Forensic Ballistics

Harlem Children Society

2009

By: Alejandro Galvan
Mentor: Dr. John Molina
Bronx Community College

Abstract

Forensic Science is the use of sciences to uncover the truth behind the events within a crime. Unfortunately not every crime is the same that is why there are various crime units which are composed of several experts from different fields; for Forensic Science has a vast amount of fields to specialize in. All of which cannot be covered within just 4 years of college. Such fields include Forensic geology, forensic pathology, forensic psychology etc. All of which require significant amount of study and dedication not only to be able to work within a forensics unit but to know what one is doing.

While working at the Bronx Community College with Prof. John Molina in the Chemistry Department on Forensics, there was a sudden interest for Forensic Ballistics. Having a small background in ballistics, it seemed to be an interesting field. Forensic Ballistics is the science of analyzing firearm usage in crimes; which involves analyzing a bullets travel down the barrel, its path through the air, and through a target.

Many might not know, but a firearm is similar to a hand. None of the imprints left behind are the same, no matter the brand. Though there is no guarantee that a bullet came from a specific gun, it is relatively easy to identify the manufacturer.

There are various techniques in which the evidence can be examined to uncover the weapon used. For example the use of a Comparison macroscope, in which if a firearm is retrieved it would be used to fire a bullet in a controlled environment to be able to compare the control with the evidence for similar striation patterns created by the firearm. Other techniques include algorithm, computer analysis, databases and Energy Dispersive X-ray Spectroscopy, all of which examine the different levels of composition of the evidence. Forensic Ballistics is a field that requires vast knowledge of physics and chemistry, making it just one of the many.

Background Information on Firearms

Gun powder is made of a mixture of sulfur, charcoal, and potassium nitrite; first appearing in China, used for firecrackers and very little within the weapons of the military. After its manufacture reached Europe during the 14th century, it did not lead to military usage. But once the effectiveness of projectiles impelled by the force of gunpowder was known, the use of firearms lifted.

As the use of firearms proliferated some important needs came about from its first stages of production: reliability of firing, accuracy of projectile, force of projectile and the speed of firing. The needs were presented for military usage. As firearms developed small changes were made to solve the many problems it encountered. The first guns had defects; where the bullet would not hit the target. At first it was discovered having a longer bore would fix the accuracy within a shot, but people were limited to the size. It was not until later that gun smiths discovered that by adding spiral grooves along the barrel, would give the bullet spin which would also give it direction. Fortunately these grooves create patterns onto the projectile allowing forensic experts to track down the manufacturer of the weapon or possibly finding the weapon.

The "breechloading" firearms led to another advantage, loading speed. Further improvements included multiple chambers, as in the revolver, for multiple shots. The sliding or pumping made it easier to load successfully a cartridge onto the barrel in a rifle.

The force of the projectile has also been modified to meet the needs. The primitive gun powder produces an expansion, when contained in a small volume, pressure will then build up firing the projectile with great force in a certain direction. With the advancement in science, the gunpowder has been reduced to not only fill smaller volumes but to create a greater expansion to increase the force on the projectile, not only creating greater impact but also a more reliable shot.

Background Information on Bullets

During the primitive stages of the firearm, man used a metallic or stone ball in a sling as a weapon and in hunting. Through the development of firearms the primitive bullets were place in front of the exploding charge. As technological advances came about during the 1500's to early 1800's, bullets changed very little. They were simple spherical lead balls only having different diameters.

This spherical ammunition was manufactured for the culverin and matchlock arquebus, original muskets. The lead ball would be wrapped in paper to hold it firmly in the barrel on the powder. Unfortunately their technique was not as reliable, for the barrel of the gun would explode if the bullet was not firmly placed on the powder. Because of the difficulties that derived from the early firearms, they were sparingly used for military purposes.

During the 1800's, many different designs of the bullet came about. Captain John Norton of the British Army introduced a bullet with a hollow base, which would cause it to expand to go with the barrels rifling. Unfortunately when presented to the British Board, the idea had been rejected because to the long use of the spherical bullet. William Greener had a similar idea to that of Norton, except that the hollow base would be fitted with a wooden plug for a more reliable force at the base of the bullet to expand and catch the rifling. Tests proved that Greener's bullet was very effective but it also was rejected. Being a-two part ammunition, it was considered too complicated to produce. By 1847, Claude Étienne Minié, a captain in the French Army, introduced another design identical to the Greener bullet. The bullet had a cone like shape with a hollowed base, which was fitted with an iron cap instead of a wooden plug. When fired, the iron cap would be force into the hollow cavity, to expand the sides of the bullet to grip and engage the

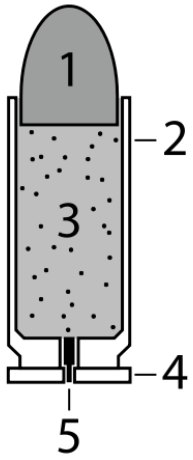
rifling. In 1855, the British adopted the Minié ball, Claude Étienne Minié's ammunition, for their Enfield rifles

In 1883, Major Rubin, director of the Swiss Laboratory at Thun, invented the copper jacketed bullet, an elongated bullet with a lead core in a copper coating. Because copper has a higher melting point, and greater specific heat capacity and hardness, copper jacketed bullets allowed greater muzzle velocities, leading to the pointed spitzer bullet. By the twentieth century, most world armies had begun to transition to spitzer bullets. These bullets flew for greater distances more accurately and carried more energy with them. Spitzer bullets combined with machine guns greatly increased the lethality of the battlefield.

Every Bullet is different

A modern cartridge consists of the following:

1. the bullet itself, which serves as the projectile;
2. the case, which holds all parts together;
3. the propellant (gunpowder or cordite);
4. the rim, part of the casing used for loading;
5. the primer, which ignites the propellant.



As a bullet is fired, it will twist and turn in the barrel creating striations from the grooves. Many are unaware that a no two firearms will produce the same marks on fired bullets and cartridge cases. This is due to the manufacturing process the use of the firearm leave surface characteristics which cannot be reproduced by any another firearm. The toolmarks produced are unique to each firearm, no matter if they are of the same make and model. Firearms do not change much over time.

Understanding Forensic Ballistics

Ballistics is the science of a projectile in flight. Forensic Ballistics is the science of analyzing firearm usage in crimes; which involves analyzing a bullets travel down the barrel, path through the air, and its path through a target. Though it does not guarantee that a bullet came from a specific gun, it is relatively easy to identify the manufacturer.

What do Forensic Ballistics experts do?

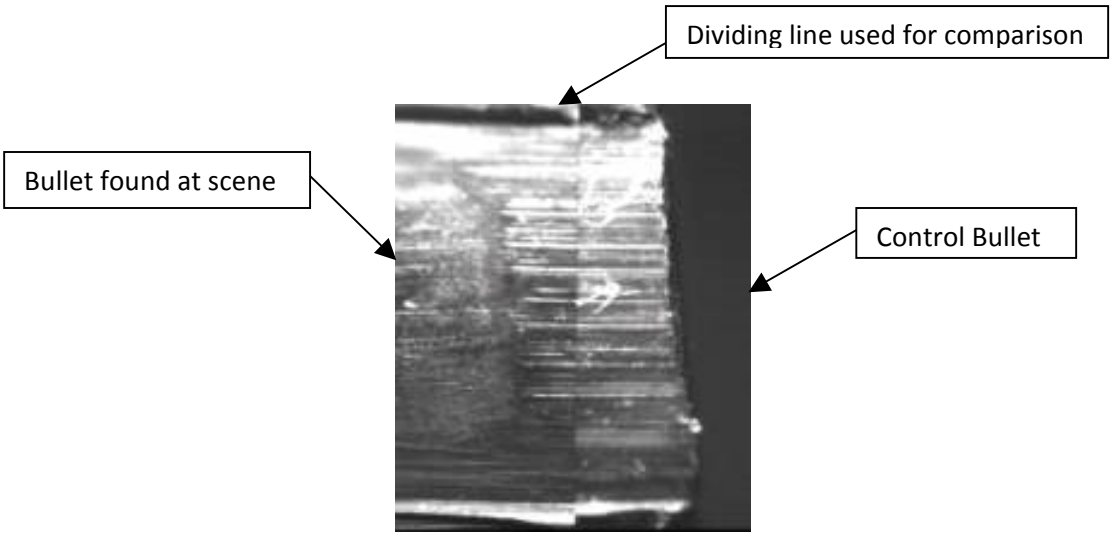
Forensic ballistic experts look at certain characteristics from the caliber of the firearm to the rifling pattern in the barrel of the firearm. Cartridges and cartridge cases are examined for similarities: breech marks, firing pin impressions, extractor marks, ejector marks and other named toolmarks. Meaning that the projectile does not need to be fired, with the simple load of a bullet a unique toolmark is created. One of the most important tools in forensic ballistics is the comparison microscope also called a comparison macroscope, where these toolmarks can be compared side by side and matched or eliminated.

Comparison Macroscope

The weapon (if retrieved) is first fired in a tank filled with water with a dimension of 10ft X 3ft X 3ft. Friction from the water slows the bullets down, ending up on the bottom of the tank about halfway its length. They are examined to determine if the barrel is producing striated marks in a consistent pattern. Once a consistently reoccurring pattern of marks is identified, the standards are compared to the evidence bullets to see if the same pattern of marks exists. To make these comparisons the firearm examiner will use a *comparison macroscope.* It is called a ***macro***scope and not a ***micro***scope. Microscopes use magnifications that are 100x and above. Magnifications used in firearms identification are 5X, 10X, 20X, 30X, and 40X.

The comparison macroscope consists of two macroscopes side by side, connected by an optical bridge. There are two stages on the lower part of the macroscope where the bullets are to be placed to compare. Images of the bullets travel up through the objectives, through several mirrors in the optical bridge, and are combined in a round field of view seen by looking into the stereoscopic eyepieces. The image will show the bullets side-by-side, with a thin dividing line down the middle.

Ex:

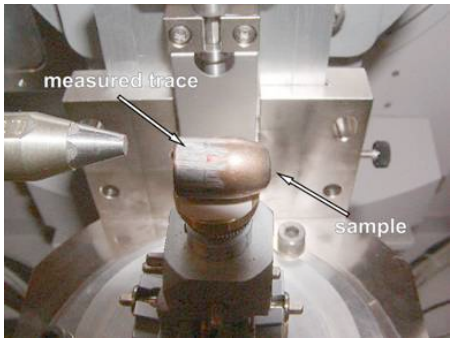


As one can observe there is a match between the control and the evidence, both have similar striations, meaning that the weapon used in the control is in the fact the weapon used at the crime scene.

SEM/EDS

Scanning electron microscopy is equipped with an energy dispersive x-ray analyzer (SEM-EDs). SEM allows for the determination of shape and size, while the EDS (Energy Dispersive X-ray Spectroscopy or EDS) documents the elemental composition of the particles. By determining its elemental composition forensic experts are able to compare it to that of another evidence or control to determine the fire arm used. EDS can provide rapid, adequate standards of elemental

composition. X-rays may also be used to form maps or line profiles, showing the elemental distribution in a sample surface.



Computer Analysis and Databases Assist Crime Labs

If the firearm is not recovered, and the crime lab has the marks on a cartridge case they can still identify the firearm. One of the ballistics databases used in forensic labs is *Drugfire.* Drugfire is an electronic database that contains digital images of fired bullets and casings, similar to the Automated Fingerprint Identification System (AFIS)

The Firearms-Toolmarks Unit (FTU) is one of many subdivisions of the FBI. They use *Drugfi*re which integrates, cartridge case, shotgun shell and bullet analysis, as well as electronic firearms reference libraries. Hits are made when the analyzer makes a match between a previously filed specimen and the specimen being analyzed.

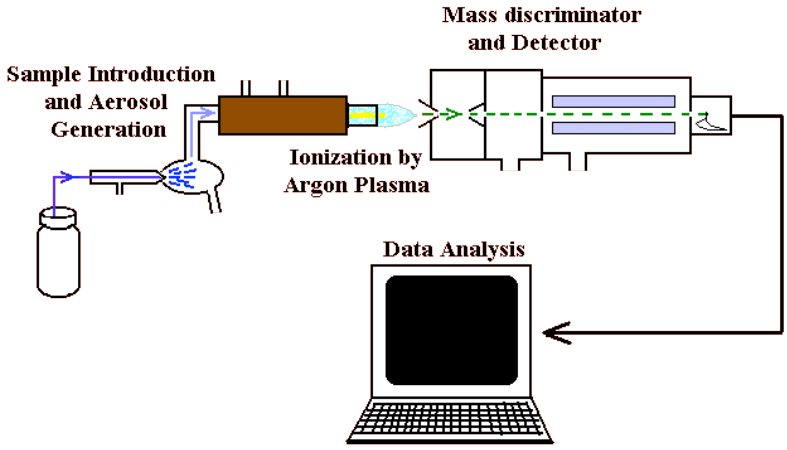
ICP-MS

Inductively coupled plasma-mass spectrometry, the study of gunshot residue. This instrumental technique is recent; it has been used to study the deposit pattern of the gunshot residue around the bullet entrance hole, through the analysis of antimony (Sb), barium (Ba), and lead (Pb). The data collected is used to make a mathematical model for estimating firing distance.

$$d = a + b(1)X(1) + b(2)X(2) + b(3)X(3)$$

$$X(1) = \ln m\,(Sb),\ X(2) = \ln m(Ba) \text{ and } X(3) = \ln m\,(Pb).$$

All three elements are not necessary to determine the distance since according to studies there is not a significant difference in using one or two.



Conclusion

With the development of newer technology it is almost impossible to escape from a crime. When a firearm is used in a crime, there will always be a trace left from which a forensics expert can look into. Many questions are left unanswered but with these techniques not only can the weapon be determined but also the distance of the attack.

Acknowledgements

- **Dr. John Molina**
- **Dr. Sat Bhattacharya**
- **Bronx Community College**
- **Harlem Children Society**

Bibliography

Image 1: http://en.wikipedia.org/wiki/File:Bullet.svg

"Bullet Identification - FirearmsID.com." *FirearmsID.com- An Introduction to Forensic Firearm Identification*. Web. July 19 2009. <http://www.firearmsid.com/A_BulletID.htm>.

"FIREARMS TUTORIAL." *EHSL - Spencer S. Eccles Health Sciences Library Home Page*. Web. 20 July 2009. <http://library.med.utah.edu/WebPath/TUTORIAL/GUNS/GUNINTRO.html>.

Lotter, Karen. "What is Forensic Ballistics? Firearms Identification is a Branch of Toolmark Identification | Suite101.com." *Forensic Science | Suite101.com*. Web. 20 July 2009. <http://forensicscience.suite101.com/article.cfm/what_is_forensic_ballistics>.