89.215 - FORENSIC GEOLOGY
USING MINERALOGY TO IDENTIFY THE SOURCE OF A SAMPLE

I. Introduction

We have previously used sand size-distributions to try and determine the location of a crime. However, similar sedimentary environments, for example low-energy beaches, will yield similar size-distributions. A second piece of evidence we can use to determine the location is the mineralogy of the sand. Many, but importantly not all (for example the carbonate and basalt sand beaches of Hawaii), beach sands are largely composed of quartz. However minor, so-called heavy, minerals may differ from beach to beach. The heavy minerals found in beach sands are largely determined by the types of rocks that are being weathered. The weathered material is transported by streams to the ocean and the sediments are then deposited on the beaches. For example, if the rocks that were being eroded contained garnet, a heavy mineral that is resistant to erosion, this mineral would be found in the beach sands.

In this exercise we will separate heavy minerals, using their magnetic properties, from several sands. We will then use a binocular microscope to identify the heavy minerals in the sands. By comparing the heavy mineral suite in the sands to that of the crime scene material, we will hopefully be able to determine where the crime took place.

II. Magnetic Separation

Magnetic separation of mineral particles depends on the magnetic susceptibility of the minerals to be separated. This is a complex phenomenon which is a function of chemical composition, especially minor amounts of iron or manganese, and atomic-lattice structure.

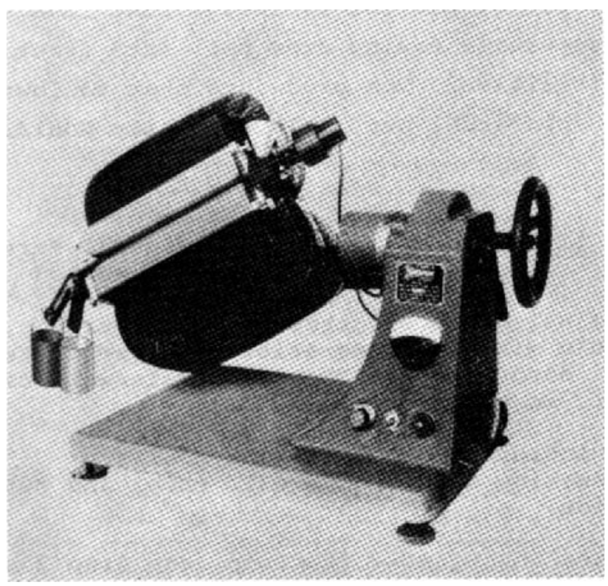

Figure 1. Frantz Isodynamic Magnetic Separator (inclined position)

The simplest form of magnetic separation is by hand magnet, a procedure which works for only one common mineral - magnetite. Other minerals having magnetic susceptibility are separated by using an apparatus that can generate strong electromagnetic fields. The Frantz separator (Fig. 1) incorporates an electromagnet with two elongate pole pieces arranged so that the space between the poles is much wider on one side than the other. A vibrating metal chute parallels the pole pieces. Mineral particles are introduced into the upper end of the chute and slide toward the lower end. Those with higher magnetic susceptibility move toward the side of the chute where the pole gap is narrow and the magnetic flux the greatest. The separator is mounted so that it can be rotated both in the direction of grain movement (slope) and in a direction normal to the direction of grain movement (tilt). The way in which mineral particles separate as they move along the length of the chute depends on (1) the tilt of the chute, (2) the amperage applied to he electromagnet and, to some extent, (3) the slope and rate of feed to the chute. At the lower end of the chute the particles are separated into two streams, one consisting of grains of higher susceptibility than that corresponding to the amperage setting used, the other consisting of grains of lower susceptibility.

Inasmuch as there is wide variation in magnetic susceptibility of mineral particles of a given species, it is common practice to set the Frantz separator slope at 10 to 30° (20° is more or less standard), the tilt at 5 to 20° (5° for minerals of low susceptibility, 15° for those of moderate to high susceptibility) and to then determine the most effective amperage by trial and error.

Separation of Heavy-Mineral Particles by the Magnetic-Susceptibility Method

1. Before using the electromagnetic separator, remove ferromagnetic minerals (magnetite and pyrrhotite) from the sample with a hand magnet. These minerals will clog the apparatus if left in the sample.

2. Using a side slope of 20° and a tilt of 25°, run the sample at a setting of 0.4 amperes. Label and retain the magnetic fraction.

3. Take the nonmagnetic fraction from Step 2 and run it at a setting of 0.8 amperes. Label and retain the magnetic fraction.

4. Take the nonmagnetic fraction from Step 3 and run it at a setting of 1.5 amperes. Label and retain the magnetic fraction and the nonmagnetic fraction.

5. Refer to Table 1 for a listing of those heavy minerals which are magnetic at 0.4, 0.8, and 1.5 amperes.

Table 1. Minerals that are Magnetic at Various Amperages Using a Side Slope of 20^0 and a Tilt of 25^0

Magnetic at 0.4	Magnetic at 0.8	Magnetic at 1.5	Nonmagnetic at 1.5
Garnet	Biotite	Muscovite	Zircon
Ilmenite	Hornblende	Spinel	Rutile
Chromite	Hypersthene	Enstatite	Titanite
Chloritoid	Augite	Tourmaline	Leucoxene
Olivine	Actinolite	Clinozoisite	Apatite
	Staurolite	Diopside	Corundum
	Epidote	Tremolite	Barite
	Chlorite		Fluorite
			Sillimanite
			Kyanite

III. Identification

1. Using a binocular microscope, for each magnetic fraction separate the grains into various groups. You can use a needle to push the grains around. Each group should consist of grains that you think represent the same mineral.

2. Use Table 2 to assign a mineral name to each group. The properties that are most easily recognized under the binocular microscope are color, luster, and shape. You will not be able to name all the groups because Table 2 only lists the minerals that might be of most use for our investigation.

3. For each magnetic fraction estimate the percent of each mineral group.

4. Compare the crime scene sample to the comparative samples. This comparison should be done by comparing the minerals and their relative percentages in each magnetic fraction of the comparative samples to those of the crime scene sample. Which comparative sample provides a best match with the crime scene sample?

5. Your final report will consist of a brief write-up of the experimental procedure, a table (Table 3) showing the relative mineral proportions in each magnetic fraction for the comparative samples and crime scene sample, and your conclusions about the location of the crime. As always, give this write-up careful thought because you will have to defend your conclusions during a hostile cross-examination.

Table 2. Physical Properties for Selected Heavy Minerals

Mineral	Shape	Color	Luster	Other
Magnetite	Cube, dodecahedra	Bluish black	Metallic	Angular and well rounded. Strongly magnetic
Ilmenite	Tabular	Brownish to purplish black	Metallic	Nonmagnetic
Pyrite	Cubes and pyritohedra	Pale brass-yellow	Metallic	May occur as globular to irregular aggregates
Hematite	Hexagon or rhombic shape	Indian red to black	Metallic to earthy	
Limonite	Amorphous	Ochre yellow, brown to brownish black	Earthy to metallic	Occur as rounded granules or as powdery aggregates and coatings
Tourmaline	Prismatic	Yellow-brown, dark brown, indigo to black		Particles occur as elongate prisms
Rutile	Tetragonal	Yellow, reddish brown, red	Adamantine	Particles irregular, generally elongate

Mineral	Shape	Color	Luster	Other
Hornblende	Long, blade-like prisms; two cleavages at 60 and 120	Dark brown and green to black	Satiny, glassy, pearly	Particles elongate, prismatic
Augite	Prismatic; two cleavages at 90	Pale brown gray or pale grayish green	Vitreous	Particles usually elongate. Cleavage distinguishes augite from hornblende
Garnet	Cubic, dodecahedra	Colorless, pale pink, orange, red, apricot-yellow	Glassy	Crystal shape, color, conchoidal fracture key features
Epidote	Monoclinic	Pale greenish yellow to lemon yellow	Glassy to dull	Particles are greenish yellow, equidimensional, sharply angular to subrounded
Sillimanite	Prismatic	Colorless	Vitreous	Particles are irregular to short prismatic
Andalusite	Square prisms	Colorless to pink	Dull to vitreous	Particles are elongate worn or broken prisms to irregular in shape. Show only conchoidal fracture
Staurolite	Short prisms	Yellow, gold, brown	When altered dull to earthy. When fresh, resinous to vitreous	Particles irregular, somewhat platy.

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Minerals and Percentage of Each Mineral

	Comparative Sample A	Comparative Sample B	Crime Scene Sample
Magnetic at 0.4			
Magnetic at 0.8			
Magnetic at 1.5			
Nonmagnetic at 1.5			