MAGNETISM

Most people are fascinated by the invisible, mysterious force we call *magnetism*. The experience of moving iron filings around on a piece of paper with a magnet beneath is not soon forgotten, nor memory of how the filings arrange themselves along observable lines of force. Magnetism, was a property first discovered in certain minerals, later came into use for such diverse purposes as navigation, ore processing, and the generation of electricity.

A large number of minerals are magnetic, although for many it takes a laboratory instrument to detect this. The magnetism of certain minerals can be detected easily. *Magnetite*, as its name suggests, offers a fine demonstration of magnetism in minerals. The variety of magnetite called *lodestone* is so strongly magnetic that a chain of four or five nails can be suspended from it. Other magnetic minerals include ilmenite, pyrrhotite, and franklinite. These are generally capable of moving a magnet suspended from a string, but not so strongly magnetic that a magnet will stick to them.

Activities

Make a compass

The first compasses used in navigation were made from lodestone. Use a small hammer and chisel to chip off a small piece of magnetite. Glue this to a circular piece of cut cork from a wine bottle, and then float the cork in water. Wait a few moments for the cork to stop rotating in the water. Use another compass to determine the direction of north, and with a marker place a dot marking this direction on the cork.

If you have the class make several such compasses and float them all in separate tubs, you will see that the compasses all align themselves in the same direction. For best results you may wish to take the containers outside, because large masses of structural iron or electrical circuits can disturb or overwhelm the natural magnetic field. For similar reasons the individual compasses must not be placed too close together, for then they will attract each other rather than align with the Earth's magnetic field.

Determine which minerals are magnetic

As noted, some minerals are magnetic, and others are not. The strength of their magnetism ranges from feeble to intense. An interesting classroom exercise is to determine which minerals are attracted to a magnet, and try to rank them from weakly to strongly magnetic. A suggested procedure:

- Procure samples of several of the magnetic minerals mentioned, plus a variety of nonmagnetic minerals such as sulfur, calcite, gypsum, quartz, feldspar, etc. Try to obtain samples of roughly equal mass.
- Suspend one or more magnets with string so the magnets rest about six inches or so above the classroom table.
- For each mineral, have students: (a) Write down the name of the mineral; (b) Describe its degree of magnetism in one of three categories: strongly magnetic, moderately magnetic, feebly magnetic, or nonmagnetic; (c) List the mineral's luster as either metallic or nonmetallic.

- Compare results for each specimen. There should be general agreement and lack of such agreement indicates more careful observations are needed.
- Discuss observed relationships between a mineral's luster and its magnetism. The results should indicate that all strongly to moderately magnetic minerals have metallic luster, though the converse is not necessarily true (not all metallic minerals are magnetic; many are not). The results should also indicate that none of the nonmetallic minerals are magnetic.

<u>Separate ore from waste</u>
The differential magnetism of minerals offers one means of separating mixtures of them. On an industrial scale this is how some ore minerals are separated from"waste" minerals in a rock containing both. The rock is first crushed to produce essentially monomineralic grains, and then the grains are moved on a conveyor belt through a strong magnetic field. The magnet will pull out the most magnetic minerals, but the nonmagnetic minerals will pass through unaffected. The minerals are separated into two 'streams' and captured in separate containers, one rich in the ore mineral and one not.

To duplicate this application in a classroom you first have to obtain a mixture of different minerals. (For those of us living in New Jersey, an appropriately complex and ready-made mixture can be obtained by going to the beach and collecting some sand. Look for the dark streaks in the sand and collect at least an liter of the sand.The dark material is the magnetic portion and contains such minerals as magnetite, ilmenite, and zircon. Almost all the rest is quartz.)

What you can do depends largely on the grade level of your class. For young students it is enough to use a standard horseshoe magnet to pull out the magnetite, or stronger magnets to remove more weakly magnetic minerals, such as ilmenite. Nonmagnetic minerals are left behind. The mixture will be separated into three fractions: one rich in iron (magnetite), one in titanium (ilmenite), and one in neither (the residue, which represents the waste material from the mining process). Both magnetite and ilmenite are black minerals with metallic to submetallic luster, and in sand-size grains can be almost impossible to tell apart, so it is interesting to note that the first and second fractions appear almost identical to the eye, yet they are composed of different minerals. Older students can be permitted to develop their own ways of using magnets to separate the minerals

<u>A Bit of Mining History</u>
The inventors of the first practical, industrial-scale magnetic separation methods for treating complex ores were Thomas Alva Edison and John Price Wetherill. During the late 1890's Edison operated a mine on the top of Sparta Mountain in NJ. The ore at Edison's mine consisted of magnetite dispersed throughout a host rock consisting mostly of quartz, feldspar, and amphibole. To concentrate the magnetite, Edison crushed the rock and used powerful electromagnets to separate the magnetite grains away from the rest. His efforts were successful, but within a few years he was put out of the iron-mining business by the discovery of the huge Mesabi iron-ore deposits in Minnesota. Wetherill developed methods that are still in use today.

Adapted from "Magnetism" by Earl Verbeek, Sterling Hill Mining Museum, Ogdensburg, NJ USA