
[1]

GEOG 4310- Dynamics of Snow and Ice

Pingo Formation

Israt Era, Gordon Hawks, Syed Hussain, Rosalyn Kish, Christina Marton


[1]

Introduction

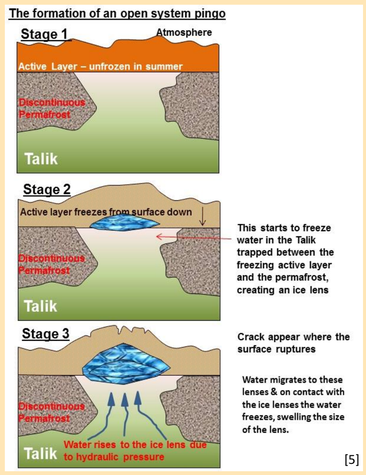
- The word “Pingo” is gleaned from Inuit the word Pinga. It is used to describe ice-cored conical hills of the Mackenzie Delta in Canada [6, 2].
- Pingos form in high latitude periglacial regions of permafrost in areas where thermokarst lakes exist. These lakes initially form due to the freeze/thaw action of the active layer [9].
- Due to their requirement of large amounts of water, Pingos tend to grow in regions with a steady supply of groundwater or in areas where there is an accumulation of outwash material [4].
- Pingos form under the ground surface and grow upward from a depression of accumulated water. The freezing water is pushed toward the surface and forms an ice structure that appears as a lens [9].

Theory of the Pingo

- The theory of Pingo development is highly variable, depending on the environmental stratigraphy of the land and the variation of the below-ground conditions seasonally and year to year.

Open System Pingos

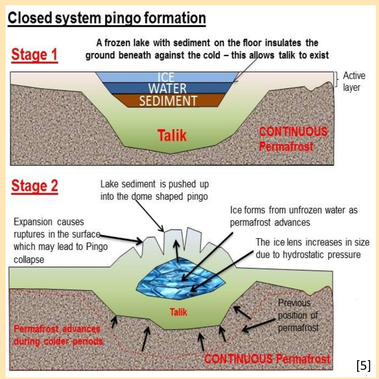
- Form on steep or gentle hillslopes and valley bottoms.
- Require a supply of groundwater under artesian water pressure [8].
- The term 'open-system pingo' is used because there is an open connection between the sub-permafrost water and the pingo dome.



[5]

Closed System Pingos

- Restricted to the continuous permafrost regions. Typically form over drained lakes and flat low lying beds overlying talik [6].
- Occur in lake sediments with sections of previously unfrozen sediments.
- Caused by the expulsion of pore water when saturated coarse- or fine-grained lake sediments freeze [3, 7].



[5]

Constructing a Pingo

- The Pingo materials were combined in a lab setting and then placed in the freezer for development. Formation occurred after the first 24 hours in the freezer and measurements were taken 4 days after construction.
- Materials: Salad bowl, newspaper, tape, shovel, 5 kg sand, graduated cylinder, 1 L water, saran-wrap, two rulers, object for scale, a freezer.

Step 1: Insulate the outside of a large salad bowl with crumpled newspaper to ensure the direction of heat loss is from the upper surface to mimic the natural process of a downward moving freeze plane.

Step 2: Add sand to fill up to 3 cm below bowl rim, shaping a depression 10 (±1 cm) in diameter in the centre of the bowl.

Step 3: Using a graduated cylinder measure 1 L (±50 mL) of water, and add it into the depression in the sand. This must be done slowly to ensure the sand becomes saturated with water before the water begins to pool at the bottom of the depression. This water-filled depression will act as a shallow thermokarst lake. Measure the height of the water pool in the depression. This will be the initial height when calculating pingo growth.

Step 4: Gently, remove sand from the edges of the bowl, insert a 25cm^2 sheet of saran-wrap over the depression, just above but not touching the pooling water. Hold the saran-wrap in place by covering its edges with returned sand. This plastic wrap will behave like a surface ground layer, and will rise with the pingo ice-lens.

Step 5: Place the pingo in the freezer at -15 °C (±1°C) for a minimum of 24 hours.

Step 6: After 24 hours or longer, check for pingo growth. If there was a vertical expansion that was less than the height of the saran-wrap, remove the wrap to check if pingo growth occurred underneath it. Measure the centre growth of the pingo from the same height of the sand that was used to make the initial water height measurement.

Results & Discussion

- We grew a hydrostatic pingo with a typical dome structure!
- Max dome height was 0.9 cm (3.7cm - 2.8cm) above unfrozen water surface.
- Sand-free ice lens visible beneath saran-wrap “overburden”.
- Surrounding sand surface was frozen solid with no indication of expelled water except in the pingo depression, indicating down-moving freeze-plane.

Figure l: a) Open water 3.7cm below sand surface and b) fully formed pingo with dome peak 2.8cm below sand surface. Difference between heights indicates 0.9 cm vertical pingo growth.

- The growth and form is in accordance with the closed system theory of pingos.
- Bowl simulated the solid structure of surrounding permafrost. Newspaper insulation forced freezing plane downward from the surface rather than upward from bowl bottom.
- Sand surface began to freeze and “permafrost” aggraded downwards. Freezing of the “residual pond” occurred after the permafrost was fully formed.
- Descending freezing plane expelled water from saturated pore spaces, causing water to move inwards toward the open depression in the bowl centre where it accumulated on ice lens underside, growing it vertically rather than horizontally.

Conclusion

- If properly insulated around the outside edges, a mini, human-made pingo can be used to demonstrate and study pingo genesis.
- The parallel in heat movement through natural (hydrostatic) and artificial pingos can be compared to one another, as the pingo growth occurs in similar ways.