POLAR DETECTIVES:
Using Ice Core Data to Decode Past Climate Mysteries

Teacher Notes: Students investigate the formation, physical and chemical properties of ice cores to determine the cause of a discrepant event.

Key Concept: Scientists analyze ice cores for evidence of climate history.

Target Ages: 10-18

Background: This activity is based on known events: 1783's Laki volcano in Iceland, an "unknown" in 1810 and the Mount Tambora eruption in 1815.

Completion Time: Allow two fifty minute periods.

Materials: Per group of 6: 6 activity copies, 1 (50 ml) graduated cylinder, 1 spoon, a small funnel, 3 hand lenses, 3 squares of black paper, ¼ c. sugar, 3 T. salt, and a small amount of pepper.

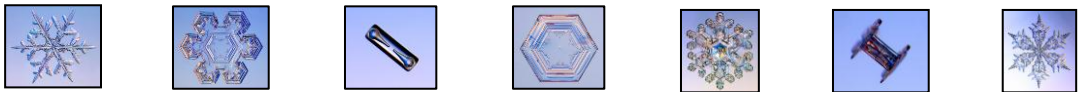
Scenario: Can you imagine a "Year Without a Summer"[1]? Both historians and scientists have found that in 1816 environmental conditions caused temperatures to drop abnormally, more than half a degree Celsius. This was enough to kill animals and crops in the northern hemisphere, to reduce the amount of sunlight due to persistent fog, and to have ice and snow forming in Europe in July and August. Conditions were so grim that author Mary Shelley holed up inside her holiday hotel and competed with friends to see who could create the scariest story. The result? Frankenstein! Figuring out what caused these events and whether they were a random occurrence is the job of climate scientists. To discover an answer, they begin with a question.

Question: "What caused the extreme 1816 summer conditions?"

Hypothesis: There may be ice core evidence of something that caused unusual temperatures.

What We Know: Snow crystals form differently under different conditions. In the center of Greenland, snow falls year round and does not melt. Layers get compressed into ice over time.

Task 1: Using your hand lens, examine the photos below. How are the snowflakes different?



Dendritic flakes, far left, form when air is moist and warm. Colder, drier conditions produce finer, needle-like crystals, such as the third photo from the left.

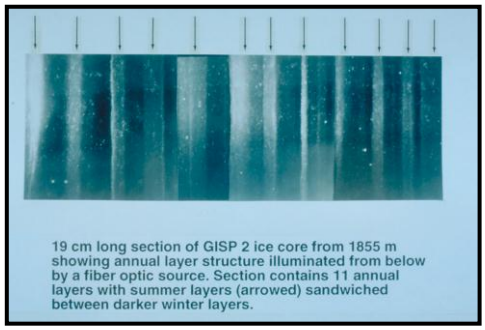
Task 2: Sulfuric volcano emissions can be transported to the poles and fall onto the ice. For this simulation, sugar represents coarser summer snow, salt represents finer, winter snow, pepper represents ash and the cylinder represents the core. Sprinkle a few grains of each substance onto separate squares of black paper and examine them with your lens. What do you observe?

[1]Evans, Robert. "Blast From the Past". Smithsonian Magazine (July 2002).

Working together, create a model ice core, using a spoon and funnel to manipulate the materials.

- Layer 1: Form the base of your core by adding summer snow to a thickness that you can clearly see, for example 10 ml.
- Layer 2: Add winter snow on top of the summer snow. These two layers represent evidence of one year of precipitation.
- Alternate summer and winter layers, filling the cylinder. Occasionally add evidence of an eruption, thick enough so you can see it when you are finished. Examine the "core". What do you observe?

How does the thickness of each layer relate to the weather at the time the snow fell? How does it relate to crystal size? In which layer(s) is there evidence of a volcanic event? How many years of accumulation are indicated in your model? Which layer is the oldest?



19 cm long section of GISP 2 ice core from 1855 m showing annual layer structure illuminated from below by a fiber optic source. Section contains 11 annual layers with summer layers (arrowed) sandwiched between darker winter layers.

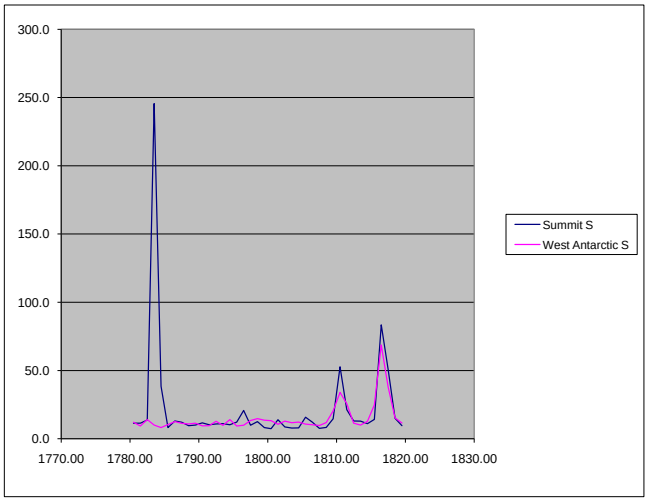
Credit: Tony Gow

What We Need to Know: In addition to physical properties we <u>can</u> observe, snow also contains chemical indicators we <u>can't</u> see that give clues to the environment when the snow fell.

Designing an Investigation: Scientists designed two expeditions to search for evidence of sulfur in ice cores. The first expedition went to Summit Station, Greenland and the second to West Antarctica.

Task 3: Analyzing Data Review the graph below. How many eruptions were indicated, during which year(s)? Which volcanoes were equitorial (sulfur distributed over both hemispheres)? Which were located in a mid- or high latitude location (deposited near the volcanic site only)?

Sulfur ppb



Year

Drawing Conclusions: Scientists were able to pinpoint ice cores from 1816 using physical and chemical means. You have examined evidence of volcanic eruptions from the same period. Could ash in the atmosphere have been a major factor, blocking northern hemisphere sunlight and causing a "Year Without a Summer"?