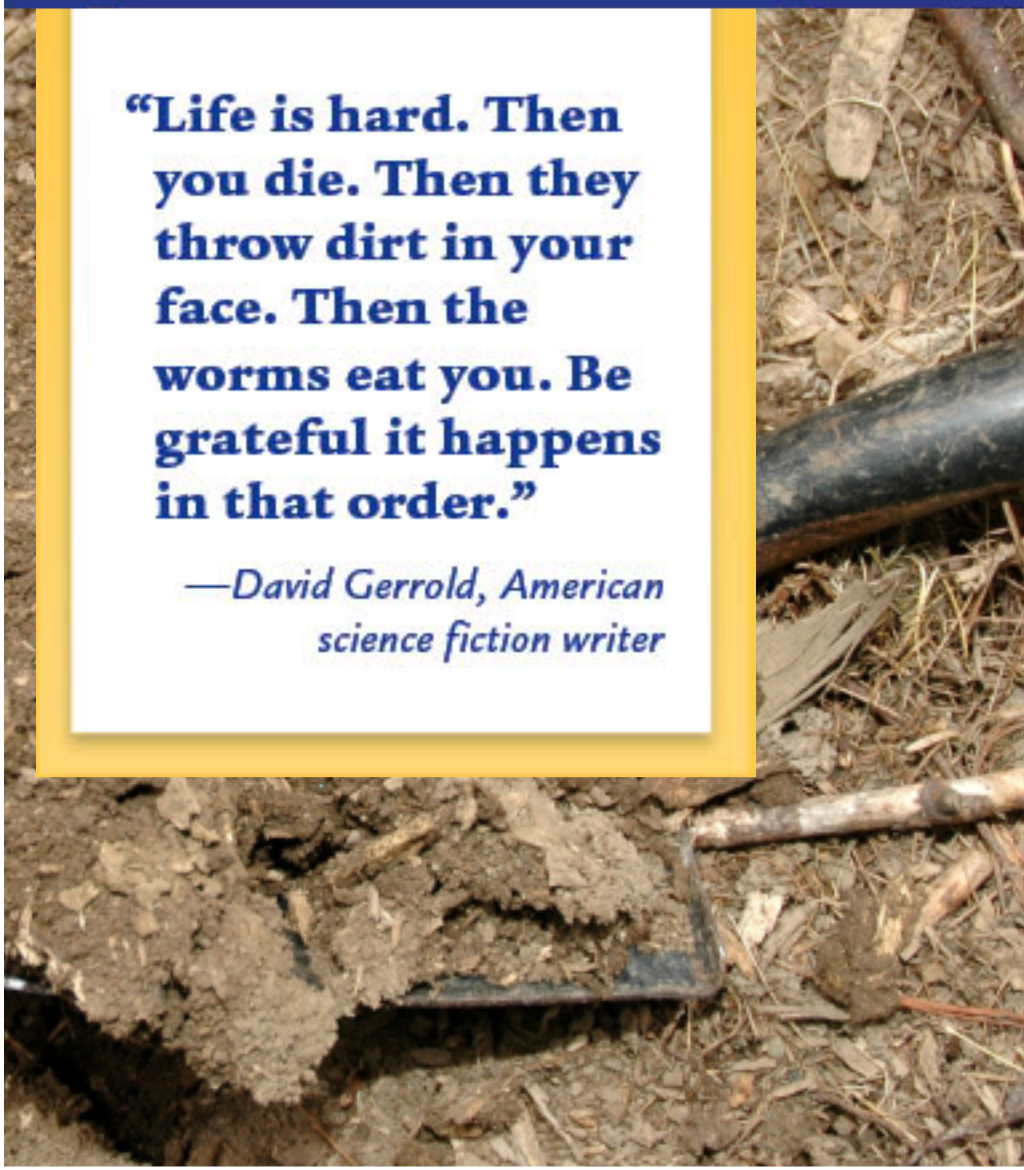
Chapter 10 Soil and Glass Analysis



> "Life is hard. Then you die. Then they throw dirt in your face. Then the worms eat you. Be grateful it happens in that order."
>
> —*David Gerrold, American science fiction writer*

Objectives

You will understand:

How to analyze and present data mathematically using graphs.

Why soils can be used as class evidence.

When soils can be used as circumstantial evidence.

Objectives, *continued*

You will understand:

The difference between physical and chemical properties.

How glass can be used as evidence.

How individual evidence differs from class evidence.

The nature of glass.

How to use the properties of reflection, refraction, and refractive index to classify glass fragments.

Objectives, *continued*

You will be able to:

Identify a soil's common constituents.

Determine the origin of a soil sample.

Interpret a topographic map.

Understand the concept of spectrophotometry and its applications.

Objectives, *continued*

You will be able to:

Make density measurements on very small particles.

Use logic to reconstruct events.

Use technology and mathematics to improve investigations and communications.

Identify questions and concepts that guide scientific investigations.

Forensic Geology

The legal application of earth and soil science

Characterization of earthen materials that have been transferred between objects or locations and the analysis of possible origin or sources

Forensic Geologist Tools

Binocular microscopes

Petrographic microscopes

X-ray diffraction

Scanning electron microscopes

Microchemical analysis

Forensic Geology History

1887–1893—Sir Arthur Conan Doyle wrote about scientific ideas and techniques for solving crimes in his writings of Sherlock Holmes. This included information about soil and its composition which had never actually been used.

1893—An Austrian criminal investigator, Hans Gross, wrote that there should be a study of "dust, dirt on shoes and spots on cloth." He observed, "Dirt on shoes can often tell us more about where the wearer of those shoes had last been than toilsome inquiries."

Forensic Geology History, *continued*

1904—Georg Popp, a German forensic scientist, presented the first example of earth materials used as evidence in a criminal case, the strangulation of Eva Disch.

1910—Edmond Locard, a forensic geologist, was most interested in the fact that dust was transferred from the crime scene to the criminal. This helped to establish his principle of transfer.

Soil

A. Definition—naturally deposited materials that cover the earth's surface and are capable of supporting plant growth

B. The Earth

- **75 percent**—oceans, seas, and lakes
- **15 percent**—deserts, polar ice caps, and mountains
- **10 percent**—suitable for agriculture

Soil, *continued*

C. Formation

- **Living matter**—plants, animals, microorganisms
- **Inorganic materials**
- **Climate**
- **Parent materials**
- **Relief**—slope and land form
- **Time**

Soil, *continued*

D. Profile

- Topsoil
- Subsoil
- Parent material

E. Composition

- Sand
- Silt
- Clay
- Organic matter

Soil, *continued*

F. Nutrients—macro

- Nitrogen
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Sulfur

G. Nutrients—micro

- Manganese
- Iron
- Boron
- Copper
- Zinc
- Molybdenum
- Chlorine

Soil Comparisons

May establish a relationship or link to the crime, the victim, or the suspect(s)

Physical properties—density, magnetism, particle size, mineralogy

Chemical properties—pH, trace elements

Probative Value of Soil

Types of earth material are virtually unlimited. They have a wide distribution and change over short distances.

As a result, the statistical probability of a given sample having properties the same as another is very small.

Evidential value of soil can be excellent.

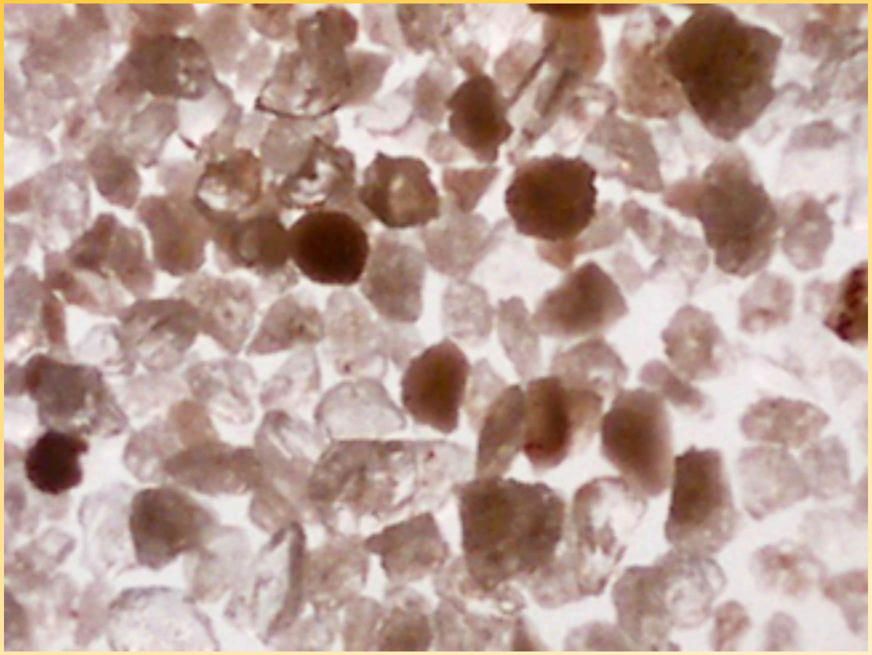
Increasing Probative Value

Rare or unusual minerals

Rocks

Fossils

Manufactured particles



Minerals

More than 2,000 have been identified.

Twenty or so are commonly found in soils; most soil samples contain only three to five.

Characteristics for identification—size, density, color, luster, fracture, streak, magnetism

Rocks

Aggregates of minerals

Types

- **Natural**—like granite
- **Man-made**—like concrete

Formation

- Igneous
- Sedimentary
- Metamorphic

Fossils

Remains of plants and animals

May help geologists to determine the age of rocks

Some are scarce and can be used to identify regions or locations

Palynology

The study of pollen and spores

Important to know:

- What is produced in a given area
- The dispersal pattern

Variation in size and weight

For additional information about palynology, visit:

http://science.uniserve.edu.au/faces/milne/milne.html

Soil Evidence

Class characteristics—the type of soil may have similar characteristics at the primary and/or secondary crime scene, on the suspect or on the victim

Individual characteristics—only if the soil has an unusual or specialized ingredient such as pollen, seeds, vegetation, or fragments

Sand

Sand is the term applied to natural particles with a grain diameter between 1/16 mm and 2 mm.

Its color and contents are dependent upon the parent rock and surrounding plant and animal life.

(The photo on the right shows color differences in sand from six locations around the world.)

Sand Characteristics

Composition is based on the material of the source; also gives the sand its color

Texture is determined by the way the source was transported

- Shape
- Grain size
- Sorting

Sand Types

Continental sands—formed from weathered continental rock, usually granite

Ocean floor sands—formed from volcanic material, usually basalt

Carbonate sands—composed of various forms of calcium carbonate

Tufa sands—formed when calcium ions from underground springs precipitate with carbonate ions in the salt water of a salt lake

Sand Evidence

"In every grain of sand is a story of earth."
—Rachel Carson

Class characteristics—the type of sand may have similar characteristics to the primary and/or secondary crime scene, on the suspect or on the victim

Individual characteristics—only if the sand has an unusual ingredient or contaminant

Virtual Sand Lab

Take a look at other examples on the website of the Geology Department at Pasadena City College:

www.paccd.cc.ca.us/SAND/SandExrc.htm

Forensic Geology in the News

A nine-year-old's body was found in a wooded area along a river in Lincoln County, South Dakota. A forensic geologist collected soil samples from the fenders of a suspect's truck and from the area where the body was found. Both soils contained grains of a blue mineral that turned out to be gahnite, a rare mineral that had never been reported in South Dakota. As a result, the soil tied the suspect to the crime.

Check out other cases at:

www.forensicgeology/science.htm

Characteristics of Glass

Hard, amorphous solid

Usually transparent

Primarily composed of silica, with various amounts of elemental oxides

Brittle

Exhibits conchoidal fracture

Common Types

Soda-lime—used in plate and window glass, glass containers, and electric lightbulbs

Soda-lead—fine tableware and art objects

Borosilicate—heat-resistant, like Pyrex

Silica—used in chemical ware

Tempered—used in side windows of cars

Laminated—used in the windshield of most cars

Physical Characteristics

Density—mass divided by volume

Refractive index (RI)—the measure of light bending due to a change in velocity when traveling from one medium to another

Fractures

Color

Thickness

Fluorescence

Markings—striations, dimples, etc.

Density

Type of Glass	Density
window	2.46–2.49
headlight	2.47–2.63
Pyrex	2.23–2.36
lead glass	2.9–5.9
porcelain	2.3–2.5

Determination of Refractive Index

Immersion method—lower fragments into liquids whose refractive index is different

Match point—when the refractive index of the glass is equal to that of the liquid

Becke line—a halo-like glow that appears around an object immersed in a liquid. It disappears when the refractive index of the liquid matches the refractive index of the object (the match point).

Determination of Refractive Index, *continued*

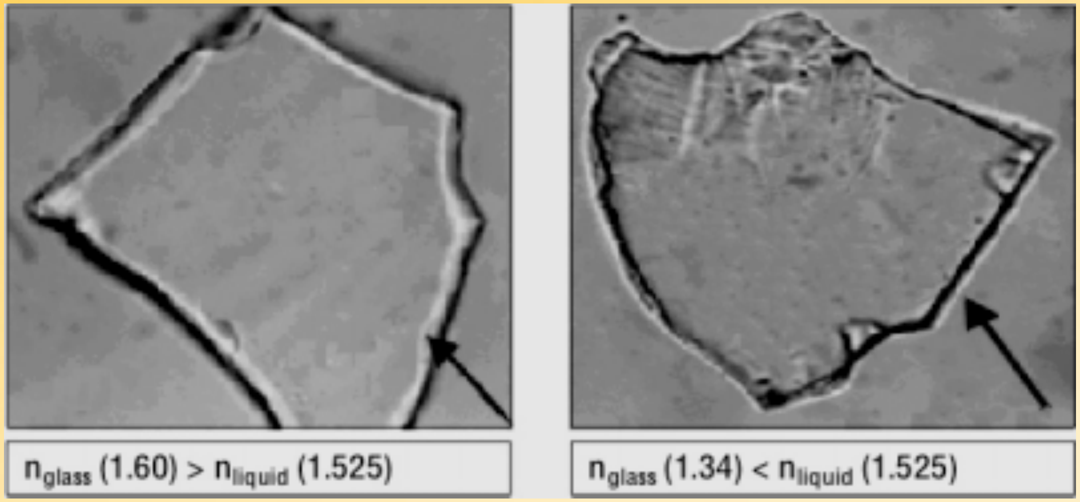
The refractive index of a high-boiling liquid, usually a silicone oil, changes with temperature.

This occurs in an apparatus called a hot stage which is attached to a microscope. Increasing the temperature allows the disappearance of the Becke line to be observed.

At match point, temperature is noted and refractive index of the liquid is read from a calibration chart.

The Becke Line

The Becke line is a "halo" that can be seen on the inside of the glass on the left, indicating that the glass has a higher refractive index than the liquid medium. The Becke line as seen on the right is on the outside of the glass, indicating just the opposite.



Refractive Index

Liquid	RI	Glass	RI
Water	1.333	Vitreous silica	1.458
Olive oil	1.467	Headlight	1.47–1.49
Glycerin	1.473	Window	1.51–1.52
Castor oil	1.482	Bottle	1.51–1.52
Clove oil	1.543	Optical	1.52–1.53
Bromobenzene	1.560	Quartz	1.544–1.553
Bromoform	1.597	Lead	1.56–1.61
Cinnamon oil	1.619	Diamond	2.419

Fracture Patterns

Radial fracture lines radiate out from the origin of the impact; they begin on the opposite side of the force.

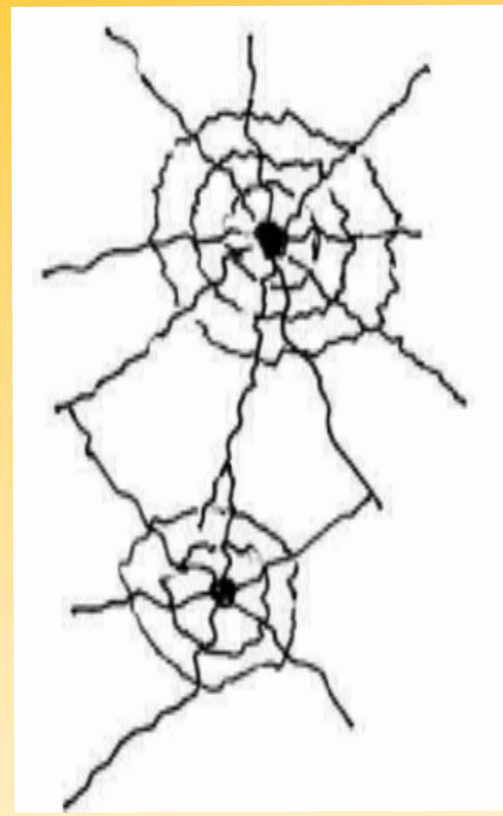
Concentric fracture lines are circular lines around the point of impact; they begin on the same side as the force.

3R rule—*Radial* cracks form a *right* angle on the *reverse* side of the force.

Sequencing

A high-velocity projectile always leaves a wider hole at the exit side of the glass.

Cracks terminate at intersections with others. This can be used to determine the order in which the fractures occurred.



Glass as Evidence

Class characteristics: physical and chemical properties such as refractive index, density, color, chemical composition

Individual characteristics: if the fragments can fit together like pieces of a puzzle, the source can be considered unique

Considerations for Collection

The collector must consider that fragments within a questioned sample may have multiple origins. If possible, the collector should attempt an initial separation based on physical properties.

The collector must consider the possibility that there may be a physical match to a known sample (e.g., a piece of glass to a fractured vehicle headlamp). When an attempt to make a physical match is made at the site of collection, the collector should take precautions to avoid mixing of the known and questioned samples.

Any glass samples collected should be documented, marked (if necessary), packaged, and labeled.

—*Forensic Science Communications*

Collecting the Sample

The glass sample should consist of the largest amount that can be practically collected from each broken object and packaged separately. The sample should be removed from the structure (e.g., window frame, light assembly). The inside and outside surfaces of the known sample should be labeled if a determination of direction of breakage or reconstruction of the pane is desired.

When multiple broken glass sources are identified, it is necessary to sample all sources.

A sample should be collected from various locations throughout the broken portion of the object in order to be as representative as possible.

The sample should be collected with consideration being given to the presence of other types of evidence on that sample (e.g., fibers, blood).

—Forensic Science Communications