Introduction to Permafrost

Levels V-VI

Grades 9-12

Overview:

Students analyze soil temperature data to determine which soil sample is permafrost and explore the effect the active layer plays on permafrost structure.

Objectives:

The student will:

- analyze graphs;
- define and identify permafrost; and
- identify the active layer.

BSSD Standards Addressed:

Science

- SC 05.10 Analyze data (i.e. mean, median, mode) through the use of graphs, tables, computer analysis, and/or pie charts.

GLEs Addressed:

Science

- [9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
- [10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

Whole Picture:

Permafrost, ground or any other substance that has remained frozen for more than two years (enduring the heat of at least two summers), occurs in areas on the planet far from the equator. This frozen ground is thousands of feet thick beneath Alaska's North Slope and decreases southward to become patchy in Fairbanks and almost nonexistent as far south as Anchorage.

Permafrost can form any time the mean yearly temperature of a place lingers near or below the freezing mark for a few years, but much of it was established during a much colder time, when thousands of years ago the cold air of ice ages penetrated deeply into the ground. That frozen ground, incredibly stable, has endured in cold climates because air temperatures haven't had enough punch to thaw permafrost. Mats of spongy vegetation help to insulate permafrost from warming summer air temperatures.

The movement of people northward has meant that more people are living and traveling over permafrost. This has resulted in clearing of land above permafrost and the building of houses and roads in permafrost areas, and the subsequent thawing of some ice-rich permafrost and damage to structures above due to settling.

Materials:

- Soil
- Straws (two per pair of students)

- Styrofoam cups (two per pair of students)
- Thermometers, narrow enough to fit inside straw (one per pair of students)
- OVERHEAD: “Active Layer”
- OVERHEAD: “Borehole”
- OVERHEAD: “Permafrost Graph”
- STUDENT WORKSHEET: “Permafrost”

Vocabulary:

permafrost – ground (rock or soil) that has remained frozen at least two full years
active layer – the top portion of ground that thaws during the summer and refreezes in winter
borehole – a narrow shaft drilled in the ground

Activity Preparation:

Place a straw in each Styrofoam cup, and fill halfway with soil to surround the straw. There should be two cups per pair of students. Place half of the cups in the freezer at least one day before the “Activity Procedure.”

Activity Procedure:

1. Ask students what they know about permafrost. Ask guiding questions as necessary to make sure students’ ideas are clear and represented correctly. List all ideas on the board. Explain by collecting ideas now, the class can look at them critically later and see how their ideas have changed over time.
2. Explain permafrost is permanently frozen ground; ground (soil or rock) that has remained frozen, below 32°F (0°C) for at least two full years.
3. Divide students into pairs. Distribute a thermometer, one cup of room temperature soil, and one cup of frozen soil to each pair. Ask students to measure the temperature of each cup of soil by placing their thermometer into the straw.
4. Ask students to label their cups, labeling one “permafrost” and the other “soil.” The cup at a temperature near or below 32°F (0°C) should be labeled “permafrost.” Verify students have correctly labeled their cups.
5. Ask students what will happen if the “permafrost” is left outside of the freezer. (*It will rise in temperature and become regular soil again*.)
6. Show OVERHEAD: “Borehole.” Explain scientists dig boreholes into the ground and measure the temperature of soil at various depths to determine where permafrost exists and to investigate how it changes over time. A borehole is a narrow shaft drilled into the ground. Boreholes are drilled for various reasons, but permafrost scientists use boreholes to measure the temperature in the ground. Sensors that collect temperature data are lowered into the boreholes and placed at specific intervals. Data loggers are hooked up to the sensors. The data loggers collect the temperature data. Then, the scientists take averages of the data and create graphs to help visualize what is occurring.
7. Show OVERHEAD: “Permafrost Graph.” Ask students which month showed the warmest soil at the surface. (*July*) Ask students which month has the coldest soil at the surface. (*March*) Does this change at 1 meter below? (*Yes, April is the coldest at 1 meter below the surface.*)

Critical Thinking Question: Puzzle Method. Develop students’ critical thinking by dividing them into pairs and asking them to provide a logical reason for why March has the coldest soil at the surface layer but April is the coldest at 1 meter below the surface. If they ask, let students know that the permafrost sites are at Pearl Elementary Creek School in Fairbanks, Alaska. Ask pairs to share their

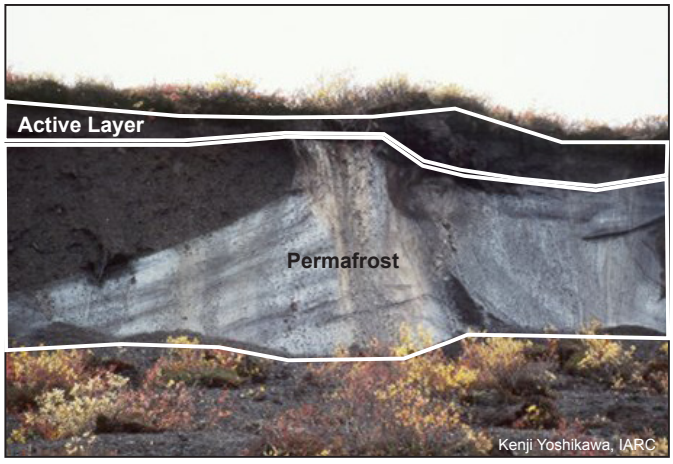
explanations with the class.

8. Explain the time it takes an object to cool is directly proportional to how much energy it contains. That is, the warmer an object, the longer it will take to cool. During daylight hours in the summer, the sun warms the surface of the soil. During the night, the soil cools. Because it takes time to cool, the time the soil is coldest is not right after the sun goes down, or in the middle of the night, but in the early morning hours. This is also true seasonally. The top layer of soil, otherwise know as the "active layer," is warmed by the sun throughout the summer. Throughout the winter the soil cools. Snow and vegetation act as insulators for the active layer of soil, resulting in faster or slower cooling. In Fairbanks, where the measurements were taken, there are usually several feet of snow cover that insulate the ground through the winter.

Teacher's Note: Heating water and measuring the temperature every minute for several minutes as it cools can demonstrate this principle. Repeat with another sample of water heated to a different starting temperature. Which sample of water takes longer to cool?

9. Show OVERHEAD: "Active Layer." Explain the top layer of soil is called the active layer. Explain this layer of soil thaws and freezes seasonally, but the permafrost underneath it does not; it stays frozen all year. Explain the active layer (mainly organic layer) insulates the permafrost in the same way that snow and vegetation insulate the active layer. The active layer also serves as a conductor, especially in winter, transferring heat to and from the atmosphere.
10. Ask students how deep the active layer is at the Pearl Creek Elementary School permafrost site. Ask them to explain their reasoning. If necessary, point out the temperature data shows the soil does not thaw below 1 meter, even though the temperature fluctuates below this point. The active layer is the layer that freezes and thaws throughout the year; therefore, the active layer is less than a meter of soil.
11. Return to the list of student ideas collected in Activity Procedure 1. Ask students if any of their ideas have changed or been refined, or if they would like to add anything to the list. This list can be revisited as the class progresses through the other lessons in this unit.
12. Make sure students understand that permafrost is permanently frozen ground, which is covered by an active layer of soil that freezes and thaws throughout the year.
13. Distribute the STUDENT WORKSHEET: "Permafrost," and instruct students to complete the worksheet individually.

Answers:

1. C. Ground that has remained frozen at least two full years
2. 

3. A. March B. July C. 1 meter

Name:_____

Permafrost

Student Worksheet

Levels V-VI

Directions: Answer the following questions.

1. What is permafrost?

   A. Ice

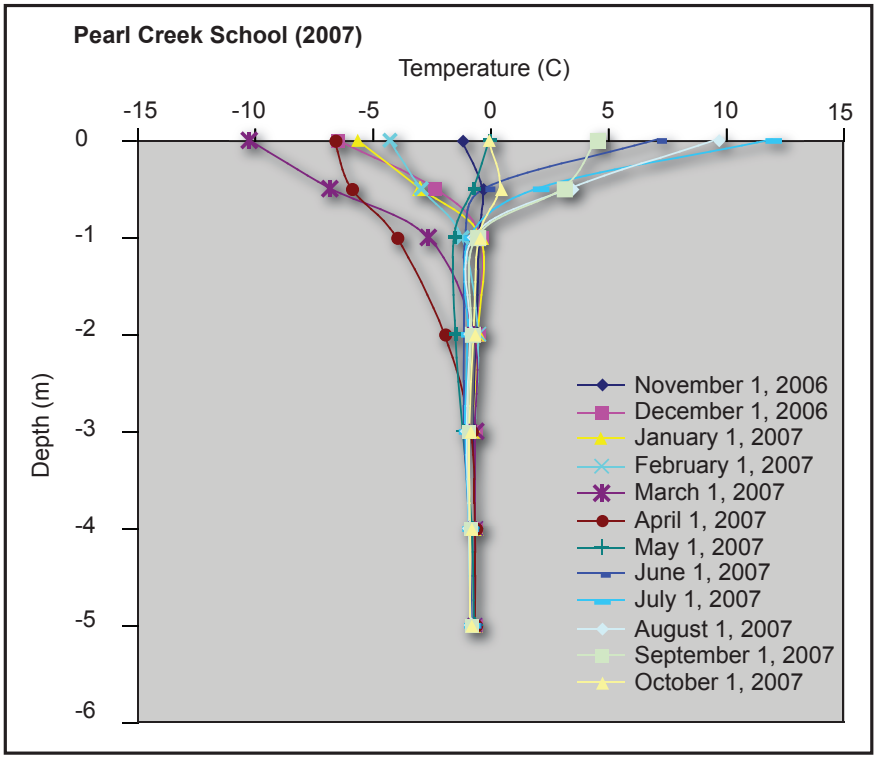
   B. Rock or soil that is frozen during the winter

   C. Ground that has remained frozen at least two full years

   D. Surface soil that never thaws

2. Label the active layer in the image below.

3. Answer the following questions using the graph below.



A. Which month has the coldest surface soil temperature?

_____

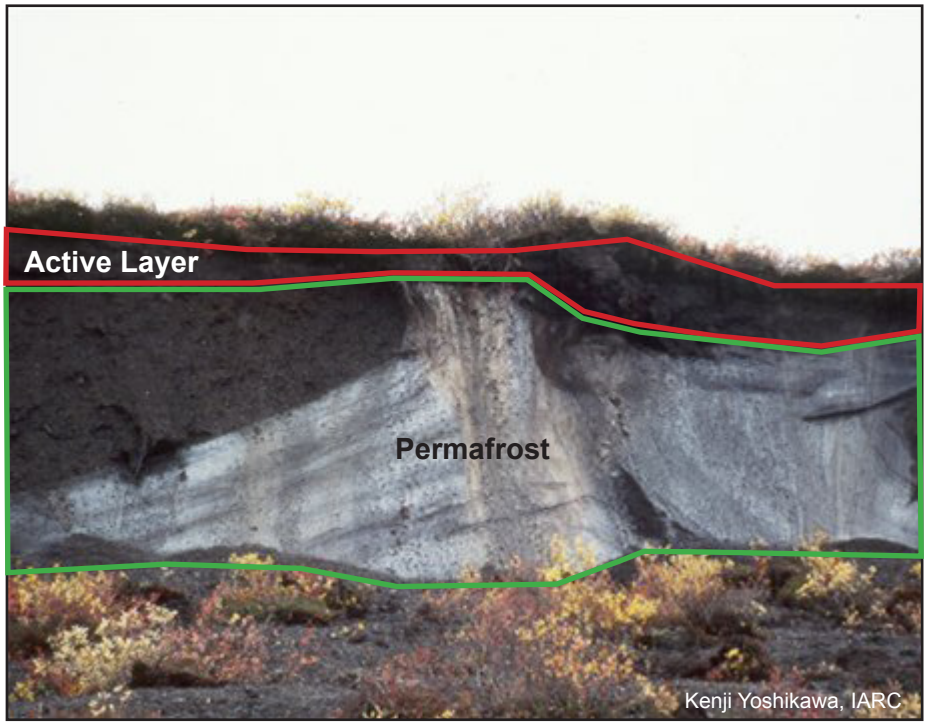
B. Which month has the warmest surface soil temperature?

_____

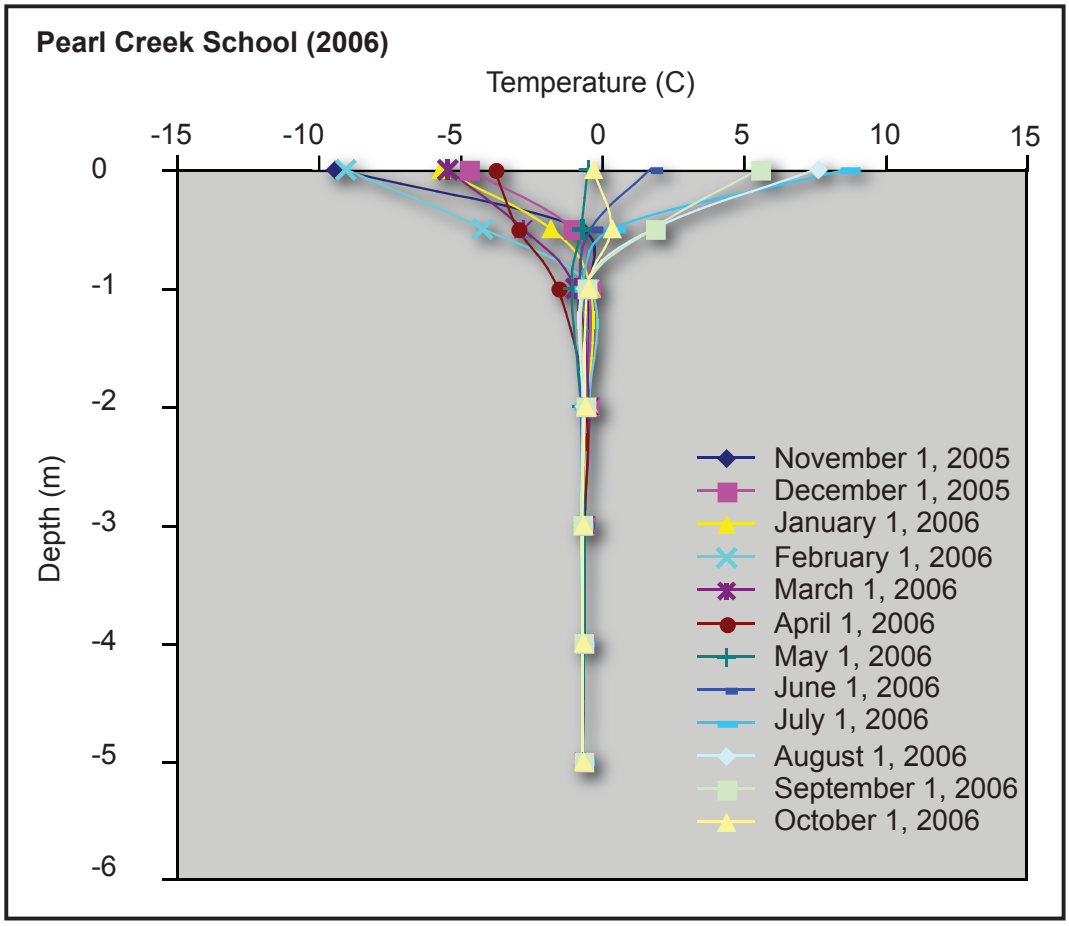
C. How deep is the active layer?

_____

Active Layer
Overhead



Permafrost Graph
Overhead



Borehole
Overhead

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