

Hazard Literacy Center

Hazard Literacy Education Program

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SOS from the Poles: Permafrost Crisis



1. Program Overview

This program explores the interconnections between Earth systems and human society through the lens of polar permafrost thaw. Students learn that permafrost—soil or rock remaining at or below 0°C for at least two consecutive years—is undergoing degradation that triggers localized impacts such as land subsidence, coastal erosion, hydrological shifts, and infrastructure damage. Furthermore, they analyze how decomposing organic matter releases carbon dioxide and methane, creating a positive feedback loop that accelerates global warming. By interpreting climate datasets, students discover that thawing rates vary by region, while examining how permafrost loss threatens housing, food security, and heritage sites for Indigenous communities. Ultimately, the program connects polar changes to students' lives through the global carbon cycle, empowering them to analyze data, navigate uncertainties, and formulate integrated strategies for climate mitigation and community adaptation.

Grade Level	High school students	Instructional Methods	Lecture, Research, Data analysis, Discussion
Learning Environment	Classroom (with computer access)	Duration	Total 120 minutes
Required Materials	Activity sheets		

2. Learning Objectives (Hazard Literacy Framework)

① Understand the concepts of permafrost and the active layer, and explain the process of permafrost thaw driven by global warming.
② Systematically analyze the environmental and social impacts of permafrost thaw on Earth systems and local communities.
③ Assess future risks based on permafrost change data, and propose response strategies incorporating greenhouse gas mitigation and local adaptation

Learning Objectives	Knowledge & Understanding		Reasoning & Skills					Values & Attitudes			Psychology & Emotion			Behavioral & Practical Engagement		
	A1	A2	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2	D3	E1	E2	E3
Objective ①	O		O		O											
Objective ②	O	O	O	O	O		O	O	O	O			O			
Objective ③		O	O		O	O	O	O	O	O		O	O	O	O	O

3. Key Concepts

- Permafrost and the Active Layer
- Permafrost Thaw and Ground Stability
- Climate Change and Global Warming
- Interconnectedness of Earth Systems

4. Program Sequence

Stage	Contents
Introduction	-Sparking student interest by posing the question: "Why are the polar regions both a 'Land of Ice' and a 'Land of Fire'? -Understanding the geographical and environmental characteristics of the polar regions through Arctic and Antarctic media -Sharing initial ideas through prompting questions like "Are there volcanoes in the Arctic and Antarctic?"
Global	-Analyzing the distribution and climatic characteristics of permafrost regions -Understanding the structure of the active layer—which thaws in summer and freezes in winter—and the underlying permafrost -Analyzing trends by comparing historical Arctic air temperatures, ground temperatures, and active layer thickness datasets
Local	-Exploring the impacts of permafrost thaw (land subsidence, ground cracking, thermokarst formation, etc.) -Creating a cause-and-effect diagram illustrating how Arctic warming drives permafrost thaw -Explaining positive feedback loops using the cause-and-effect diagram
Personal	-Drafting a "Permafrost Crisis Response Report" for a hypothetical Arctic village -Developing response strategies categorized into "driver reduction measures (mitigation)" and "adaptation measures for ongoing changes" -Explaining why non-permafrost regions like South Korea should care about this issue, in connection to the carbon cycle, global climate, economics, and international responsibility
Wrap-up	-Presenting findings and engaging in reflection -Formulating personal perspectives on polar hazards and disasters

5. Theoretical Background and Activity Design for Disaster Education

This program is designed to present permafrost thaw as a climate hazard driven by interactions among the atmosphere, geosphere, hydrosphere, biosphere, and human society. Permafrost is defined as soil or rock that remains at or below 0°C for at least two consecutive years, topped by an active layer that freezes and thaws seasonally. As air and ground temperatures rise, the active layer thickens and the ice within the permafrost melts, altering soil volume and structural strength. When ice-rich permafrost thaws, the ground surface sinks unevenly, forming thermokarst landforms. These changes compromise the stability of buildings, roads, runways, pipelines, and water supply systems, while exacerbating landslides and coastal erosion. Consequently, permafrost thaw must be understood as a compound hazard where environmental shifts interact with infrastructure vulnerabilities.

Permafrost stores vast amounts of organic matter from long-undecayed plant and animal material. As permafrost thaws, heightened microbial activity decomposes this stored organic matter, releasing greenhouse gases such as carbon dioxide and methane into the atmosphere. Arctic frozen soils and permafrost hold immense carbon reserves, and greenhouse gas emissions driven by thawing contribute to further global warming. This process illustrates a positive feedback loop: rising temperatures accelerate permafrost thaw, and the resulting emissions drive further temperature increases. However, because factors such as increased vegetation carbon uptake, soil moisture, drainage conditions, wildfires, and microbial activity interact simultaneously, greenhouse gas emissions vary in volume and form across regions. Consequently, significant uncertainties remain regarding the magnitude and rate of the permafrost carbon feedback. The "Permafrost Crisis Response Report" activity provides a structured framework for students to analyze the causes, impacts, future risks, and potential responses associated with permafrost thaw. Working with data, students distinguish current environmental shifts from future possibilities while formulating combined strategies for mitigation (reducing climate change drivers) and adaptation (responding to ongoing changes). Through this process, students come to understand that polar environmental change is both a localized phenomenon and a global issue demanding international responsibility and cooperation.

6. Instructional Considerations

First, avoid describing permafrost as a layer composed solely of ice. Permafrost is a layer composed of soil, rock, sediments, and ice in varying proportions, and the degree of ground deformation after thawing varies depending on its ice content.
Second, take care not to present all permafrost as thawing simultaneously or at the same rate. The rate and impact of thawing vary depending on regional temperatures, snow cover, vegetation, soil ice content, moisture conditions, and topography.
Third, avoid oversimplifying the relationship between permafrost thaw and greenhouse gas emissions. Emission patterns of carbon dioxide and methane differ depending on the moisture and oxygen conditions of the thawed soil, and uncertainties remain regarding future emission levels.
Fourth, avoid overemphasizing individual lifestyle actions as the sole solution to climate change. Address the necessity of structural responses—such as energy and industrial policies, infrastructure improvements, global greenhouse gas mitigation, and support for local communities—alongside personal actions.

7. References

- Lee, E. J. (2021). Bukgeuk-ui geodae singkeuhol balsaeng deung yeonggudongtochung-ui geupgyeokhan haebing-i jigu hwangyeong-e michineun yeonghyang [Impacts of rapid permafrost thaw on global environment: Giant Arctic sinkholes and beyond]. Polar Issue Report, 2021(2021), 44–55.
- Lewkowicz, A. G., & Way, R. G. (2019). Extremes of summer climate trigger thousands of thermokarst landslides in a High Arctic environment. Nature Communications, 10, Article 1329.
- Obu, J. (2021). How much of the Earth’s surface is underlain by permafrost? Journal of Geophysical Research: Earth Surface, 126(5), Article e2021JF006123. https://doi.org/10.1029/2021JF006123

SOS from the Polar Regions: Permafrost Crisis

Topic	Permafrost Crisis
What will we learn?	① Explain the characteristics of permafrost and the active layer. ② Students can propose mitigation and adaptation strategies based on data on permafrost changes..

1 What is permafrost?

active layer, permafrost, summer, winter, 2 years, 0°C

▸ Permafrost is a layer of soil or rock that remains at a temperature of _____ or below for at least _____ consecutive years.

▸ Above the permafrost is the _____, which freezes and thaws seasonally.

▸ This layer generally thaws during the _____ and refreezes during the _____.

2 Draw a Cross-Section of Permafrost

➢ Draw a cross-section in the space below and label the ground surface, active layer, permafrost, ice, and soil.

3 Cascading Impacts of Permafrost Thaw

- What cascading impacts can permafrost thaw have on the Earth system and human society?
- Freely express the cause-and-effect relationships.

<Condition>

Solid line: A relationship confirmed by the data

Dashed line: A relationship inferred from the data

Star (★): The impact considered to be the most severe

Question mark (?): A relationship for which additional data are needed

Feedback symbol (↻): A relationship in which the outcome reinforces the original cause

4 Response and Adaptation Strategies for the Permafrost Crisis

➢ Propose national-level measures and policies to respond to the permafrost crisis.

➢ Evaluate another group's response plan using the criteria below.

Criterion	Evaluation Question	Rating
Scientific Validity	Is it based on valid evidence and scientific principles?	High / Medium / Low
Feasibility	Can it be implemented in a real-world setting?	High / Medium / Low
Effectiveness	Can it reduce risks and impacts?	High / Medium / Low
Equity	Does it sufficiently consider people who are vulnerable to impacts?	High / Medium / Low
Sustainability	Can it be sustained over the long term?	High / Medium / Low