# Activity 8 - Geomagnetism II: Magnetic Reversals

TEACHER'S GUIDE

Earth's magnetic field does, in fact, flip its poles every 300,000 years or so. Currently the South Magnetic Pole is in the Northern Hemisphere in northern Canada. Magnetized compass needles marked with 'N' are actually north-type magnetic poles that are attracted to the south-type polarity of the South Magnetic Pole. About 800,000 years ago, it was Earth's North Magnetic Pole that was located in our Arctic Region. The plot below shows that there have been many times in the last 800,000 years when the strength has dipped well below 50% of its current value (8.0×10^{22} Ampere x meters^2). During the last magnetic reversal that happened 780,000 years ago, the value of B reached almost zero. Also, the rate of change of the field was very rapid. Is there a magnetic reversal in our future? This seems very likely, but it's nearly impossible to predict exactly when this might happen.

GOALS

1) Students will recognize how Earth's magnetic field strength has changed over the last 800,000 years.

2) Students will determine at what time Earth's magnetic field will reach zero.
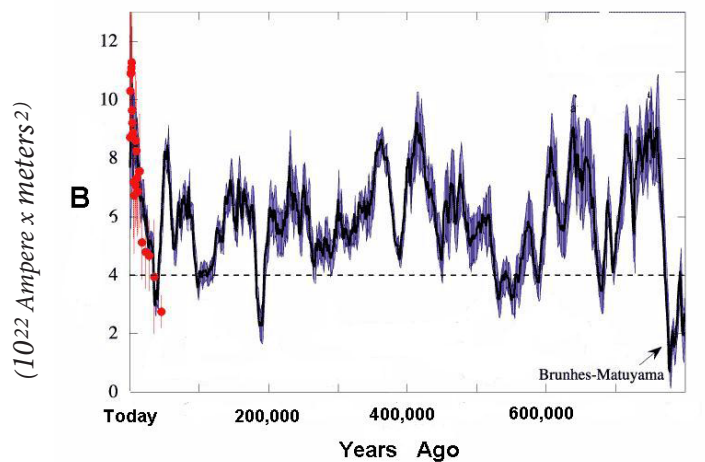
MATERIALS

• Graph paper

PROCEDURE

In this activity, students will plot the changes in Earth's magnetic field during the last 800,000 years, and investigate answers to some important questions about past magnetic variations and future magnetic reversals. The data for the student table used in this study and plotted in the figure above are from the research by Yohan Guyodo and Jean-Pierre Valet at the Institute de Physique in Paris and were published in the journal *Nature* on May 20, 1999 (pages 249-252). Note, the units used in the figure above to represent the magnetic dipole strength, B, are 10^{22} Ampere x meters^2. The dashed line represents the approximate lowest intensity of the magnetic field for which reversals are not likely to be a significant issue.

Student Name _____ *Date* _____

Geomagnetism II: Magnetic Reversals

Geologists have measured the strength of Earth's magnetic field going back thousands of years. They do this by measuring its fossil traces left in the rock deposits around the world whose ages can be accurately dated. These measurements are shown in the table below. The units used to represent the magnetic dipole strength in the table below are 10^{22} Ampere x meters^2. Today's strength (Time = 0.0) has a value of 8.0×10^{22} Ampere x meters^2 on the vertical scale. The "Time" columns indicate how many thousands of years *before* the present time that the field was at the indicated strength. For example, the first table entry '20' means 20,000 years ago, at which time the strength was 12.0×10^{22} Ampere x meters^2.

Create a graph of Time (in years) versus Magnetic Field Strength using the table below. Remember to mark your x- and y-axis with labels and units.

Time	Strength	Time	Strength	Time	Strength	Time	Strength
0	8.0	220	5.7	440	6.3	660	7.0
20	12.0	240	6.5	460	7.0	680	3.5
40	3.2	260	4.5	480	6.0	700	5.0
60	5.0	280	5.0	500	5.7	720	5.5
80	6.6	300	6.0	520	4.6	740	8.2
100	3.8	320	5.8	540	3.8	760	6.5
120	4.3	340	6.4	560	4.2	780	0.5
140	6.5	360	8.5	580	4.7	800	3.4
160	6.3	380	5.0	600	6.0		
180	2.2	400	7.5	620	5.5		
200	6.0	420	8.4	640	8.5		

From the tabulated entries above, answer the following questions:

1. What is the range of the magnetic field strength?

2. What is the average value of the magnetic field strength?

3. How many times has the magnetic strength dipped below 1/2 of its current value of 12.0×10^{22} Ampere x meters^2?

4. When was the last time that the magnetic field strength reached 1/3 of its current level?

5. When was the last time the magnetic strength was close to zero?

6. When did the fastest change in the magnetic field strength occur in the last 800,000 years?

Inquiry Problem: Do you think the magnetic field strength will actually reach zero? Using the plotted data, explain your reasoning.

TEACHER ANSWER KEY

(The students' graphs should look approximately like the one on page 6).

1. What is the range of the magnetic strength?

   Answer: [0.5, 12.0] range = 12.0 – 0.5 = 11.5 x 10^{22} Ampere x meters^2.

2. What is the average value of the strength?

   Answer: Add all 40 'Strength' numbers together and divide by 40, to get 5.7 x 10^{22} Ampere x meters^2 after rounding.

3. How many times has the magnetic strength dipped below ½ of its current value of 12.0 x 10^{22} Ampere x meters^2?

   Answer: The half-way strength is 6.0 units, so there are 10 occasions in the following periods: 120,000; 180,000 ; 220,000 ; 280,000 ; 320,000 ; 380,000 ; 540,000; 620,000 ; 680,000 and 780,000 years ago.

4. When was the last time that the strength reached ⅓rd of its current level?

   Answer: This level corresponds to $^{12}/_3$ = 4 x 10^{22} Ampere x meters^2. These two events happened 180,000 and 780,000 years ago.

5. When was the last time the magnetic strength was close to zero?

   Answer: 780,000 years ago.

6. When did the fastest change in the magnetic field strength occur in the last 800,000 years?

   Answer: Students have to look for the biggest change in strength in the shortest amount of time. Between 40,000 and 20,000 years ago, the intensity changed from 3.2 to 12.0 x 10^{22} Ampere x meters^2. This equals 12.0-3.2 = +8.8 x 10^{22} Ampere x meters2 in 20,000 years. By comparison, after the last reversal between 780,000 and 760,000 years ago, the change was 6.5 – 0.5 = +6.0 x 10^{22} Ampere x meters^2 in 20,000 years.

7. Inquiry Problem: Do you think the magnetic strength will actually reach zero? Explain your reasoning.

   Answer: From the above data, students might conclude that the field has increased and decreased in strength many times, and only rarely reaching near-zero conditions. It may simply continue to decline for a few centuries, and then begin to increase again as it has done before. However, the last time it changed as rapidly as it has in the last 40,000 years, was during the last reversal — 780,000 years ago!