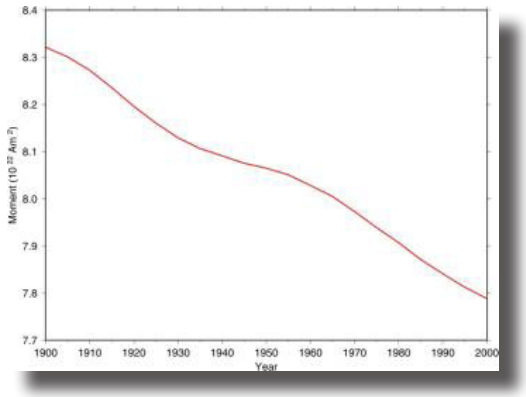
Activity 7 - The Declining Magnetic Field

TEACHER'S GUIDE

GOALS

1) Students will analyze how the strength of Earth's magnetic field is declining.
2) Students will predict what effects would take place if Earth's magnetic field vanished temporarily.



Measurements have been made of the Earth's magnetic field more or less continuously since about 1840. If we look at the trend in the strength of the magnetic field over this time (for example the so-called dipole moment shown in the graph) we can see a downward trend. Indeed projecting this forward in time would suggest zero dipole moment in about 1500-1600 years time. (Figure from http://www.geomag.bgs.ac.uk/reversals.html)

PROCEDURE

In this activity, students will analyze a plot of the most recent field measurements to estimate how long it will take Earth's field to decline to zero strength and perhaps trigger the next magnetic reversal. The units are in multiples of 10^{22} Ampere x meters^2.

Note: This activity has students calculate the slope of the curve on a data plot. Review the definition of the slope of a line. Also make sure the students understand that the numerical value for a slope has mixed units (e.g., miles per hour).

The slope of a line that extends from Point A to Point B is defined as the difference between the vertical axis value at Point B minus the value at Point A - divided by the difference in the horizontal axis value at Point B and Point A.

$$\text{Slope} = \frac{Vb - Va}{Hb - Ha}$$ where 'V' is the vertical axis and 'H' is the horizontal axis

Students will need to select two points on the curve and determine their difference in magnetic field strength, B, and their difference in Years. This will require using a ruler and interpolating data values on the vertical or horizontal axis. It is easiest of they select two years such as '1900' and '2000' and determine the values for B in each case. Then divide the difference in the B values by 100 years to get the slope.

TEACHER ANSWER KEY

Question 1 – By how much has the field changed in intensity between 1900 and 2000?
Answer – From about 8.32 to 7.79, which is a difference of – 0.53. This also equals (0.53/8.32) x 100% = 6.4% decline from its initial value in 1900.

Question 2 – What has been the magnetic field's rate of change per year in terms of its percentage per year?
Answer – The decline was 0.53 units in 100 years or 0.0053 units per year. In terms of percentage, this is a change of 6.4% in a century or 0.064% per year.

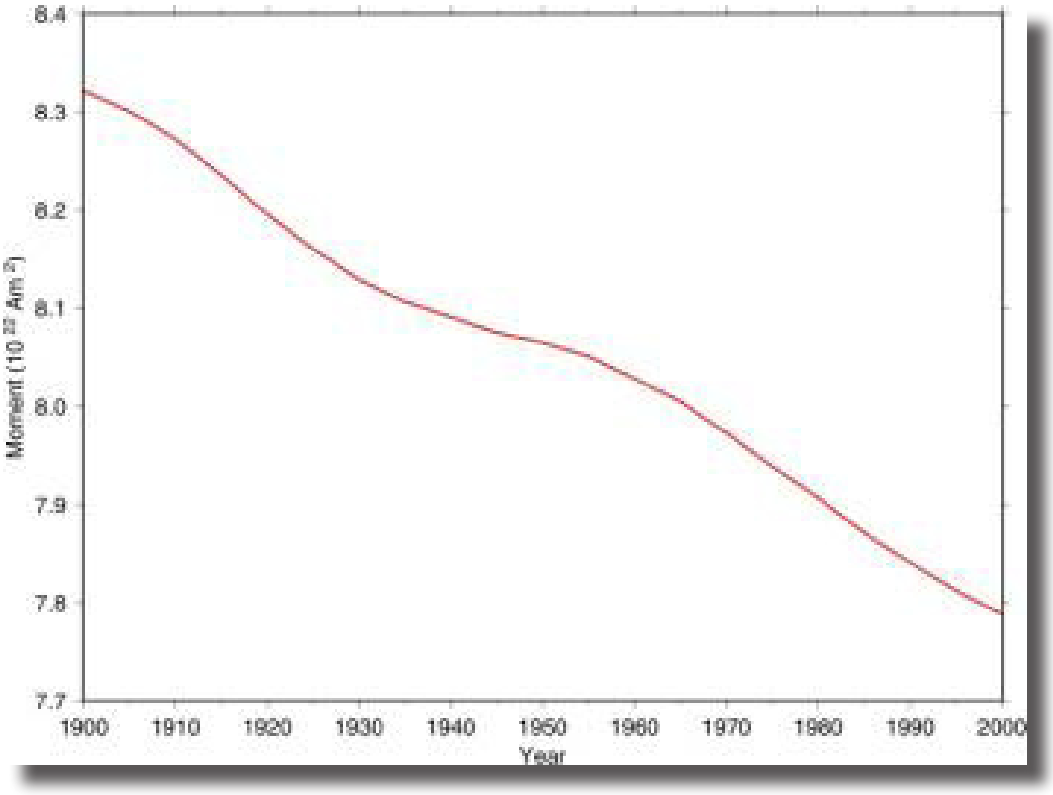
Question 3 – Based on your answer to Question 2, how many years from now will it take for the field to decrease to zero strength?
Answer – It has to decline by another 7.79 units, and at a rate of 0.0053 units per year, it will take (7.79/0.0053) = 1469 years. Students may also replot this graph and by using a ruler, extend the line from 1900-2000 to 1469 years in the future in a "linear extrapolation."

Question 4 – What year will it be when the field reaches zero strength?
Answer – 2000 + 1469 = 3469 AD.

Inquiry Problem – What effects do you think will happen when Earth's field vanishes temporarily for a few decades or centuries?
Answer – No more spectacular Northern Lights. No more magnetic storms. Higher levels of cosmic rays entering atmosphere. Solar wind may penetrate to upper atmosphere and cause additional heating. Some animals may experience navigation problems. No one will die and the rotational poles remain intact.

Student Name _____ *Date* _____

The Declining Magnetic Field



Earth's magnetic field is declining in strength. Some scientists think that it may actually vanish in the near future, and be replaced by a growing magnetic field with an opposite magnetic polarity – a phenomenon called a Magnetic Reversal. The above graph shows the measured strength of Earth's magnetic field since 1900, measured in multiples of 10^{22} Ampere x meters^2.

Question 1 – By how much has the field changed in intensity between 1900 and 2000?

Question 2 – What has been the rate of this change per year, in terms of its percentage change per year?

Question 3 – Based on your answer to Question 2, how many years from now will it take for the field to decrease to zero strength?

Question 4 – What will be the year when the field reaches zero strength?

Inquiry Problem – What effects do you think will happen when Earth's magnetic field vanishes temporarily for a few decades or centuries? Support your conjecture with evidence from relevant information sources.