Climate Change

Compared to 40 million years ago, Earth's overall temperature is now cooler by about 5°C. Evidence from rocks, including fossils of plants and animals, shows that global climate has changed over time. Detailed studies reveal that the average temperature didn't decrease steadily; instead, every 5 or 10 million years, the temperature dropped by a degree or more. Other times, the temperature remained steady or got warmer for a while. The causes and timing of these types of temperature changes are what climate scientists want to learn about as they attempt to predict how Earth's climate will change in the future.

Some of the causes of climate change are known. For instance, a regular pattern in Earth's orbit causes our planet to receive more or less energy from the sun for thousands of years at a time. In addition, the sun's output of energy changes slightly over time. Changes in Earth's atmosphere are another factor: the mixture of gases and the number of small particles in the atmosphere control how much energy the planet absorbs and how much it reflects.

In the past 50 years, Earth's average temperature has warmed by 0.6°C. Projecting current conditions into the future, we can expect another 1°C of warming over the next 50 years. Though we know that natural variations have caused changes in climate throughout Earth's history, the rate of climate change is now much faster than usual. A growing body of evidence indicates that human activity is affecting Earth's climate.

People are wondering what impact higher global temperatures will have on Antarctica's ice. ANDRILL scientists are gathering evidence that will help answer that question: they are reading the rock record from around Antarctica to find out how ice on Antarctica reacted during times in the past when temperatures were warmer.
Activity 5A

Unit 5 - Decoding Antarctica’s Climate History

Reading Climate Clues from the Rock Record

Layers of rock from the seafloor around Antarctica show how the Antarctic climate has changed. ANDRILL cores reveal that many cold-to-warm climate cycles have occurred over the last 10 million years. Though the details are more complex than what is presented here, the descriptions will help you connect different rocks to the climates that produced them.

Cold climates

Ice sheets on Antarctica grow during times when its climate is cold. Snow that falls never melts, so the frozen ice sheets get larger, moving out onto the seafloor around the continent. The growing ice sheets grind over the former seafloor, carrying rocks of all sizes and shapes off the continent. These rocks are deposited below the ice as a layer of mixed sediments. As additional layers are deposited, these sediments are pressed together and turn into solid rock. This type of rock is called **diamictite**; it forms when the climate is relatively cold.

Warming climates

As the climate begins to warm, the area covered by ice sheets starts shrinking. Solid ice on land begins to melt, raising sea levels, and ocean water moves in below the edges of the ice sheet. Ice at the bottom of the ice sheet melts first because it is in contact with ocean water. Ice at the surface remains solid longer. This part of the ice sheet is still attached to land, but it is floating on ocean water as an ice shelf. Sediments that were trapped in the bottom of the ice sheet continue to melt out and pile up under the ice shelf. When the piles get too steep, underwater landslides occur, spreading the sediments across the seafloor. Larger grains in the fast-moving landslides come to rest first, then progressively smaller sediments settle on top of them. The **layered rocks** that form from these sediments go by a variety of names. Around Antarctica, they indicate a time when an ice shelf existed over the seafloor—a time when the climate was somewhere between cold and warm.
Warm climates and open ocean

When Antarctica’s climate warms even more, ice shelves melt and the open ocean surrounds the continent. Diatoms live and die in these waters—their cell walls fall to the seafloor where they form a layer of sediments. During these relatively warm periods, sea ice can still form. Comparing the numbers of open-ocean and sea-ice diatoms offers more detailed evidence of past climates. Layers of diatoms form a light-green rock called diatomite; it forms during times when Antarctica has a relatively warm climate.

When Did It Happen?

With undisturbed sedimentary rock layers, the deeper the rocks are, the older they are. The older rocks had to be there first before the younger rocks could be deposited on top of them. This simple fact makes it easy to understand the ORDER of environments that produced the rocks, but figuring out WHEN the environments existed takes more information.

Clocks in the rocks

Igneous rocks, those that form from melted rock, contain certain elements that change into other elements over time. From the time hot liquid rock cools into solid rock—when it erupts from a volcano, for instance—these elements change into other elements at a predictable rate. Scientists called geochronologists (geo = Earth; chron = time; ologists = people who study) have figured out how to measure the amounts of unchanged and changed elements. They use those amounts to calculate how long ago the rock solidified.

Volcanic ash forms when lava cools quickly as it is blown apart by escaping volcanic gases. When Antarctic volcanoes erupt, this volcanic ash is lofted into the air and settles out over the landscape. Ash particles fall on areas of open ocean and settle onto the seafloor in a new layer.

Where ANDRILL scientists find suitable layers of volcanic ash in the core, they can get an age date. The date tells the number of years ago that the layer was deposited. Layers beneath the ash were deposited before that date and layers above it were deposited after that date. Using this information along with data from fossils, geochronologists figure out when different climates existed and how quickly they changed.
Activity 5A

Unit 5 - Decoding Antarctica's Climate History

Prepare

In this activity, you'll build an interactive display to illustrate how Antarctica's climate timeline can be interpreted from ANDRILL's rock cores. The picture at right shows an example of the finished product: the adjustable thermometers indicate relative temperatures on Antarctica through time.

Assemble the frame

Measure and mark the following lengths of ½-inch PVC pipe. Double-check your measurements, then use a PVC cutter or a small saw to cut the pipe.

- 2 Connectors, each 2 inches long
- 4 Legs, each 3½ inches long
- 2 Side Bars, each 16 inches long
- 2 Top & Bottom Bars, each 26¾ inches long

Assemble the pieces as shown:

PVC frame assembly tips

- When assembling the PVC pipe and fittings, insert the pipe into the fitting and twist while pushing them together.
- For a snug fit, you can lightly sand the ends of the pipe with fine sandpaper before assembly.
- You don't need to glue the pieces — this allows you to disassemble the frame for transporting and storing it.
Prepare the “thermometer” ribbons

1. Measure and cut five 20-inch-long red ribbons and five 20-inch-long white ribbons.

2. Have an adult use a candle flame or butane lighter to carefully and quickly pass the ends of each ribbon through the flame to fuse the threads. This will keep the ribbon from fraying. Lay all the ribbons out flat to keep them organized.

3. Cut ten 1½-inch-long pieces of VELCRO®. "Rip" the two sides apart so you have 10 hook pieces and 10 loop pieces.

4. Peel the backing off one hook piece of VELCRO® at a time and stick it close to one end of a red ribbon. Add another hook piece at the other end of the same side of the ribbon. Repeat for all 5 red ribbons.

5. Attach loop pieces of VELCRO® to each end of the five white ribbons. All VELCRO® pieces go on the same side of the ribbons.

6. Connect each red ribbon to a white ribbon by pressing the VELCRO® pieces together.

Prepare additional pieces

1. Cut out the Template for Thermometer Bulbs and use it to make 5 "bulbs" out of red construction paper.


3. Attach the Relative Temperature label vertically along the left edge of the poster.

4. Cut out and fold the six Antarctic landscape picture cards and the age-date markers on the dashed lines. (NOTE: The age-date markers do NOT go with their adjacent landscape picture cards.)

5. Cut and fold the Antarctica’s Climate Timeline tent card. It will serve as the graph’s title.

6. Cut out the Core Cards.

Final assembly

1. Tape the poster board to the sides of the PVC frame with clear packaging tape. This is the background of your temperature graph.

2. Lay the ribbons over the PVC frame with the white part going over the top bar and the red part going under the bottom bar.
3. Pull the ends together and connect them by pressing the VELCRO® pieces together. Make the ribbons snug enough to stay taut, but not too tight for them to slide around the top and bottom of the PVC frame. If necessary, release and adjust the VELCRO® connection to tighten the ribbons. Space the ribbons evenly across the frame.

4. Place a small rolled piece of tape on each side of the five thermometer bulbs. Stick each bulb to the bottom bar of the PVC frame over one of the ribbons. Make sure the ribbons can move freely behind each bulb.

**Decode a rock core to show a climate timeline**

1. Take one of the Core Cards at a time. Your task is to read the rock layers and set the timeline graph to show how climate changed over the time the rocks were deposited in that core.

2. Decide what climate the oldest rock layer on the card indicates. Select the Antarctic landscape picture card that illustrates this climate and place it at the top of the first thermometer on the left. Adjust the thermometer ribbon to show the relative temperature of the climate you decided on.

3. Repeat the process for the next four thermometers.

4. Add the age-date markers indicated by your core along the top of the frame.

5. Describe the climate history that your timeline shows. Discuss how certain or uncertain you are about different parts of your interpretation.

6. Repeat this process with each of the other two Core Cards.
Relative Temperature

Cut out along the dashed line…

cooler

warmer

Cut out along the solid line…

TEMPLATE FOR THERMOMETER BULBS

MAKE FIVE USING RED CONSTRUCTION PAPER
Graph Title Tent Card
This sign is the title for your temperature graph. Cut it out and fold it along the dotted line to form a “tent” shape, and place it on the table in front of your graph frame.
Cut out cards along the solid lines and fold on the dashed lines.

6.9 Million Years

Note: This age date marker does not go with this landscape scene.

1.1 Million Years

Note: This age date marker does not go with this landscape scene.
Unit 5 - Decoding Antarctica's Climate History

Activity 5A

Cut out cards along the solid lines and fold on the dashed lines...

5.4 Million Years

Note: This age date marker does not go with this landscape scene.

2.2 Million Years

Note: This age date marker does not go with this landscape scene.
Cut out cards along the solid lines and fold on the dashed lines...

6.4 Million Years

Note: This age date marker does not go with this landscape scene.

4.3 Million Years

Note: This age date marker does not go with this landscape scene.
Unit 5 - Decoding Antarctica's Climate History

Activity 5A

Core Cards

Cut out cards along the dashed lines...

Core 1

Volcanic Ash
1.1 Million Years Old

Volcanic Ash
2.2 Million Years Old

Volcanic Ash
6.4 Million Years Old

Core 2

Volcanic Ash
6.9 Million Years Old

Core 3

Volcanic Ash
4.3 Million Years Old

Volcanic Ash
5.4 Million Years Old

Antarctica's Climate Secrets

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Activity 5A

Unit 5 - Decoding Antarctica's Climate History

Core 3
- Volcanic Ash 4.3 Million Years Old
- Diatoms
- Layered Sediments
- Mixed Sediments
- Mixed Sediments
- Volcanic Ash 5.4 Million Years Old
- Diatoms

Core 2
- Mixed Sediments
- Mixed Sediments
- Volcanic Ash 6.4 Million Years Old
- Diatoms
- Mixed Sediments
- Layered Sediments

Core 1
- Volcanic Ash 1.1 Million Years Old
- Diatoms
- Layered Sediments
- Mixed Sediments
- Volcanic Ash 2.2 Million Years Old
- Diatoms
- Mixed Sediments
Unit 5 - Decoding Antarctica's Climate History

Activity 5A

Ponder . . .

The red and blue pattern on the Decoding Antarctica's Climate History banner represents a scientific interpretation of climate changes in Antarctica. Use the colors, times, and landscapes on the banner to write a description of Antarctica's climate over the past 50 million years.
Practice

Got the Big Idea?
Rock layers are records of the climates that produced them. By “reading” rocks in order, we can figure out how the climate of the place where they formed changed over time. Age dates from volcanic rocks are used to determine when different climates existed and how quickly the climate changed.

Get ready to present
Read the introductory text for Unit 5 and activity 5A carefully. Read one paragraph at a time, then discuss the idea with your team members to make sure that everyone understands. For each section, practice describing the most important point in your own words. This will prepare you to explain the ideas to visitors at the Flexhibit.

Decide what information visitors will need to be able to set the climate timeline from the Core Cards. You may want to make a chart that connects the different rock types to the climates that produced them. For instance, you might show the three types of rocks in one column with the landscape pictures that match them in another column.

Come up with an introductory comment or question you can use to invite people to interact with you at the graph. Be ready to explain how the rocks indicate different climates and how the order of the layers tells the sequence of climates. Make sure you can explain how the volcanic ash layers give age dates.

You may want to show visitors one of the Core Cards and challenge them to set the climate timeline themselves. If the task seems too difficult at first, consider setting the thermometers for the first two or three ribbons, then inviting visitors to set the remaining ones.

Present
Set up the frame and tent card with the graph title. Place the landscape pictures and age-date markers where visitors can choose the ones they need.

Encourage visitors to set the thermometer ribbons themselves, even if you need to place the landscape pictures along the top of the frame for them according to the Core Card. This will help you communicate the idea that we can read rocks to tell how climate has changed over time.

In some cases, if visitors are reluctant to interact with the graph, you might demonstrate how you interpret a rock layer’s climate and set the thermometer yourself.
Unit 5 - Decoding Antarctica's Climate History

For visitors who are interested and engaged with the climate timeline, describe how the red and blue pattern on the Decoding Antarctica's Climate History banner shows a scientific interpretation of climate changes in Antarctica.

When a group of visitors leaves your station, “reset” the graph so that the next group can start fresh, interacting with the graph and making the climate timeline.