Following in the Footsteps of Edison, Part 2

Getting the Iron Out

Content area: Science, Technology, History

Grade level(s): 5 to 12

Objective: Students will recreate some of the steps involved in recovering valuable metals from the ores that contain them and will become familiar with Thomas Edison's lasting contributions to ore processing technology.

NGSS/NJ SLS: Students develop proficiency towards the following performance expectations:
5-PS1-3 Make observations and measurements to identify materials based on their properties.
3-*5-ETS1-1* Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Background Historical Information for the Teacher:
Most of New Jersey's iron mines exploited veins of magnetite. In some areas the magnetite vein was so thick and pure that the entire mine was *in* the vein, and relatively little waste rock was produced along with the ore. This, however, was exceptional. In most areas the vein was thinner, or there were multiple veins separated by layers of rock, leaving no choice but to mine waste rock along with the ore and separate them by some means before shipping the ore for smelting. Thomas Edison, however, recognized that immense amounts of magnetite weren't in veins at all, but were disseminated as small grains throughout large bodies of rock. This was the type of iron ore that most captured his attention – but how to get the magnetite out of the rock? In this activity, students will start with a rock and end with an ore concentrate, just as Edison did more than a century ago.

Materials Needed:
For each item listed below you will need enough for every four students. The first three items can be obtained at low cost, while supplies last, from the Sterling Hill Mining Museum. Send e-mail to earlrverbeek@gmail.com to inquire.

- Specimens of magnetite (fairly pure)
- Rock sample containing disseminated grains of magnetite
- Crushed magnetite ore (or beach sand containing some magnetite).*

- Magnets (one per every three or four students)
- Large plastic food containers (2-3 quart capacity, to hold crushed iron ore)
- Small plastic food containers or bowls (to hold magnetite separated from the crushed ore)
- Plastic bags (sandwich size)

* Much of the beach sand along the northern New Jersey coastline contains magnetite in the dark layers. The sand along beaches in southern New Jersey contains mostly ilmenite as the principal dark mineral and would not be appropriate for this activity. In any case, if you decide to collect sand from some of the dark layers in New Jersey beach sands, test them with a magnet first before using them for this activity. Alternatively, simply crushing a piece of magnetite to fragments with a hammer and mixing the resultant powder with normal beach sand will work quite well.

Class Management: Divide the students into teams of four, with each team receiving one of each item listed above.

Time: One class period.

Teaching the Lesson:

1. Have students examine the specimens of pure magnetite. Tell students this is the type of iron ore that was exploited in most of northern New Jersey's iron mines. Ask students to note in particular the magnetite's density (it is heavy for its size) and its strong magnetism.

2. Have students examine the specimens of disseminated magnetite ore. Stress that the percentage of magnetite in such a rock is low, but since large tonnages are available it represents an important resource of iron. The ore that Thomas Edison was mining in the Davenport open cut ran about 7% magnetite, meaning that the bulk rock contained about 5% iron by weight. Ask students to verify, with the hand magnet, that magnetite is indeed present in the rock. Students should also note that the rock is much less dense than pure magnetite.

3. Ask students how they would go about getting the magnetite out of the rock. There are several correct answers to this (melting the rock, chemical extraction, crushing followed by density separation, etc.), but the most direct means is to crush the rock and use magnets to remove the magnetite from the other minerals. Keep taking suggestions until this method is mentioned. Remind them of the mineral's name, *magnetite*, if they're not "getting it."

4. How finely should the rock be crushed? Answer: It depends on the grain size of the rock, but the rock should be crushed into particles *smaller than the average diameter of the mineral grains in the rock,* so each particle will be essentially monomineralic.

5. Place magnets into plastic bags and have the students stir the crushed ore with the magnet until a goodly portion of magnetite is adhering to the magnet. Bring the magnet over to a collection container, hold the bag, and remove the magnet from it, allowing the magnetite to drop into the container. Repeat until a small pile of fairly pure magnetite has been collected.

5. Tell students they have now prepared an *ore concentrate,* a product that contains a very much higher percentage of iron than the original rock. If they've done the magnetic separation carefully their concentrate will be 90% or more magnetite by weight, giving a content of iron metal of more than 60%, twelve times more than the original rock. Given that transportation

costs of heavy products like rock are quite high, it pays to generate ore concentrates at or near the mine site before shipping the concentrate for smelting.

6. Tell students they have essentially duplicated the process that Edison used on an industrial scale to process the low-grade iron ore he was mining. For Edison's process to work he had to invent equipment to crush rock on a scale never before attempted, and he had to build electromagnets to separate the magnetite from the nonmagnetic minerals (feldspar, quartz, and biotite) that composed the rest of the rock. Information on the equipment used, with illustrations of the massive rock crushers, appears in Rodney P. Johnson's 2004 book, *Thomas Edison's "Ogden Baby."* Two illustrations of Edison's operations appear on pages 4 and 5 of this lesson.

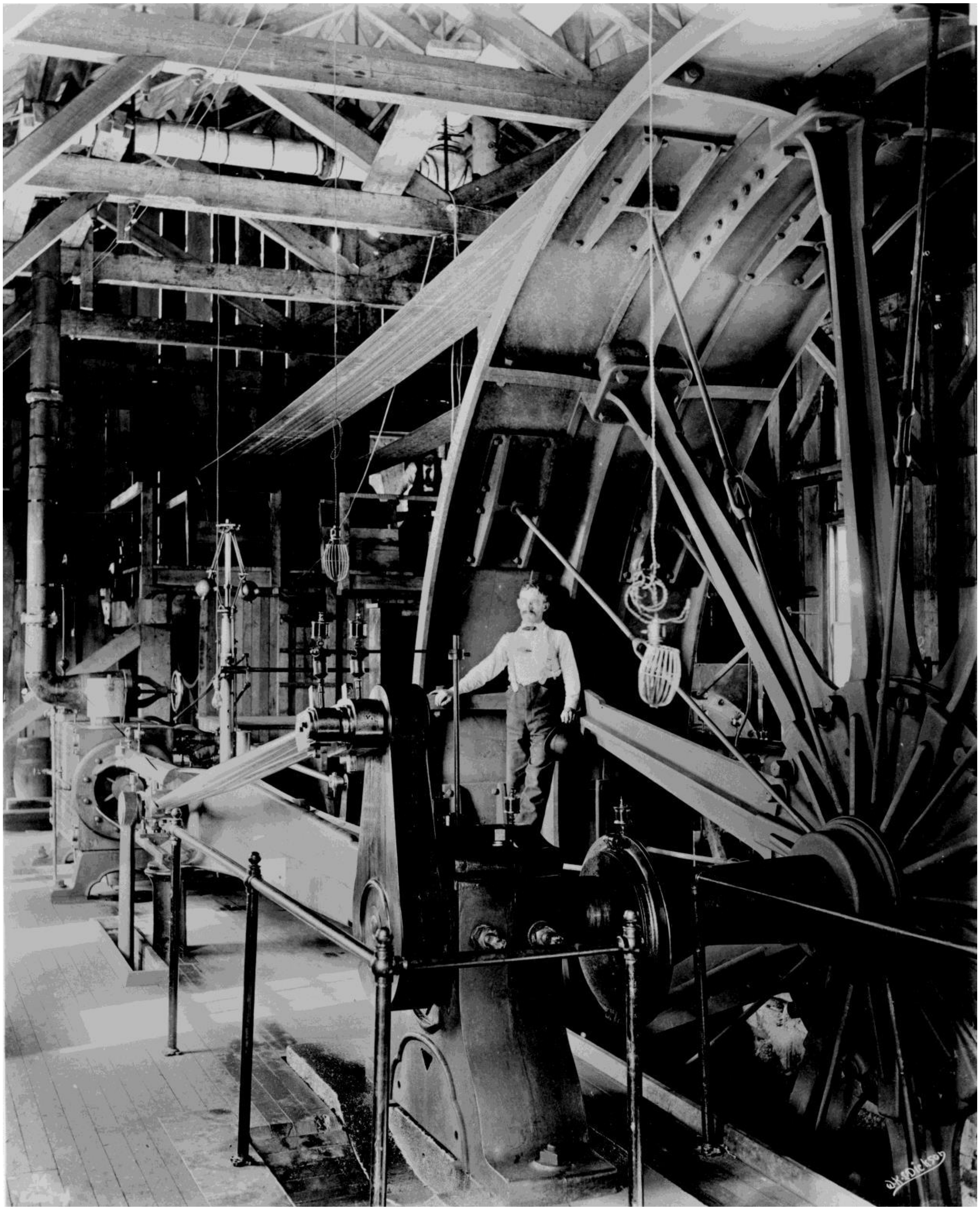
Note to teachers: After completion of this activity, combine and save the magnetite concentrates that the students prepared. The concentrates will be needed for Part 3 of this activity set.

Assessment:
● Students demonstrated understanding that some types of metal ores require multiple processing steps before metals can be extracted from them.
● Students understand that magnetism is more than a curiosity but is put to use in myriad ways, Edison's electromagnets being just one example.
● Students understand the historical context of Edison's work and realize that he had to invent new methods and new equipment, and make them work on an industrial scale, for his process to be successful.

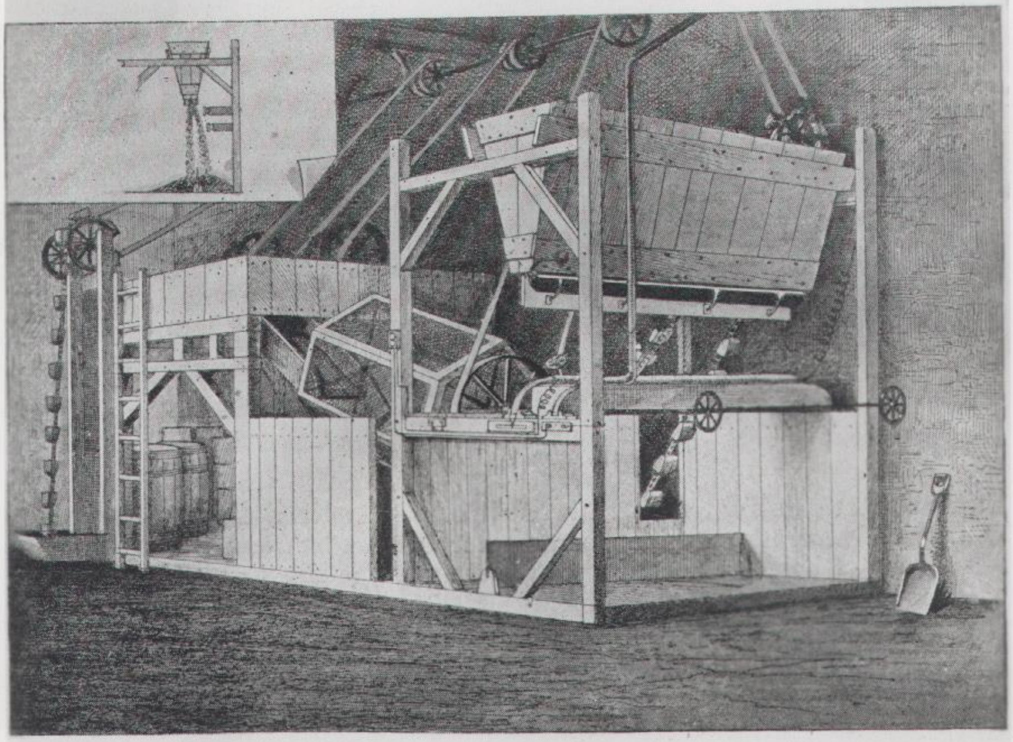
- End -

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.



Corliss engine used to power the giant crushing rolls at Edison’s concentrating works.



THE EDISON PRIMARY MAGNETIC ORE SEPARATOR.