this activity students will:

1. Understand pore space and permeability.
2. Quantify porosity in a material.
3. Test the permeability of material.

National Standards

Properties and Changes of Properties in Matter

NH Standards

2c. Students will demonstrate an increasing ability to analyze, synthesize, and communicate scientific information using technology.

5a. Students will demonstrate an increasing ability to distinguish among materials by utilizing observable properties.

Teacher Preparation

1. Obtain enough ice chips (from standard-sized ice cubes broken with pliers or small specialty ice cube approximately 1 centimeter to 1.5 centimeters in length) and parafin wax.
2. You might want to start by demonstrating to the entire class that parafin wax will not melt through or fill space in solid ice. This can be done by pouring melted parafin wax over a block of ice or an ice cube. The wax will coat but not penetrate the solid ice. This demonstrates the lack of porosity and permeability of solid ice (if glacial ice was permeable gas bubbles would escape).

Materials (assume student groups of 2)

1. Ice chips (1 centimeter to 1.5 centimeters in length) (2 cups per group)
2. Small bowls (cereal bowls work fine but “square bowls” make it easier to calculate volume)
3. Latex house paint (dark colored paint) (3-4 ounces)
4. Two inch paint brush
5. Plain recycled scrap paper (8.5” x 11”), 3-4 pieces per student
6. Small metric rulers (1 per student)
7. Calculator (1 per every 2 students)
6. Pencils (1 per student)
8. Sponges (cello sponges from grocery store and natural sponges available at health food stores)
9. Other objects with varying amounts of porosity, e.g. bubble wrap has high porosity but zero permeability, wood has high porosity but low permeability, a natural sponge has high porosity and high permeability.

Time Frame

1-2 class periods

TEACHING SEQUENCE

Engagement and Explanation

1. Define/discuss porosity and its importance in the movement of gases through an object.
2. Have students pour ice chips into small bowls (any material but plastic bowls are flexible and maybe easier to remove wax from).
3. Have parafin wax pre-melted on hotplate.
4. Pour wax into bowl of ice chips.
5. After 5-10 minutes (just as wax becomes firm to touch) remove ice/wax mixture from bowl.

6. Allow wax time to cool slightly (approximately 5 minutes during which time the ice cubes melt).
7. While the wax is still soft to the touch, cut the wax cast in half (vertically) with a knife.
8. Paint with dark latex paint
9. Place on plain paper and “print” (or press paper against wax).
10. Identify and count number and size (difficult because of the irregular shape of pore spaces) of pore spaces (the pore spaces are the unpainted surfaces).
11. Measure/calculate area of print (maybe by refilling with water to measure volume).
12. Calculate percent of pore space to solid space.
13. The permeability can be measured by passing water through the pore spaces in the wax mold (measure permeability in vol./time).
14. Students can then compare the permeability of their wax mold to other materials (see figure 1) which contains varying amounts of porosity.
15. Students can record their information on a spreadsheet and plot their findings on a graph (Figure 1&2).

Material	Porosity (%)	Permeability (vol/time)
Bubble wrap	high/95%?	none/0
Wood (dry)	medium/ 25%?	Low/1 ml/hr
Cello sponge	high/50%?	High/600ml/hr
Natural sponge	high/90%?	Very high/6000ml/hr
Wax mold	high –med/75%?	Very high/6000ml/hr

Figure 1: Spreadsheet (example results are not accurate)

Porosity Bubble Wood Cello Wax (ice) Natural

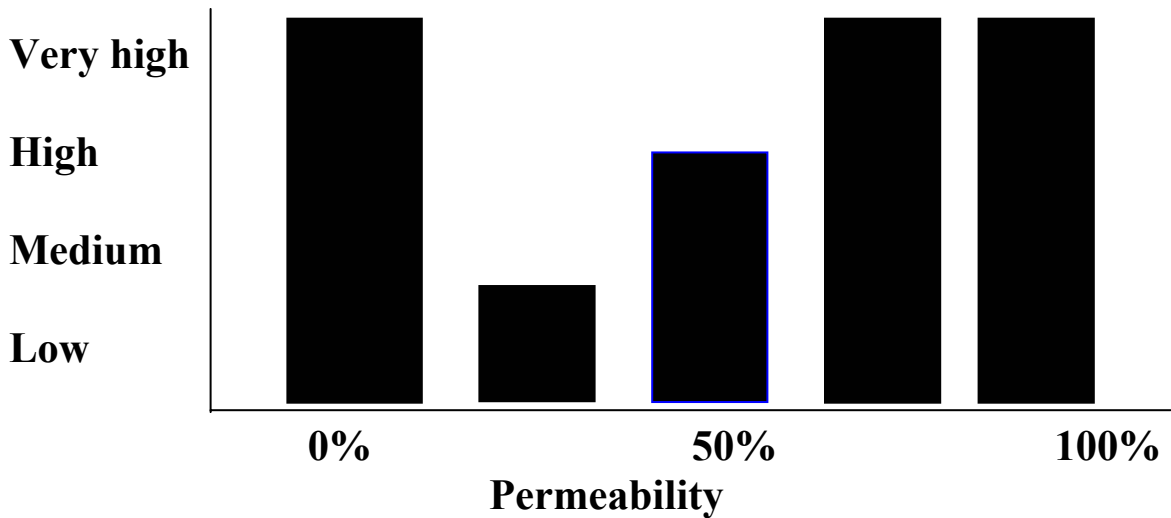


Figure 2: Porosity/Permeability (example results are not accurate)

Elaboration

Porosity measures the volume of empty space and permeability measures the ability of the sponge to transmit fluid (or gas). Dr. Mary Albert's ITASE experiment has two parts. The first part of her experiment measures porosity in a similar fashion to the wax and crushed ice experiment. The second part of her experiment measures permeability by forcing air through the snow samples collected in Antarctica. Students can follow Dr. Albert's experiment by simulating permeability with water. The amount of water that passes through the material per unit time is a measure of permeability (colored water may make this test more interesting and easier to follow the flow of water through the materials. Pictures from Dr. Mary Albert's experiment can be found at- <http://www>. Not finished!!!!!!

Exchange

After the students have finished their testing, have them sit in a group and discuss:

Evaluation

1. How do pore spaces in snow/ ice form?
2. What happens to the pore spaces as the snow is compressed into ice and the ice into more dense ice?
3. What happens to the gas held within those pore spaces?
4. How can the trapped gas be useful to scientists?
5. How does gas in snow migrate up and down through the snow while gas in ice is held in place and does not "travel"?
6. How does the percentage of pore space change as snow is compressed to ice?
7. What other materials contain pore space? How permeable are they?

Author

D. Zachary Smith, Paleoclimate Program Coordinator, Climate Studies Center, Institute for Quaternary Studies, University of Maine, Orono, Maine
zach.smith@umit.maine.edu

Background

Dr. Mary Albert, Cold Regions Research and Engineering Laboratory (CRREL),
Hanover, NH
malbert@crrel.usace.army.mil

Resources

ITASE web site- <http://www.secretsoftheice.org>

CCRC web site - <http://breeze.sr.unh.edu/ccrc>

USA Cold Regions Research and Engineering Laboratory web site - <http://crrel.us.gov>

Glossary

Permeability: A measure of the ability of water (gas) to pass through a material.

Porosity: A ratio of the amount of empty space to the amount of solid space in a material.