Ice Cores: The Past is the Key to the Future

Setting the Stage

Climate scientists have used the gases trapped in ice cores over the last quarter of a century to understand how Earth's atmosphere has changed in the past. They use this information to build models that try and predict how the climate system may change in the future.

An ice core. Credit: NASA's Goddard Space Flight Center/Ludovic Brucker

Demonstration Overview

The students will come to understand how an ice core forms and how they are useful in looking at past atmospheric concentrations of carbon dioxide.

- *Activity 1 – Engage (5-10 minutes) Age of Trapped Carbon Dioxide*
  Show the students an image of ice core carbon dioxide data.
- *Activity 2 – Explore (5-10 minutes) Trapping Carbon Dioxide*
  Students make observations about snow in a sealable bag.
- *Activity 3 – Explain (5-10 minutes) From Ice in a Bag to Glacier Formation*
  Have a group discussion about students' observations.

Instructional Overview	
Grade Level	Middle School
Instructional Time	15-30 minutes *(total time needed)*
Standards Alignment	NGSS: DCIS:ESS3.D *(partial)* SEPs: Developing and Using Models CCCs: Energy and Matter
Lesson Phenomenon	● Ice cores contain clues about past climates
Driving Question	● How do ice cores form and how are they useful?
Learning Goals	● Understand that snow forms into ice on glaciers and ice sheets via compaction. ● Understand that air bubbles from the atmosphere that are present in the snow become trapped as the snow turns into ice and can be sampled 100,000's of years later.
Materials	● A clear gallon-size sealable bag ● Fresh snow, snow cone material, or shavings of frost from the inside of a freezer ● A few heavy books
Material Preparation	○ Make sure the “snow” remains frozen until the demonstration is performed
Instructional Strategies	This teacher demonstration could be used at the beginning of a unit that unravels past climates based on proxy indicators. In this demonstration students make observations of how snow becomes ice through compaction.

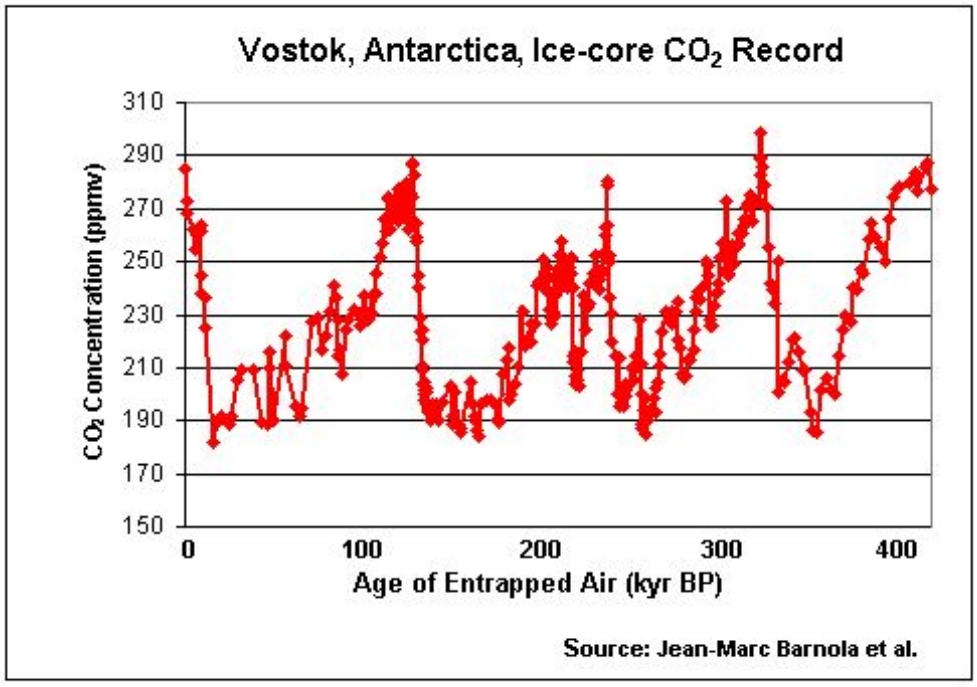
	Lesson Resources
Activity 1	● Data: Example of Ice core carbon dioxide data: https://gcmd.nasa.gov/records/GCMD_CDIAC_CO2_VOSTOK_ICECORE.html ● Visual: Example of Snow-firn-ice transition: https://www.polartrec.com/expeditions/ocean-atmosphere-sea-ice-and-snowpack-interactions/journals/2013-09-05 ● Website/Text: How are glaciers formed? https://nsidc.org/cryosphere/glaciers/questions/formed.html

Activity 1 (Engage)

Age of Trapped Carbon Dioxide (5-10 minutes)

Activity 1.1

Show the students a graph of ice core carbon dioxide data.



Make sure the students pay attention to the x axis (time). Ask them to identify the patterns they see in the data. Ask the students how we could possibly know how much carbon dioxide was in the atmosphere 400,000 years ago, if we only started measuring atmospheric carbon dioxide a little over 50 years ago (Mauna Loa record). Students may respond that the gases must have been stored somewhere.

Activity 1.2

Now introduce the students to the idea of ice cores. Explain to the students how ice sheets form, how air gets trapped inside the snow and that as that snow gets compacted it turns to ice and the air gets trapped. You will need to explain this again after the activity.

See the figure below to help students understand the steps in glacial ice development along with the following background information:

> Glaciers and ice sheets form as snow accumulates. As overlying snow accumulates, the pressure increases, weighing down the underlying snow. This creates a layer of dense snow, called **firn**. Eventually, the firn gets further compacted and develops into solid ice. As the process occurs, air between the snow grains gets trapped. This air, once preserved in the ice, can be sampled to learn about the composition of past atmospheres. Scientists who study ice cores use these trapped-gases to understand how concentrations of greenhouse gases like CO2 and CH4 (methane) have varied over time." (Authors: Dan Zwartz and Heidi Roop, Antarctic Research Centre, Victoria University of Wellington, New Zealand)

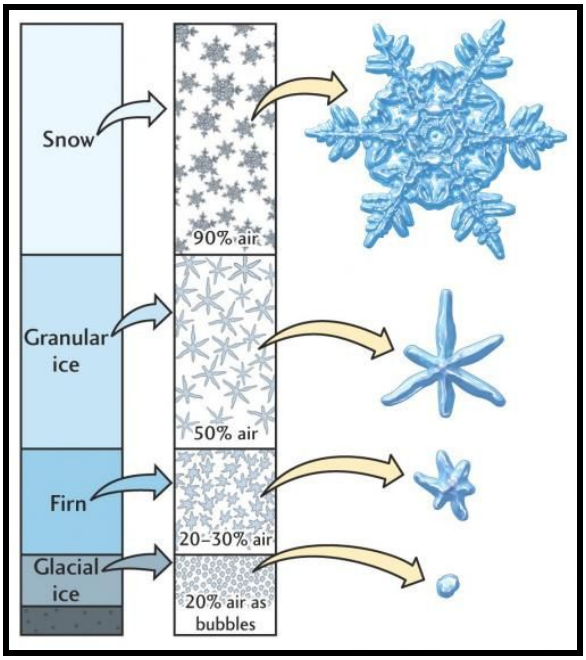


Figure: *Creating a Glacier* from the PolarTrec journals

Additional information on glaciers can be found on the National Snow and Ice Data Center website.

Activity 2 (Explore)
Trapping Carbon Dioxide (5-10 minutes)

Activity 2

In this step of the demonstration, students make observations of how compression of snow can turn it into ice while trapping any gases that may be in the snow. Ask students what they think will happen if pressure is placed on the snow. Expect students to say that the snow will be compacted and almost look like ice.

Add snow to the sealable bag, evacuate as much air as possible, and allow students to make observations of what they see and don't see (air). In their notebooks, they draw a model of what they see and identify the components of the model (bag, snow, air). Some air will still remain. Tell them to label it as "before." Ask them to redraw their model with a few heavy books on the bag. Ask them what the books represent in the model. Ask them to redraw the model again, but this time it is their hypothesis about what the snow will look like after the books are removed.

Place the books on the bag of snow until it compacts (about 3 minutes), and remove the books. Students make observations comparing what they drew for their last model, and what they see in the bag.

Activity 3 (Explanation)
From Ice in a Bag to Glacier Formation (5-10 minutes)

Activity 3
In the final activity of this demonstration, students report on their models of what happened to the snow as it was compressed. Ask them how their models could be the same or different from what happens to snow in the polar regions. Show them the graph they saw in Activity 1 and ask them how scientists gather data to create the graph. They should respond that the ice at the bottom of the ice sheet is older than ice at the top, and that scientists would need to drill into the ice sheet to get the old ice. Trapped in the ice (like in their models) are gases that are collected and analyzed.

Wrap-up
Ask the students if they think ice cores could be good for measuring anything other than carbon dioxide. In the end they can be used for other atmospheric gases (CH4, N2O, VOC's, ash from fires, dust blowing off Southern Africa and Southern South America, snow accumulation, wind direction and MORE!).

Activities	Extensions
General	The website below provides information on a recent American effort to drill an ice core in Antarctica. There is a wealth of information and pictures detailing how drilling an ice core is done and what the day-to-day life is like at camp. West Antarctic Ice Sheet Divide Ice Core: http://www.waisdivide.unh.edu/