Geologic Material as Physical Evidence

By JOSEPH A. FINLEY, Jr., Ph.D.

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Whenever two objects come into contact, there always is a transfer of material. The methods of detection may not be sensitive enough to demonstrate this, or the decay rate may be so rapid that all evidence of transfer has vanished after a given time. Nonetheless, the transfer has taken place.[1]

The field of geology and its relationship to forensic science has remained shrouded in mystery for many years. Although the interaction of humans with the environment long has been the object of much interest to physical scientists, published literature on this topic is relatively limited.

Geologic material, commonly used as physical evidence in both criminal and civil cases, can play an important role in forensic science. Geologic material, as with all physical evidence, contributes scientific support that can assist in establishing the guilt or innocence of an individual. In general, the usefulness of geologic material as physical evidence depends on the number of significant variations in the material and the ability to compare and contrast these variations. The inorganic nature of geologic material can make qualitative identification relatively straightforward. Combined with the scientific objectivity of the analysis and testimony of the expert witness, geologic material has a great advantage as physical evidence. To this effect, investigators must ensure that they use proper collection and preservation techniques for processing and analyzing various materials.

SOIL

Today, most major crime laboratories throughout the world, both public and private, study soils. The FBI was one of the first forensic laboratories in the United States to extensively use soil and mineral analysis in criminal cases.[2] As early as 1935, the FBI Laboratory worked with soils; by early 1939, heavy mineral separations and mineral identifications were standard practices for the FBI Laboratory in soil cases.[3]

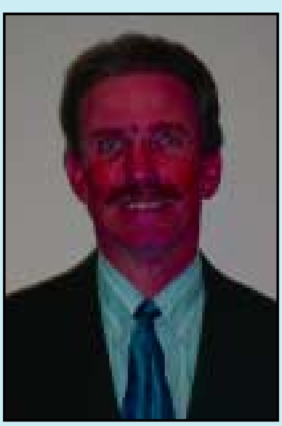
Formation

Soil material generally is formed by nature in one of two ways, residual or transported. This loose material (soil) is composed of fragments of minerals and rocks generated from the breaking up or dissolving of the earth's solid rocks. Residual soil material forms in places where solid rock is exposed in outcrops at the earth's surface. This solid rock endures the natural weathering processes, which, over time, break up and dissolve the rock. This procedure turns the outcrop into a mass of fragments and removes some of the material in solution (dissolving of the minerals normally occurs in rain or groundwater).

Transported soil materials occur where fragments of minerals are produced elsewhere and transported to the location where they are found. Fragments of rocks and minerals created by the weathering of a rock outcrop may be carried away by rivers and deposited as sandbars, gravel, or fine mud. Wind can move vast quantities of fragments great distances, depositing them as dunes and dust layers. Wave and current actions break down rock and mineral formations along shores of seas and lakes, transporting this material and depositing it as beaches or undersea sediment. The force of gravity may cause landslides and move tons of material down a slope, thereby producing a mass of newly transported soil on the land below.

Composition

Characteristically, soil is a very complex system composed of certain quantities of solid, liquid, and gaseous materials. The unconsolidated mineral matter on the earth's surface has been subjected to and influenced by genetic and environmental factors, such as parent materials, climate (including moisture and temperature effects), macro- and microorganisms, and topography. Over a period of time, these factors produce a product (soil) that differs from the material from which it derived in many physical, chemical, biological, and morphological properties and characteristics.[4]



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Special Agent Finley, formerly an expert witness in the Mineralogy Unit, FBI Laboratory Division, now serves in the FBI's Miami, Florida, office.

The important distinction in a forensic definition of soil appears in the sampling of earth material, either accidentally or deliberately. For forensic purposes, the definition of soil is earth material collected accidentally or deliberately and associated with a matter under investigation. In general, the usefulness of most types of physical evidence, recognizing that probability and chance are most important, depends on the number of significant variations easily observed and measured in the material; specifically, how many different kinds of classes can exist and how widespread each class is. The value of soils, rock, minerals, and fossils lies in the fact that many variations and possibilities exist. Any process that aids in generating a uniquely identifiable material determines the value and type of examinations that will prove most useful. These processes constitute the keys to a meaningful soil comparison from which the forensic scientist can draw valid conclusions.

Soils pass through a cycle of development involving youth, maturity, and old age.[5] Based upon this readily accepted concept of soil alteration, the comparison of soil by color, texture, and mineral composition is justified. Color is one of the most important identifying characteristics of minerals—virtually all possible colors of the visible light spectrum occur. With most geologic materials and soils, the native minerals contribute directly to the soil color, as well as organic matter present.

Soil structure, an arrangement of the soil particles, can be recorded descriptively. Some soils, particularly loose sands, consist of a structureless mass, whereas most soils tend to cluster together to form compound structures. Particle sizes of soil minerals are classified as sand, silt, and clay (based on a physical measurement). A wide range of textural (particle) size exists in soil, depending upon the rocks from which it derived and the processes by which the soil has accumulated.[6] Soils are coarse- or fine-grained.

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Soil structure constitutes one of the most important soil properties, but forensic scientists must approach it carefully due to the inherently smaller sample sizes. In most soil samples, mineral composition is the constituent material that relates directly to the ability to compare it by using a microscope. The importance of mineral composition is apparent in soil because minerals can comprise approximately 45 percent of an entire sample.[7] Geologists use various methods to positively identify the sample. The soil examination associates or disassociates a “known” sample from a “questioned” sample. Some techniques used to make this comparison may destroy the sample; therefore, appropriate personnel should use them accordingly.

Because forensic geologists must be aware of the context and source of the samples examined, investigators should ensure that they remove earth material from clothing, vehicles, or other sources with extreme care, ensuring preservation of the original sample. Specifically, investigators should pay close attention to layering and lumps of materials.[8]

Evidence value rests upon the fact that soil varies from point to point on the surface, as well as below the earth’s surface. For depth of the sample, investigators should note the approximate depth of their own footprints in the soil at the scene. Investigators should take numerous samples at the immediate scene radiating outward from the center and also an “alibi” sample away from the immediate scene. This type of sampling will allow

Examining Geologic Evidence

The stereobinocular microscope helps identify the various minerals and mineral sites present in a sample. The widefield, low-power stereobinocular microscope gives an erect, three-dimensional image that makes it ideal for manipulating a sample. Minerals also have different densities, an identifiable property. Normally, these differences are divided into two groups of “heavy minerals” and “light minerals” with the boundary drawn at approximately 2.9 grams/cc.

Additionally, forensic geologists use a polarizing or petrographic microscope to positively identify the sample. This differs from the stereobinocular microscope in that it has filters for polarizing the light and rotating the state and attachments for viewing the characteristic effects on light that has passed through minerals. Minerals, especially small-sized ones, commonly are identified using x-ray diffraction and spectrographic techniques. Other instruments of value to the forensic geologist exist, particularly the scanning electron microscope and the electron microscope. With these instruments, geologists can examine extremely small mineral particles using magnification in excess of 100,000 times. Where applicable, pH-size particle determination and elemental analysis may be used in conjunction with color, texture, and mineral composition.

the forensic geologist to see any variation. If sample variations are wet or moist, investigators should air-dry them before placing them in a vial or similar container to prevent biological activity from continuing and to avert any breakdown of the sample. The amount of sample required for analysis depends on the type of examination conducted; however, most analyses require approximately 1 cup of soil. If considerable gravel or other coarse material is present, investigators should increase the size of the sample. They can make the first determination of the soil’s color at the scene, for example, and the color of the soil on a suspect’s clothing. They should ensure that the soil is dry when packaged and limit the possibility of contamination. Only plastic locking bags or glass vials should be used, never envelopes.

BUILDING MATERIALS

Building materials long have been an important part of people’s interaction with and impact upon their environment. Natural materials used to form manmade products that will become part of a structure, dwelling, or similar fixture can be classified as building materials.

When handling building materials, investigators must consider the various types of combinations at a given location. Because building materials commonly are made of mineral materials and represent the combination of a variety of minerals or rocks at a specific time for a certain purpose, they can be highly distinctive. Regional differences in the base aggregates used to produce these materials prove useful to the forensic scientist. Different building materials contain suitable aggregates, such as quartz, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale, and pumice or volcanic scoria, all of which may indicate a particular geographic area.[9]

Building materials can include bricks, cinder and concrete blocks, cement, plaster, ceramics, fiberglass, abrasives, cleaning and face powders, and commercial sands. Each particular type of material lends itself to similar comparative examinations. Most plaster and cement contain rock and mineral particles. Investigators must ensure that these materials are placed in airtight containers and not heated again, as in the initial formation, to prevent the possible conversion of the gypsum back to the plaster, or low-water, form.

Cleaning and face powders commonly have a mineral base or mineral filler. The specific minerals used tend to differ from one product to another, and manufacturers often change the size and composition of minerals through time. Abrasive materials may be natural or artificial—natural materials tend to be more diverse. Further, a wide variety of sands are used for commercial purposes.

The alteration of the environment with building materials can prove important to the forensic scientist who will use various methods to examine building materials broken down into several areas. However, for the forensic scientist to make an accurate determination, investigators should sample all types of material present at the scene. Most cases involving building materials are related to burglaries where someone has broken into a dwelling or structure. Brick, cinder block, fiberglass, and gypsum board most likely would be involved, and investigators should take representative samples of each material. They should package materials in appropriate containers, such as plastic locking containers, to avoid any chance of contamination.

> ***"Soil, building materials, and safe insulation...can benefit law enforcement agencies as evidence in cases."***

SAFE INSULATION

Found between the walls of fire-resistant and burglar-resistant safes and safe cabinets, safe insulation often is soft and very porous and, therefore, can be readily transferred to tools and clothing. Various types of materials are used as safe insulation, including wood chips, gypsum, fiberglass, and asbestos. Many safes made before 1936 contain natural cement as insulation.

Collecting safe insulation at a crime scene is a relatively simple procedure. If the safe is present at the scene, investigators should take samples of all walls because replacement of one or more walls with different safe insulation is common. Investigators should keep the sample dry and intact to prevent destroying any of the unique physical characteristics of the insulation. Additionally, they should ensure that cross-contamination of specimens does not occur. Investigators should leave any questioned material intact on the specimen because removing the insulation may render its value worthless in the forensic examination.

CONCLUSION

Geologic material can prove an invaluable tool as physical evidence in criminal and civil proceedings. The field of forensic geology can expand to contain virtually all inorganic materials used as physical evidence. Soil, building materials, and safe insulation represent just three examples of the numerous types of geologic materials that can benefit law enforcement agencies as evidence in cases.

The usefulness of most types of physical evidence depends on the number of significant differences that exist in the material. Nature has provided geologic materials with large variations and possibilities.[10] Investigators must ensure that they follow appropriate procedures when securing, packaging, and preserving geologic materials. The forensic scientist then can provide an expert opinion to the inference or conclusion drawn from facts determined during the examination of these materials. ✦

Endnotes

[1] The Locard exchange principle, developed by Edmond Locard in 1929, is the basic precept of forensic geology.

[2] R. C. Murray and C. F. Tedrow, *Forensic Geology* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1992), 23-24.

[3] Ibid.

[4] G. D. Smith, et al., "Glossary of Soil Science Terms," *Soil Science Society Proceedings* 26, no. 3(1965): 305-317.

[5] A. K. Lobeck, *Geomorphology: An Introduction to the Study of Landscapes, Soils* (New York, NY: McGraw Hill, 1939).

[6] L. C. Nickolls, "Identification of Stains of a Nonbiological Nature," in F. Lundquist, ed., *Methods of Forensic Science, 1* (New York, NY: Interscience Publications, 1962), 355-362.

[7] Although scientists have identified over 2,000 minerals, only about 20 are commonly found in soils, with the bulk of soil containing only 3 to 5 different minerals.

[8] Two possible types of "known samples" exist: samples collected from the crime scene, or "alibi" location, and samples scientists use as part of their normal professional resources. "Known samples" from scientists' normal professional resources are numerous and varied. Use of these samples for comparison may provide the scientist with a correct identification of the material and, in some cases, the particular area of origin.

[9] American Society for Testing Materials Standards, *Book of ASTM Standards*, 1955, 421-611.

[10] Supra note 2.

Book Review

Law Enforcement Funeral Manual, *by William P. Sanders, Charles C. Thomas, Publisher, Springfield, Illinois, 2001.*

Death is never easy. However, whenever it strikes within a law enforcement agency, it can have long-lasting effects on officers and administrators alike. Therefore, to cope with such a tragedy, it is imperative for an administrator to be prepared. Less than 100 pages long, the *Law Enforcement Funeral Manual* provides sample funeral services, memorials, poems, short readings, and hymns for use under a wide range of circumstances. Containing information gathered by the International Conference of Police Chaplains, the book presents administrators and law enforcement personnel with the tools to help promote healthy healing. In addition, this manual provides services for multiple religious beliefs. Overall, this concise, helpful book compiles components necessary to conduct a thoughtful and appropriate ceremony for a law enforcement funeral.