Activity 38: A Magnet as a Magnetometer

Maine Geological Survey

Objectives:

To make the student aware of the nature and significance of the earth's magnetic field. To show how local fluctuations in this field can be used to locate underground materials having magnetic properties.

Time:

This preliminary discussion for this activity will take 15 minutes and the activity will take 40-50 minutes.

Background:

The magnetometer is an instrument which measures the strength of the earth's magnetic field. This magnetic field is not uniform, but varies from place to place around the earth.

In one type of magnetometer, the proton magnetometer, an electric current is applied to a coil around a bottle containing a fluid such as kerosene. The electric field produced in this coil realigns the protons in the fluid. When the electric current is shut off, the spinning protons again realign to line up with the earth's magnetic field. In so doing, they generate a signal which is proportional to the strength of the immediate (local) magnetic field. This signal is amplified electronically and measured by the use of counter circuits. The reading then appears on the digital display of the instrument.

Once the magnetometer is adjusted for the area where it is to be used, it becomes an instrument for detecting many buried features which affect local magnetism. Because compaction concentrates magnetic particles in the soil, the magnetometer will indicate ancient roads and dwelling places. Since heating magnetizes clay particles used in brick making, walls of long buried buildings can be located. Since rocks are more compact than soil, making them more magnetic, the magnetometer can detect the walls of long forgotten cities now buried. Certain ore deposits are readily found with this instrument. It is the basis of the military mine detector.

The magnetometer is currently being used to detect buried drums which may contain hazardous waste materials. Because these drums are made of steel, they have magnetic properties to which the magnetometer is sensitive.

Magnetometers measure magnetism in units called gammas. In Maine, the earth's magnetic field is normally 55,000 gammas. When this number is discounted, any change in magnetometer readings is due to local effects, that is, objects or formations which have magnetic characteristics.

Materials:

Students should work in groups; each group will need the following:

- A large flat plastic container several inches deep and at least 2 feet long
- Loose filler material such as dry beach sand or sawdust
- Iron object(s) at least 4 ounces in weight
- A spring scale sensitive to .5 ounces
- Suspension apparatus (movable rack, see Appendix E for sample row and station assembly)
- A horseshoe or similar magnet capable of being held easily by the spring scale
- Toothpicks
- Rulers, pens, and notebooks

Procedure:

Place the solid iron object(s) at random in the container and fill the container with the filler material to a depth sufficient to completely cover the objects.

Have students trace and mark a three-inch grid on the surface of the filler. Use toothpicks to mark the grid points. See line and station sequence on student sheets.

Be certain the students keep the magnet a fixed distance above the filler when they make their readings.

Follow-Up:

After several normal trials, start reducing the size of the objects buried and find the lower limits to the sensitivity of your "magnetometer."

Construct a profile along one of the lines by using the scale readings as one axis and the reading stations as the other axis. Construct profiles for the other lines. Discuss any anomalies and explain why these profiles are so useful.

Have student teams bury objects and have other teams try to find them. The team hiding the objects should try to develop "strategy" so that the hidden objects are not found. All objects must be iron however.

See Activity #39 (Field Use of a Magnetometer).

References:

Activity developed by Herbert Dobbins during the 1991 CREST intern program.

Name____________________________

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Student Sheet

Purpose:

To construct and gain experience in using a simple magnetometer.

Materials:

Plastic tray, loose filler material such as sand, a four-ounce iron object, spring scale, suspension rack, magnet, toothpicks, notebook and pens, rulers.

Procedure:

Your teacher has buried at least one four-ounce iron object in the filler material in the tray. You will construct a grid in the tray using toothpicks for markers. Follow the pattern below (two inches between lines and three inches between stations in the line.

Grid Pattern

Line A	o	o	o	o	o	o
Line B	o	o	o	o	o	o
Line C	o	o	o	o	o	o
	1	2	3	4	5	6

Set the first toothpicks one inch in from the edge of the plastic tray when establishing the first line. Be careful to make your grid very uniform in size and shape.

After your grid is established, hang the magnet from the spring balance away from any metal object, and record the weight of the magnet in the data table. This is your "natural" magnetic field. Now move the magnet down each line stopping at each station. Make sure the magnet and spring are not moving. Observe the weight of the magnet at each station and record this value in your data table. Be certain to keep the magnetometer a fixed distance above the sand.

The number of both lines and stations will depend on the overall size of your box. The above pattern will grid a box 6 inches wide and 16 inches long.

Data and Observations:

1. Record the "natural" weight of your magnet: ___________________________________

2. Record the magnet weight at each toothpick in the data table below.

	1	2	3	4	5	6	7	8	9
A									
B									
C									
D									
E									
F									
G									
H									
I									
J									

Questions:

1. Where do you notice any changes in magnetic pull in the grid?

2. Where do you think the object or objects are located? Draw a sketch if necessary.

3. Devise a plan to more precisely locate the object. Explain the logic of your plan.

4. Execute your plan and record the results.

5. Can you draw any conclusions about the size of the buried object? Explain.

6. Dig when you think you have exactly located the object. Were you correct? If not, explain why.

7. Where would you use an instrument like this in business or industry? Explain.