Following in the Footsteps of Edison, Part 1

Where's the Iron Ore?

Content areas: Technology, Science, History

Grade level(s): 5 through 12

Objective: Students will learn how early prospectors who came to New Jersey used the magnetic properties of magnetite to find hidden deposits of iron ore by observing deflections of a compass needle from its normal orientation. Students will demonstrate that process, either outdoors on the school grounds or in their classrooms.

NGSS/NJ SLS: Students develop proficiency towards the following performance expectations:
2-PS1-1 Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
2-PS1-2 Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
5-PS1-3 Make observations and measurements to identify materials based on their properties.
4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.
MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

Background Information for the Teacher:
New Jersey over time had more than 450 iron mines, the majority of them magnetite mines, plus more than 1,000 prospects, mostly found by compass or dip needle. The earliest record of magnetite mining was in 1710 at Mt. Hope in Rockaway, New Jersey. As its name implies, magnetite is magnetic. In a region such as ours, where thick soil and heavy vegetation largely conceal the rocks beneath, the strong magnetism of magnetite proved critical in locating iron ore deposits not exposed at the surface.

The key to detecting buried veins of magnetite was to observe deflections of a compass needle from its normal orientation. A compass normally points north because the Earth has a magnetic field with two poles, one near the northern tip of our planet and another near the southern tip. The magnetic field owes its existence to large amounts of iron in the Earth's core. The magnetic lines of force around the Earth's surface not only align with magnetic north – which enables us to use compasses to navigate – but also, in nearly all places, are inclined. In northern New Jersey they plunge steeply into the ground by about 67^{o}. For this reason the needles on compasses, which must swing freely around a vertical pivot to always point toward magnetic north, are weighted on the south (nonmagnetized) end to keep the needle horizontal. If, however, a magnetized needle is mounted on a *horizontal* pivot, so it is free to swing from horizontal to vertical, it will remain at an inclination of about 67^{o} until one approaches some strongly magnetic object. Such a device is called a *dip needle*, and it proved quite effective in locating many dozens of New Jersey iron deposits.

The general method was simplicity itself. From experience the early prospectors knew that rock units in our area trend northeast, so the iron-ore deposits are elongated in that direction. Thus, they set up traverse lines oriented north*west* and simply walked along the lines in sequence, recording the inclination of the dip needle as they went. As a hidden vein of magnetite was approached the needle would be deflected, and it would point almost straight down if one stood directly above the vein. By pacing distances along traverse lines and taking dip needle readings along the way, prospectors discovered many magnetite deposits and delineated their general thickness and lateral extent simply by walking through the woods. This activity duplicates that experience for students, scaling it down to a small area so the process can be completed in one-half hour or less. We substitute compasses for dip needles in the belief that most schools will have compasses readily available.

Advance preparation:

Note: This exercise is designed as an outdoor activity and requires some advance preparation as discussed below. However, a simple tabletop activity for indoor use can be set up with much less fuss. See the section on Alternate Activity on p. 3.

1. <u>Select a magnetic source</u>. A cast iron pipe about 8-12 ft long is ideal in that it is highly magnetic and linear, and thus a good stand-in for a magnetite vein. Be sure to check the magnetism of the pipe beforehand, for the composition of the iron or steel has a great effect on the strength of its magnetism. For example, when we compared a 5” cast iron pipe to a thick-walled fire hydrant and intake pipe, we found the cast iron pipe, though far less massive, to be much more magnetic. Whatever you choose to use, make sure that it strongly deflects a compass needle held at waist level when you stand above or just to one side of it.
2. <u>Select your “exploration area”</u>. Any relatively flat, open area will do, as long as it is far enough away from other sources of magnetism (fences, electrical lines) to not interfere with the activity. A grassy field is ideal.
3. <u>Bury the pipe</u>. A shallow depth of burial, one foot or less, will provide the best results. Before refilling the trench where you’ve buried the pipe, make sure you note its location so you can find it again. Record also the direction of its long axis. If possible, align the pipe in a northeast direction, the same as the trend of the iron deposits in our region.
4. <u>Lay out traverse lines</u>. The traverse lines should be roughly perpendicular to the long axis of the pipe. One traverse line should pass directly over the midpoint of the pipe to ensure maximum deflection of the compass needle in that area. For our activity we used five lines, each 70 ft long and spaced 10 ft apart, to give a rectangular “exploration area” measuring 70 x 40 ft, but the dimensions are not critical and can be modified to suit your needs. It is best if the pipe is not located near the exact center of the exploration area so students don’t suspect beforehand where the “magnetite vein” can be found.

Time Required: One class period.

Materials Needed: Enough compasses, pencils, clipboards, and data sheets (p. 4) for each team of three students.

Teaching the Lesson:

1. Divide the students into teams of three and give each team a compass, a data sheet (p. 4), a clipboard, and a pencil to record their readings.
2. Each team should select one person to pace off distances. The stride length will vary from one student to another, but for any given student will be nearly constant. It doesn't matter what the stride length is – it matters only that the readings along any given traverse line be taken at roughly equal intervals. A second student will serve as a data recorder and the third as a visual target, as explained below.
3. Have the pacer and recorder of each team stand at the beginning of a traverse line, with their respective target students at the other end.
4. Tell the pacer students to point their compasses directly at the target students and take a compass reading. Record this reading on the data sheet. Then have the students move one pace forward and take another reading, then another, and so on until they reach the end of the first traverse line. The teams then switch to another traverse line and repeat the process until each team has walked all the traverse lines.
   Hint: To avoid confusion it is best if the lines are walked in a consistent direction, either SE to NW or the converse. This makes visualization of the process much easier and recording of the results more straightforward.
5. Ask each team to inspect their data sheets and stand where they think the "magnetite vein" to be. Appraise and discuss the results.

Assessment:

● Students demonstrated understanding that compass needles always point toward magnetic north unless a nearby mass of magnetic material disturbs the local magnetic lines of force.
● Students understand that the deflection of a compass needle or a dip needle was the key to finding hidden veins of iron ore.
● Students understand that this technique was useful in northern New Jersey, where many iron deposits are rich in magnetite, but cannot be used to find deposits of other metals whose ores are weakly magnetic or nonmagnetic.

Alternate Activity: A tabletop model of this activity can be made for classroom use, if desired. For this activity you will need 2-3 gallons of clean sand or kitty litter, a short length (6"-8") of magnetic iron pipe (gas pipe is ideal), and a large, shallow tray. Note that the tray itself cannot be magnetic, so choose one made of aluminum (such as a turkey baking tray), plastic, or wood. Place the tray on a table, put the pipe at an oblique angle toward one end of the tray, and pour the sand into the tray to a uniform depth. Students can then move compasses over the tray a few inches above the sand to find the "magnetite vein."

Related Activities:

● A nearly identical activity could be run in the context of locating a leaking underground storage tank or barrels of discarded chemicals at an industrial site. Land cleanup and reclamation specialists commonly use the magnetism of steel containers to locate pollution sources.
● Although magnetite is one of the few minerals that is so strongly magnetic that it easily deflects a compass needle, many other minerals are magnetic to some slight degree, particularly metallic ones. This comes in handy when prospecting for ore deposits. A common method is to mount a sensitive magnetometer to an airplane and perform an *aeromagnetic survey*. The

magnetic "highs" are the places to drill. The U.S. Geological Survey has long published a series of aeromagnetic maps for selected areas, and many exploration firms employ the same technique.

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Author: Earl R. Verbeek, Ph.D.

Dr. Verbeek worked for 20 years as a research geologist with the U.S. Geological Survey in Denver, Colorado and is now Resident Geologist and Curator at the Sterling Hill Mining Museum.