89.215 - FORENSIC GEOLOGY
INTRODUCTION

I. Types of physical evidence

Forensic geology is that branch of the earth sciences that uses rocks, minerals, fossils, soils, and a variety of geochemical techniques to provide physical evidence in criminal investigations and trials. Forensic evidence can be of two types:

1. Individual - items that can have only one source. Examples are fingerprints, some took marks, bullets, DNA, etc.

2. Class - items that can come from a variety of sources. The value of a class item depends on its uniqueness. For example, paint scrapings from a car may identify the year, make, and model of the car but not the specific vehicle. The usefulness of the evidence would then depend on how common this car was in a particular area. Most geologic evidence is of the class type.

Physical evidence is generally more reliable than human evidence (eyewitness accounts) that rely on memory, emotion, and many other factors. Besides outright dishonesty, eyewitness accounts are often unreliable because individuals may only observe certain aspects of a scene, are subject to suggestion, and often remember an event in the context of their own personal experiences. Eyewitness identifications of perpetrators of crimes are notoriously unreliable. The reliability of physical evidence, of course, depends on the competency and skill of the forensic scientist. There are also cases where physical evidence is tainted for a variety of reasons including incompetence of the investigator.

II. The exchange principle

Another important concept is that of the “Exchange Principle”. This principle was first articulated by the French scientist Edmond Locard and is often called the “Locard Exchange Principle”. Locard believed that when a criminal came into contact with another person or place, small items such as hairs or fibers would be left by one person and perhaps picked up by the other. The "Locard Exchange Principle" can be stated as "When any two objects come into contact there is always a transfer from one object to the other." To quote Locard: “Wherever he steps, whatever he touches, whatever he leaves, even unconsciously, will serve as a silent witness against him. Not only his fingerprints or his footprints, but his hair, the fibers from his clothes, the glass he breaks, the tool mark he leaves, the paint he scratches, the blood or semen he deposits or collects. All of these and more, bear mute witness against him. This is evidence that does not forget. It is not confused by the excitement of the moment. It is not absent because human witnesses are. It is factual evidence. Physical evidence cannot be wrong, it cannot perjure itself, it cannot be wholly absent. Only its interpretation can err. Only human failure to find it, study and understand it, can diminish its value." Professor Edmond Locard (1877-1966).

III. Types of geologic evidence

While most geologic evidence is of the class-type, there are instances where the uniqueness of the material leads to a unique (individual) match. An example would be the ability to match at the microscopic level a piece of rock used in a crime to its source rock. Geology is such a broad field that many different lines of evidence can be developed by applying geological methodology and inference. Consider the following examples:

1. Approximately 3500 minerals have been identified. Of these number only a hundred or so are common. These minerals exist in a wide range of compositions. It is thus possible, in any given case, to have a limited number of possibilities in terms of the location of a particular mineral or group of minerals. *Example: A body is found in a field overlying an abandoned mining area. The soil in this area contains the rare mineral* ***niocalite*** *(so rare that its only be found in one place in the world). A suspect is apprehended several miles from the crime scene. He claims that he was never near the crime scene. Examination of the soil adhering to his shoes reveals the presence of* ***niocalite*** *thus placing him at the scene of the crime.*

2. More than a million different kinds of fossils have been identified. Fossiliferous rocks have populations of fossils that reflect the depositional environment in which the rock formed and the age of the rock. Hence, the source of a fossiliferous rock can often be pinpointed with reasonable accuracy. *Example: a moonshiner is arrested for illegally selling whiskey (what else would a moonshiner do?). The revenue agents demand to know the location of the still, but he refuses to divulge the location. A few small pieces of limestone are found in the sack that contained the whiskey. The limestone contains fossils and there is only one known nearby location that is underlain by this type of fossiliferous limestone. The revenuers visit the location and find the still.*

3. Rocks are not randomly distributed across the earth's surface. Their occurrence is determined by the geologic processes that have occurred in a particular area. The distribution of rock types (lithologies) is shown by a geologic map. It is often possible to link a rock specimen to a specific area using a geologic map. *Example: A Lowell resident orders a carton of very expensive wine from a vintner in Argentina. When the wine arrives in Lowell the box contains scoria (a volcanic rock) - somewhere between the winery and Lowell the wine has been removed by a third party. The Lowell resident immediately suspects the driver of the delivery van (who appears slightly inebriated) and verbally attacks the man (he is restrained from a physical attack by his significant other. One should never mess with a man's wine.). The delivery man proclaims his innocence, and since he is a geology student who is working his way through college driving the delivery van, he points out that the rock in the box cannot be found anywhere in the Lowell area. Further investigation reveals that the box of wine was transferred from one mode of transport to another in two locations - one in Argentina and the other northern Mexico. A perusal of geologic maps of the two areas reveals that volcanic rocks occur in northern Mexico, thus suggesting that was where the transfer took place.*

4. The type of sediments deposited in various depositional environments (such as beaches and streams) differs in texture and mineralogy. In certain cases this allows us to pinpoint the source of the sediment. *Example: a body is dumped in a classroom at the university. The body is wrapped in a sheet and there is a significant amount of sand associated with the body. Size analysis of the sand, plus a study of the mineralogy of the sand and the appearance of the sand grains, enables investigators to identify the location where the crime took place.*

5. The concentration of chemical elements in rocks, minerals, and soils is controlled by a number of processes. It is possible for specific locations to have unique chemical signatures. *Example: investigators wish to track the source of cocaine that is being sold on the streets of your town. Analysis of the cocaine detects a number of trace elements. The poppies from which the cocaine is derived take up trace elements from the soil. Different soils have different trace element concentrations and ratios. Comparisons to soil chemistry from various regions show that the source of the cocaine was a particular valley in southeast Asia.*

6. Stable isotopes can be used to fingerprint the source of an environmental spill. *Example: a gasoline spill enters the groundwater system and contaminates the groundwater. This groundwater is used as drinking water by a local town. Two gasoline stations are the potential source of the leak. Both declare their innocence. Analysis of the isotopic chemistry of the gasolines distributed by the two stations reveals a difference in their composition. Isotopic analysis of the contaminant in the groundwater allows investigators to determine which station is the source of the spill and the company is required to clean up the groundwater.*

IV. Examples of geological crime solving

In October, 1904, George Popp, a chemist, microscopist, and earth scientist in Germany, was asked to examine the evidence in a murder case in which a seamstress named Eva Disch had been strangled in a bean field with her own scarf. A filthy handkerchief had been left at the scene of the crime and the nasal mucus on the handkerchief contained bits of coal, particles of snuff, and most interesting of all, grains of minerals, particularly hornblende. A prime suspect was known to work both in a coal-burning gasworks and at a local gravel pit. Popp found coal and mineral grains, including hornblende, under the suspect's fingernails. It was also determined that the suspect used snuff. Examination of soil removed from the suspect's trousers revealed that minerals in a lower layer in contact with the cloth matched those of a soil sample taken from the place where the victim's body had been found. Encrusted on this lower layer, a second soil type was found. Examination of the minerals in the upper layer revealed a mineralogy and size of particles, particularly crushed mica grains, that Popp determined were comparable with soil samples collected along the path that led from the murder scene to the suspect's home. From these data it was concluded that the suspect picked up the lower soil layer at the scene of the crime and that this lower and thus earlier material was covered by splashes of mica-rich mud from the path on his return home. When confronted with the soil evidence the suspect admitted the crime, and the Frankfurt newspapers of the day carried such headlines as, "The Microscope as Detective". (From R. C. Murray, 1975)

In 1906 Conan Doyle became involved in an actual criminal case during which he applied some of the methods of his fictional creation Holmes. An English solicitor was accused and convicted of killing and mutilating horses and cows. After serving three years in prison he was released but not given a pardon despite some evidence that he was actually innocent of the crimes. Doyle observed that the soil on the shoes worn by the convicted man on the day of the crime was black mud and not the yellow, sandy clay found in the field where the animals had been killed. This observation, combined with other evidence, ultimately led to a full pardon and contributed to the creation of a court of appeals in England. (From R. C. Murray, 1975)

In a case of rape in an eastern United States city, the victim reported that the crime took place in a vacant lot, which was underlain by the beach sands of an ancient glacial lake. The suspect had sand in the cuffs of his trousers. Study of the sand from the cuffs and samples collected at the crime scene showed that the two sands were comparable. Both contained the same minerals and rock grains in the same amounts. Thus it was established with a high degree of probability that the two samples could have come from a common source. One of the rock types was fragments of anthracite coal. These fragments were very common but were not natural to the area. Coal fragments are widely found in the soils of most of our older cities. In this case, however, there was too much coal in the sand. Further investigation revealed that sixty years before the crime the site had been the location of a coal pile for a laundry. Although the minerals involved in this case might have been duplicated in other places, the presence of the coal became a crucial factor in greatly increasing the probability of a single common source. This geologic evidence, when combined with other evidence and testimony by the victim, led to the conviction of the suspect. (From R. C. Murray, 1975)

Most interesting is the insulation material used in safes and strong boxes. When fire-resistant safes are broken into by drilling, blowing, cutting, or prying, the fire insulating material that fills the space between the outer and inner metal walls is disrupted. It commonly clings to the tools and clothing of the safe breaker. There is a classic case in which a man was arrested and brought to the police station on a routine minor charge. An observant detective, noticing that the suspect appeared to have a severe case of dandruff, examined his hair. The substance was, not dandruff, but diatoms, the microscopic fossils that make up the diatomaceous earth used to insulate some safes. On further examination it was learned that the diatoms in the suspect's hair were of the same species as those present in the insulation of a safe that had been blown the previous day. The suspect was accordingly charged with the burglary. (From R. C. Murray, 1975)

In 1925, Edward Heinrich undertook an intriguing case to which he would apply his knowledge of geology. Mrs. Sideny d'Asquith, sometimes known as Mrs. J. J. Loren, had been murdered and her body dismembered. Parts of her body, including an ear, were found in a marsh near El Cerrito, California. The rest of the body could not be found despite an intense search. Heinrich determined that the grains of sand he found on the ear of the victim did not come from the black mud of the marsh and reasoned that the body with the ear attached had been placed elsewhere. Later the ear with the sand grains from the earlier location and part of the head had been removed and taken to the marsh. He studied the sand grains, noting their size and composition. He also observed that they had what he considered insufficient salt crystals adhering to them to have been sand from an ocean beach. There was some salt present and he deduced that it came from a river or brook at a place where it entered the ocean. He studied maps with the assumption that he was looking for the nearest place to the marsh where such conditions exist. The place he suggested was Bay Farm Island, 12 miles from the marsh at El Cerrito, near the mouth of San Leandro Creek. Despite some doubts, a search was instigated at Bay Farm Island and the rest of the body was found buried under the drawbridge between Alameda and Bay Farm Island. The case has never been solved. However, the combination of skill, and perhaps luck, that Heinrich employed introduced forensic geology to the United States in a most dramatic way. (From J. Crelling)