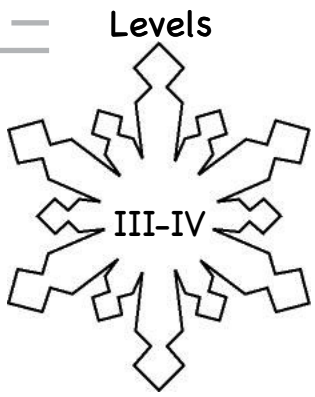
Polygons, Pingos, and Thermokarst! Oh my!



Overview:

Areas underlain with permafrost exhibit common features due to freezing and thawing in such areas. Ice wedge polygons, pingos, and thermokarst are some of the most common land features to be seen in Alaska. In this lesson, students will create a pingo, and explore the processes that create all three aforementioned features.

Objectives:

The student will:

- create a pingo;
- make observations; and
- explain the processes involved in polygon, pingo and/or ice wedge formation.

BSSD Standards Addressed:

Science

- SC 03.24.a The student demonstrates an understanding of the forces that shape Earth by describing how wind and water tear down and build up the Earth's surface resulting in new land.
- SC 04.27.d The student demonstrates an understanding of geochemical cycles by applying knowledge of the water cycle to explain changes in the Earth's surface.

GLEs Addressed:

Science

- [5-8] 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.
- [5] SG2.1 The student demonstrates an understanding of the bases of the advancement of scientific knowledge by reviewing and recording results of investigations into the natural world.
- [8] SD1.2 The student demonstrates an understanding of geochemical cycles by applying knowledge of the water cycle to explain changes in the Earth's surface.

Vocabulary

pingo – a small hill or mound consisting of a core of ice

ice wedge – a large, wedge-shaped body of ice with its apex pointing downward, composed of vertically banded ice

polygon – patterned ground feature resulting from thermal contraction cracking of the ground

upwelling - the process or an example of rising or appearing to rise to the surface and flowing outward

thermokarst - the often irregular topography resulting from the melting of excess ground ice and subsequent thaw settlement.

Materials:

- Materials for modeling, such as: paper, scissors, glue, tape, clay, etc.
- Metal bucket
- Sand
- Water
- OVERHEAD: “Permafrost Features”
- OVERHEAD: “Ice Wedges”
- OVERHEAD: “Pingos”
- STUDENT WORKSHEET: “Polygons, Pingos, and Thermokarst! Oh my!”

Activity Procedure:

1. Display the OVERHEAD: “Permafrost Features.”
2. Ask students to define ice wedge polygons, thermokarst and pingos. Write student definitions on the board.
3. Ask students how these features are formed or what processes create them. Explain that, unlike other substances, ice expands when it freezes. Soil, on the other hand, contracts when it is cooled. Soil in cold climates tends to contract and crack, forming polygons. Ice wedges can also form polygons.
4. Show OVERHEAD: “Ice Wedges.” Ice wedges are formed when water works its way into the cracks during spring melt. As the water freezes, it forms a thin wedge of ice in the soil. In summer, the small wedges of ice remain in the permafrost. In the winter, contraction cracks again form in the soil. This cycle repeats. Over time, vertically layers of ice are formed.
5. Show OVERHEAD: “Pingos.” Pingos are small hills or mounds consisting of a core of ice. They are formed in two ways and are differentiated into two categories, closed-system pingos and open-system pingos. Closed system pingos are formed when a lake drains, leaving sand that is saturated. The very wet sand is squeezed under pressure by the surrounding freezing process and ultimately pushed upward, where it freezes, forming a pingo.
6. The upwelling of groundwater contributes to the formation of an open-system pingo. As groundwater pools together near the surface of the ground and freezes, pressure and ice lift up the ground to make dome-shaped mounds.

   Teacher’s Note: The upwelling of groundwater occurs through a process called artesian pressure.

7. Explain thermokarst is the often irregular topography resulting from the melting of excess ground ice and subsequent thaw settlement. Thermokarst terrain often includes features such as depressions in the ground (alas), lakes, and mounds. When ice wedges in an ice wedge polygon melt, they often leave behind small mounds typical of thermokarst terrain.
8. Divide students into small groups. Distribute the STUDENT WORKSHEET: “Polygons, Pingos, and Thermokarst! Oh my!” and explain each group will pick one of the three formations discussed in this lesson (ice wedge polygon, pingo, or thermokarst), create a model of it, and describe how it is formed. Groups should use the worksheet to guide their work. Groups may use any class materials to make their model; they may draw, sculpt, carve, etc.
9. Ask students to share their model and their explanation of how the feature is formed. Allow time to discuss the questions and observations from #4 of the worksheet.
10. In the winter, demonstrate the formation of a closed-system pingo by filling the bottom of a metal bucket with sand. Add water to the bucket until the sand is just saturated. Place the bucket outside. Check the bucket every two hours for a day or two. Ask students to draw the contents of the bucket

and make observations each time. By the end of the experiments, students should be able to see a small mound form in the center of the bucket. Remind students that the water in the sand is under pressure; water constantly pushes in on itself. Ultimately the water will move in the direction of least resistance (up). The temperature will cause it to freeze, forming a pingo.

Extension Ideas:
(1) Interested students may wish to research and report on artesian pressure.
(2) Introduce mathematical polygons and contrast them with permafrost polygons (which are not always closed and do not always have straight lines). ([6] G-1, [7] G-1, [8] G-1)

Answers:

1. Either “A” or “B.”
2. Answers will vary, but should resemble the formation identified in #1.
3. Answers will vary, but should be correct. Possible answers include:
   A. For Ice Wedge Polygons: Ice wedges are formed when water works its way into the cracks during spring melt. As the water freezes, it forms a thin wedge of ice in the soil. In summer, the small wedges of ice remain in the permafrost. In the winter, contraction cracks again form in the soil. This cycle repeats. Over time, vertically layers of ice are formed.
   B. For Pingos: Closed-system pingos are formed when an Arctic lake drains, leaving sand that is saturated. The very wet sand is squeezed under pressure by the surrounding frost layer and ultimately pushed upward where it freezes, forming a pingo. Open-system pingos are formed by the freezing of the upwelling of ground water in the permafrost.
4. Answers will vary, but should be relevant to the selected formation.

Name:_____

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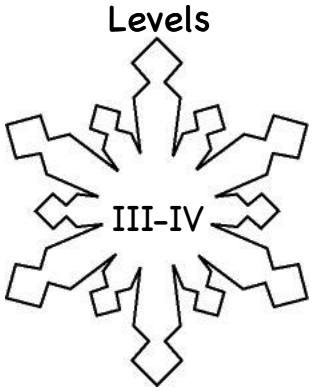
Student Worksheet



1. Pick a formation to model and describe:
   A. ice wedge polygon
   B. pingo

2. Draw a sketch of your model.

3. Explain the process that causes the formation.

4. List any questions or observations you have about this type of formation.