Magnets at the Core

Activity of the Month - January, 2008

Summary

Students use core models with embedded magnets and compasses to measure and record magnetic orientation in their cores. These model cores simulate the magnetic fields recorded in real deep-sea sediment cores obtained from a scientific ocean drilling vessel, such as the *JOIDES Resolution*.

Learning Objectives

Students will be able to:

- Explain how a paleomagnetic record is recorded in rock and sediment and obtained by scientists.
- Measure and record magnetic orientation in model cores.
- Identify different styles for data collection (e.g., graphs, charts).

National Science Education Content Standards

- Standard A: Science as Inquiry
- Standard D: Earth and Space Science

Ocean Literacy Essential Principles

7. The ocean is largely unexplored.

Target Age: Grades 7-12

Time: One or two class periods.

Materials

- Foam swim tubes/noodles. (Each tube makes two cores.) Note: You can purchase these at a local swim shop or online at places like http://pooltoy.com/waternoodle.html.
- Bar magnets (any size). *Note: You'll need about three per core. One core model could have either two or four to have different magnetic readings, but three seems to be the best for this length.*
- Compass (one per group); cheap round compasses work well.
- Meter stick (one per group)
- Unlined 8.5" x 11" paper (one sheet per student)
- Scissors (one pair per group)
- Scotch tape (one roll per group)
- Masking tape (for core preparation)
- Optional: double-sided tape for core preparation

Background

Over time, Earth's magnetic poles change strength and location. They also completely reverse directions episodically. The north magnetic pole is currently moving northwest at 40 kilometers per year. It moved from 81.3° N, 110.8° W in 2001 to 82.7° N, 114.4° W in 2005. (For more information on this: www.ngdc.noaa.gov/seg/geomag/faqgeom.shtml)

The strength and direction of the Earth's magnetic field at any given time in geologic history is recorded by sediments and oceanic crust deposited or formed at that time. After scientists collect a core from the ocean floor, they use an instrument called a magnetometer to "read" its magnetism and indicate the magnetic orientation of the core's different layers. This number can be measured in degrees (360°) or inclination (dip), the angle of magnetism with relation to Earth's surface up to 90° or – 90°, (e.g., 0°, horizontal, at the equator). This instrument also indicates pole reversals and the motions of plates on the Earth's surface.

For more information:
http://www.joilearning.org/schoolofrock/PDFs/SWFs/About_Paleomagnetism.swf

January 2008

What to do

Preparation for Making the Magnetic Cores

(This must be done ahead of time.)

1. Cut the swim tubes into two halves. Most swim noodles are about 140 cm, so this will give you two 70-cm cores. This size makes the cores short enough for easy handling.

2. Use a box cutter to slit the tube lengthwise the whole length of the simulated core. Do not cut the tube all the way open, but slice down halfway into the tube.

3. Wad masking tape around each magnet, so that it sticks to the magnet and the inside of the tube.

4. Place the taped magnets lengthwise inside the tubes in the same direction as the length of the tubes, so that each magnet fits in the opening of the foam tube (Figure 1). Make sure to alternate the magnetic poles of these magnets and place a magnet near the top, the middle, and the bottom of the tube. (*Note: Each core should have magnets placed in different locations, so that each core is unique. The magnets should NOT be spaced evenly, to better model the sporadic nature of the core.*)

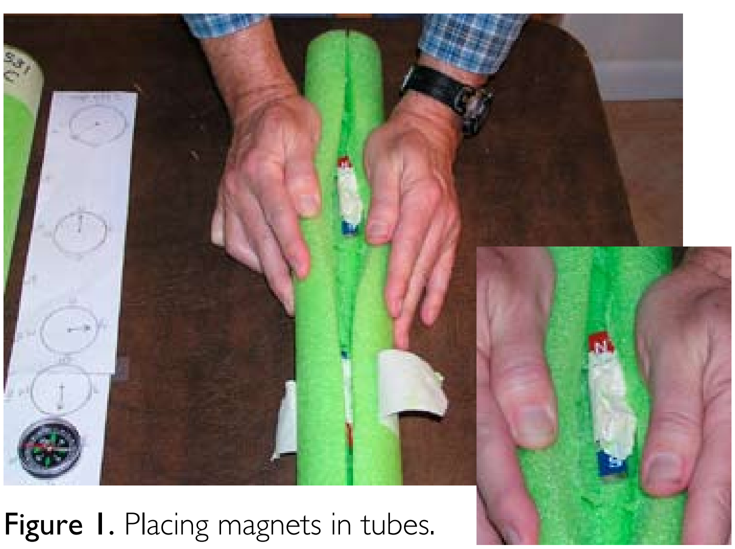

Figure 1. Placing magnets in tubes.

5. Tape the tubes closed with masking tape, so the magnets remain hidden and stay in place.

6. Label each core at the top by noting on masking tape, "Top" and a different core site number that you make up (e.g., 531 C) for each core. This label is necessary so the students know how to align and label their data strips and compare different core samples.

With the Students

1. Divide the class into groups of two to three students each.

2. Instruct each student to cut an 8.5"x 11" piece of copy paper into three similar-sized lengthwise strips. Each student should use Scotch tape to join his or her three strips end-to-end to make one long "data strip."

3. Each student will write the word, "Top" at one end of his or her data strip.

4. Have each student start at the top of the strip and label every five centimeters (e.g., 5 cm, 10 cm, 15cm, and so forth) down along the edge until he/she reaches the bottom of his/her strip.

5. Have each group tape one of the data strips down on the table within easy reach. The students must be able to view the entire strip and record their data on these data strips.

6. Hand out a small compass to each group. If the students do not have a round compass, they will need a round shape, (like a quarter) to record their data. Let the students examine their compasses to familiarize themselves with the north, south, east, and west orientation and the magnetic red arrow. Be aware that metal objects in the room can affect the compass.

7. Give each group a model core and ask students to record their core number on their data strip. They will lay this core alongside the data strip, with the top of the data strip lined up with the top of the core.

8. Each group will place its compass on the data strip and orient the "Face," (not the needle) of the compass, so that the north/ south orientation is parallel with the model of the core (Figure 2). This face must stay oriented in this manner throughout the entire activity.

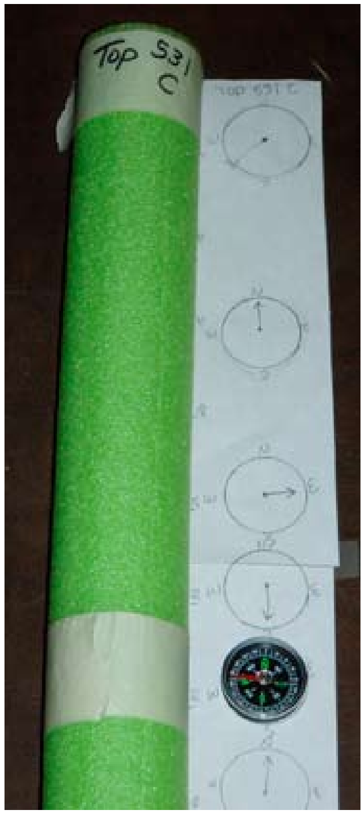

Figure 2. Data strip with oriented compass face.

9. Starting at the top of the model core and the data strip, the group will draw a circle (using the compass or quarter) on the data strip to represent the compass. The students will record by drawing an arrow within the circle to indicate the direction of the red arrow. They should label N, E, S, W on each circle they draw. The group will slide the compass slowly down the data strip by keeping the face oriented in the north/south direction. The group should record and draw a circle every time the compass points directly at north, east, south, or west. Continue this procedure until the group reaches the bottom of its core. Note that circles can overlap.

10. When their data strip is completed and as time allows, have students swap core models and use a new data strip to record the data from their new core. The students should follow the same procedure. This will give students the opportunity to compare core models and to see that all cores are not the same.

11. Have students circle or highlight the recorded arrow on their data strips every time the compass needle points to either the North or the South Pole.

12. When all the groups have finished, ask students to discuss and compare their findings with the class. The strips may be mounted side by side on the wall for easy viewing by everyone.

13. Lead a class discussion:
    a. How many times did a polar reversal take place on their data strips?
    (This is when the reading on the compass needle went from north to south, or south to north.)

    b. Were the reversal transitions evenly spaced?
    (In authentic geologic cores, they are not.)

    c. Where are the oldest and youngest parts of the core on their core model and data strip?
    Please note that if the sediment has not been disturbed, the top is the youngest and the bottom is the oldest (as stated by the Law of Superposition regarding relative age; for more information, see http://academic.brooklyn.cuny.edu/geology/leveson/core/topics/time/froshlec8.html).

    d. Did different cores have the same readings?
    If the magnets were placed in different locations for each core, then the readings should be different.

    e. How do you think the model cores were made?
    Discuss how the cores were made. Open up one model core to show where and how the magnets were placed in relation to a data strip.

14. Have students examine actual data using Figure 3, Geomagnetic Polarity Timescale, from the Shipboard Scientific Party, 2001: Cande and Kent, 1995. Explain that the black bands in the polarity column represent the "normal" periods in Earth's history (similar to today's polarity), while the white bands represent periods of reversed polarity (north and south magnetic

poles opposite from today). Have students refer back to their own data strips and notice that their strips show similar north and south reversals. The compass needle pointing toward the north of their compass face would indicate a normal period, while the compass needle pointing toward the south of their compass fields would show reversed fields of polarity.

Useful Links

http://www.joilearning.org/schoolofrock/Library.html
http://image.gsfc.nasa.gov/poetry/magnetism/magnetism.html
http://www.howstuffworks.com/compass.htm

Extension

Have students create a magnetic field inclination (dip) graph by using the data strips drawn from this initial activity. The value for the north is + 90 °, for the south – 90°, and the value for east and west would be 0°. The x-axis would be from 0 cm to the length of the core model (e.g., 70 cm). The y-axis would be + 90 ° to - 90° with the x-axis being 0°. Students can plot each compass drawing from their data strip on this graph, and draw a line to connect the dots. When plotted, the curve on the graph will indicate polar reversals.

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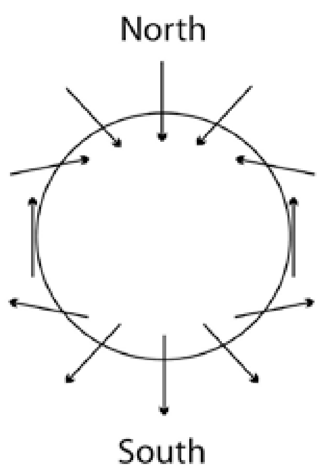

Cross-section of Earth showing magnetic field inclination (dip). The arrows represent the direction of the Earth's magnetic field relative to the Earth's surface. Magnetic minerals that crystallize at a point on the Earth's surface would be magnetized in the direction of the arrow (modified from Cox, A., and Hart, R.B., 1986). (Note that the field inclination at the poles is ± 90°, horizontal at the equator, and some intermediate value in between).

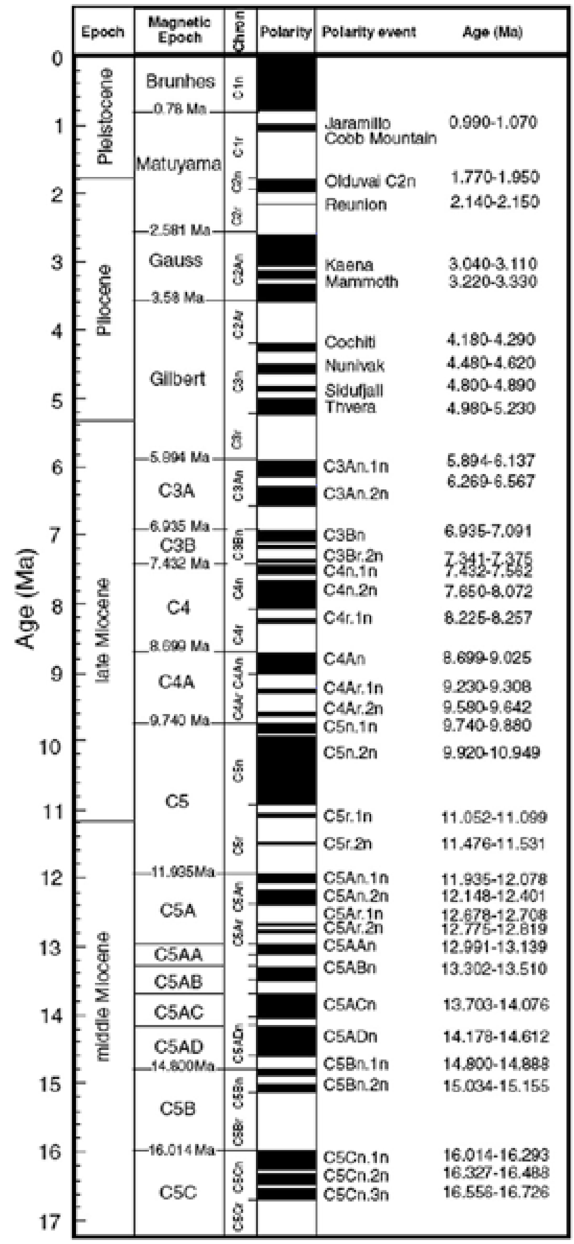

Figure 3. This is the geomagnetic polarity timescale for middle Miocene to Holocene time. In the polarity column, black represents periods in the Earth's history when the magnetic field was normal (as it is today); white represents times of reversed polarity (north and south magnetic poles opposite from present day). The ages of the polarity boundaries are well-established in the literature (Shipboard Scientific Party, 2001; from Cande and Kent, 1995).