Antique Firearm Examined With Scanning Electron Microscope (SEM) to Determine the Persistence of Firearms Discharge Residue (FDR)[1]

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After attending this presentation, attendees will understand some of the developmental features and characteristics of the Smith Carbine, the type of components used in the manufacture of 19th-century ammunition, and the identification and persistence of Firearms Discharge Residue (FDR) in an antique firearm.

This presentation will impact the forensic science community by providing an in-depth Scanning Electron Microscope (SEM) examination to determine the persistence of firearm discharge residue from an 1876 Smith Carbine. The techniques used in this examination will determine if FDR remains in the bore of the barrel after a period of three decades.

The Smith Carbine fired by Henry Mason Wheeler during the Northfield Bank raid on September 7, 1876, was examined for FDR. Even though antique firearms are collected for aesthetic reasons, many continue to function as a firearm and could be used in the commission of a crime. However, limited research has been conducted on the persistence of FDR in antique firearms.

In this study, the Smith Carbine had not been fired in over 32 years. Since the 1876 raid, only six other individuals have owned the Smith Carbine other than Edward Dampier, the original owner. The six owners include: Dr. Charles Dampier, Henry Mason Wheeler, Mae McCulloch Wheeler, Henry Mason "Hank" Wheeler, Jr., Charles R. Dickson, and the present owner in Grand Forks, North Dakota, who has requested to remain anonymous.

The Smith Carbine was developed by Gilbert Smith of Buttermilk Falls, New York. Smith developed a method for sealing the chamber in a breech-loading gun and was granted patent # 15,496 on August 5, 1856. A series of patents led to the development of a carbine identified as the Smith Carbine. The carbine originally fired a manufactured paper cartridge but subsequently fired manufactured cartridges made from other materials. The actual number of Smith Carbines produced is unknown; however, the military purchased approximately 30 thousand carbines and approximately 19 million cartridges. The Smith Carbine was primarily used by the Union Cavalry during the Civil War.

The firearm examined was a single-shot breech-loading .50 caliber Smith Carbine and serial number 19359 was stamped near the hinge. A sample was collected from the barrel using a 100% cotton patch. Residue from the cotton patch was collected using two aluminum stubs with adhesive applied to the end of the stubs for SEM analysis. The sampling procedure involved contacting the adhesive end of the aluminum stub on the surface multiple times to collect the FDR.

In the early 1800s, a typical percussion cap primer mixture contained potassium chlorate, charcoal and sulfur. However, by the time the Smith Carbine was developed, the percussion cap primer mixture consisted of mercury fulminate, potassium chlorate, antimony sulfide, and powdered glass. The metal cup that contained the priming mixture was made from copper or brass. A typical formula for black powder during the Civil War era would have consisted of 75% potassium nitrate, 15% charcoal, and 10% sulfur. Early black powder formulations substituted sodium nitrate in place of potassium nitrate; however, the powder was considered inferior

because the sodium nitrate absorbed moisture. A typical alloy cast bullet contained 90% lead, 5% antimony, and 5% tin.

The type of electron microscope used in the analysis was a JEOL 5800 Low Vacuum Scanning Electron Microscope (LV SEM). The operating conditions of the SEM included an accelerating voltage of 25keV with a beam current of 0.6nA. Analyses were performed in the low-vacuum (p = 17 Pa) mode of the SEM. A working distance of 11mm was used for the examinations.

Sixteen particles were analyzed on stub #1 and 23 particles were analyzed on stub #2 to produce an elemental profile from the barrel residue. The particle sizes were found to be approximately 1μm. The Energy Dispersive Spectrometry (EDS) analysis from the residue revealed the presence of ten elements. They included antimony, barium, calcium, copper, iron, lead, potassium, silicon, sulfur, and tin. However, one element not detected was mercury.

Seven of the ten elements collected and analyzed (antimony, copper, lead, potassium, silicon, sulfur, and tin) are consistent with 19thcentury ammunition components. The silicon likely originated from the powdered glass portion of the priming mixture. Since iron is not an ammunition component, this metal could possibly derive from the barrel of the carbine. The source for the barium and calcium are unknown. However, these two elements could be contaminants in the ammunition or they could have been introduced into the barrel as a result of swabbing the bore during the cleaning process.

In conclusion, the SEM examination demonstrates that FDR can persist in the bore of an antique firearm for more than three decades. The SEM did not detect any particles of mercury in the residue. Most mercury particles vaporize when the firearm is discharged and the remaining mercury particles may dissipate since mercury is a volatile element. Although it is difficult to estimate the time of discharge, absence of mercury could indicate the weapon has not been fired for an extended period of time.

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