Investigation of the death of Colonel James Sabow: Gunshot residue, backspatter and crime scene analysis.

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Summary

An analysis of the gunshot residue (GSR) and the backspatter residue (BSR) associated with the death of Colonel James E. Sabow was performed. The Colonel died either by homicide or suicide with the intraoral discharge of a 12 gauge shotgun. Some observations of the crime scene and autopsy photographs are presented. Conclusions of this study:

1) The Ithaca double barrel 12 gauge shotgun, Model 200E found at the crime scene, leaks GSR from both the breech and the trigger housing.

2) The hands of the victim were sampled at the crime scene for GSR and analyzed by scanning electron microscopy/energy dispersive X-ray spectroscopy (elemental analysis) (SEM/EDS). Both the sampling and the analysis are reliable (i.e., GSR was found on the left, but not the right hand). [Note that the actual GSR report was not seen by me.]

3) Neither the bathrobe nor the pajama bottoms had detectable burdens of GSR or BSR. The suicide scenario for the death of Colonel Sabow predicts that both GSR and BSR would be on the clothing, especially the bathrobe.

4) The lack of GSR on the right hand and the finding that there is shotgun trigger housing leakage of GSR indicates that Colonel Sabow did not depress the trigger of the shotgun.

5) The right hand in some of the crime scene photographs shows small blood spatter on the ulnar aspect of the palm and a middle finger nail. These areas would be protected from projected blood in a suicide scenario. The right hand also shows a blood transfer on the ulnar part of the back of the right hand and onto the palm, apparently from blood in the grass. This indicates that the right hand was moved prior to the photographing of the crime scene.

6) Bruising of the lower lip by the front maxillary teeth was prior to the shotgun discharge.

7) Based on my analysis, a suicide scenario is untenable in the death of Colonel Sabow. The body of Colonel Sabow was staged to appear that the death was suicide by an intraoral shotgun blast. The death of the Colonel was by homicide.

NOTE: The following report has been updated from the report submitted to Dr. David Sabow on February 21, 2005. The content and conclusions of that report have not changed. Small grammatical errors were corrected and fixes to a few awkward sentences were made. Additional data were acquired for Table 2 and the text modified in reference to Table 2. The report submitted to Dr. Sabow may be obtained through him. BRB 02/23/2005

Introduction

On January 10, 2005 I received a call from Dr. David Sabow requesting that I perform a gunshot residue analysis on evidence associated with the death of Colonel James Sabow, brother of Dr. David Sabow. I agreed to perform a series of analyses using scanning electron microscopy (SEM)/energy dispersive X-ray spectroscopy (EDS = elemental analysis) on this evidence. I was also asked to review the crime scene and autopsy photographs.

The crime scene. Colonel Sabow was found in the backyard of his home (Fig. 1). He was lying on his right side, dressed in a white terrycloth bathrobe, white undershirt, light blue pajama bottoms, white underpants, white socks and black slippers. His Ithaca double barrel 12 gauge shotgun was in front of him with the stock under his lower legs and feet. A lawn chair was on top of him.

The case. A number of conversations with Dr. Sabow established that the circumstance of Colonel Sabow's death is controversial. There appear to be two theories as to how Colonel Sabow died:

1) Colonel Sabow received a blow to the back of his head, which rendered an apparent fatal injury. The person or persons involved in this act then approached the body and inserted Colonel Sabow's 12 gauge double barreled shotgun into his mouth and fired the left barrel. This part of the scenario is reenacted in Fig. 2A. The shotgun was then placed close to the body and a lawn chair placed on the body in order to make it appear this was a suicide.

2) Colonel Sabow committed suicide with his 12 gauge shotgun by sitting in the lawn chair placing the shotgun in his mouth. He held the shotgun muzzle at his mouth with his left hand and pushed the trigger with a finger or the thumb of his right hand. The position of the body suggests that consistent with this scenario, the shotgun was held outside Colonel Sabow's right leg (e.g., Fig. 2B). The position of the body also suggests that after the shot, Colonel Sabow fell from the chair to his right causing the lawn chair to upset and end up on top of him.

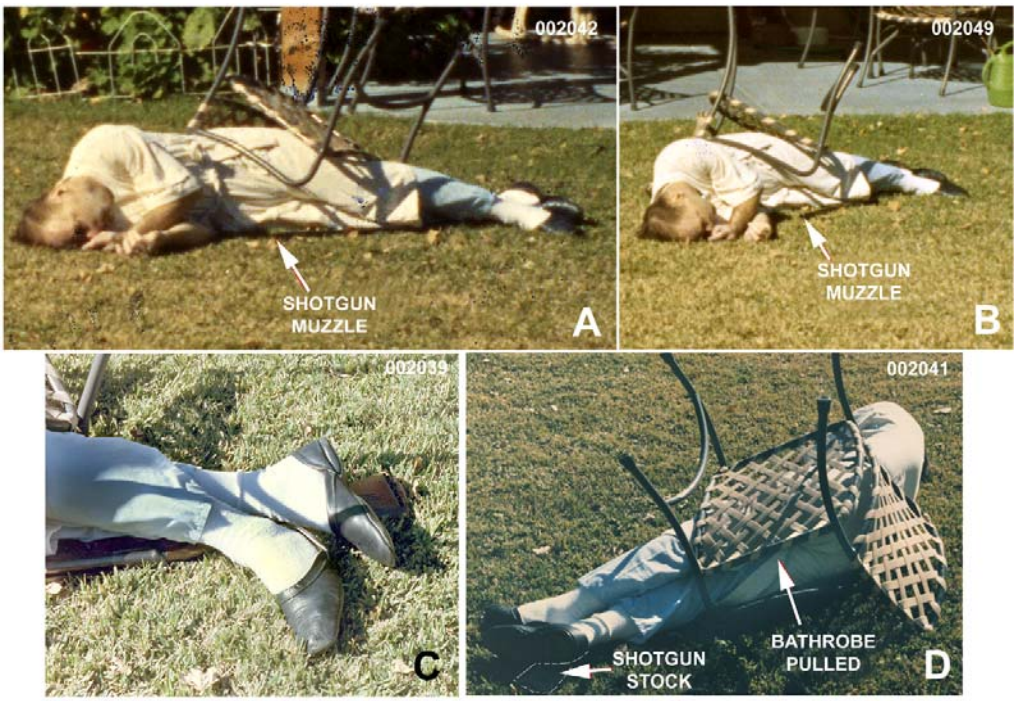

Figure 1. *Photographs from the crime scene. Numbers in upper right of each image are the crime scene photograph numbers. A: The body in the backyard of his home. Note that the bathrobe is tucked between his legs. The shotgun is in front of him with his lower legs over the stock of the shotgun. A lawn chair is on top of the body. Both hands are in front of the victim's mouth. B: Another view of the body. C: View of the victim's lower legs and feet with the shotgun underneath. D: View of the body from the rear. The bathrobe is pulled toward the buttocks.*

Meixa Tech. The business of Meixa Tech (Bryan Burnett, General Partner) is the forensic application of scanning electron microscopy/energy dispersive X-ray analysis both in civil and criminal cases. My training, expertise and publications are described in my Curriculum Vitae (see meixatech.com). The scanning electron microscope and energy dispersive X-ray detectors as well as a description of the technology is discussed at meixatech.com.

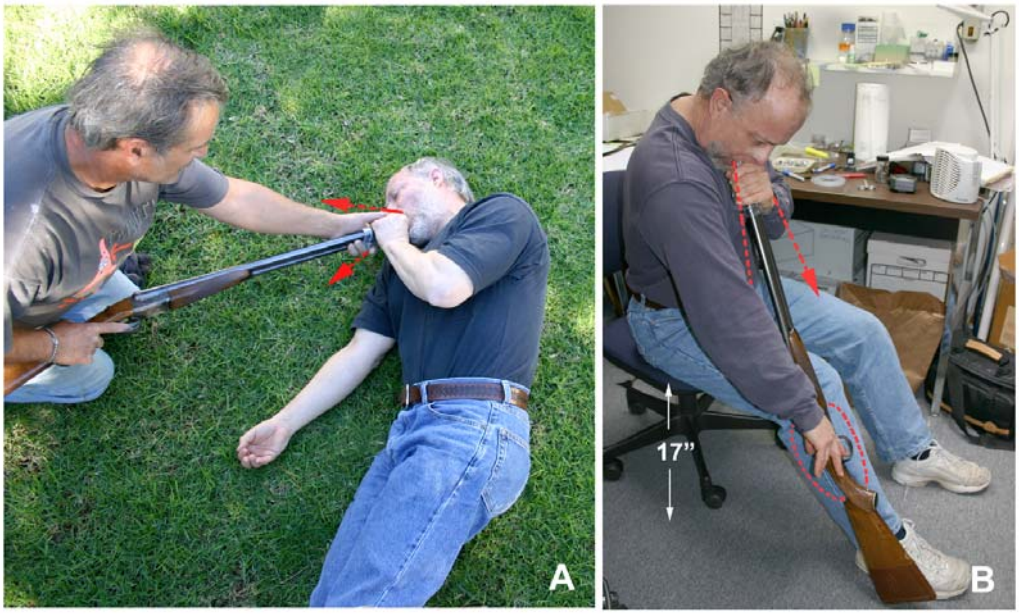

Figure 2. *A: Reenactment of the homicide scenario where the shotgun is inserted into the mouth of the victim by the assailant. In order for the muzzle to stay in the mouth when the shotgun is fired, the butt of the shotgun would have to be supported. Support for a rapid removal of the muzzle of the shotgun in this scenario is the lack of significant ripping around the margins of the mouth (see Fig. 15) as well as an unexpectedly small amount of BSR on the shotgun muzzle (Nordby, 2004). The right hand, due to its lack of GSR (see text) was apparently not exposed to GSR . Blood spatter is on the right hand (see p. 18) which would likely place that hand closer to the mouth than shown here. The crime scene photographs show the victim's right hand near the mouth. Red arrows: route of the gas expellation when the shotgun muzzle is in the mouth. B: Reenactment of the suicide scenario with the victim sitting in a chair and inserting the shotgun into his mouth. The muzzle is supported by the left hand and the right depresses the trigger. The shotgun was found close to the body, partly under the right lower leg (Fig. 1). This would place the shotgun in the reenactment on the outside of the right leg. In this scenario, gas escape from the mouth would spray the thighs (red arrows) with GSR and BSR and deposit on the front of the bathrobe or, perhaps, the thighs of the pajama bottoms. The dashed line on the lower right leg outlines the probable area of GSR deposition if there were breech and trigger housing gas leakage by the shotgun.*

Particle types. There are two general particle types involved in this case:

1) ***Gunshot residue*** **(GSR)**. That is, the particles produced by the firing of a gun are usually composed of lead (Pb), antimony (Sb) and barium (Ba) in various combinations. These particles are generated by the primer of the cartridge. Other elements that are occasionally found associated with GSR, are aluminum (Al), silicon (Si), sulfur (S), chlorine, (Cl), potassium (K), calcium (Ca) and iron (Fe). In addition, bullet-origin particles composed of copper (Cu), zinc (Zn) and nickel (Ni) are also produced and are often associated with the primer-origin particles. Unjacketed bullet and some jacketed bullets will produce lead particles. Lead shot ablation and heat would generate lead particles as they travel down the bore.

2) ***Backspatter residue*** **(BSR).** These are particles produced by a contact or near contact shot to the head. The interaction of the bullet, or in this case, lead (Pb) shotgun pellets and hot gases with bone (calcium (Ca) and phosphorus (P)) will produce unique particles. Particles composed of bone (calcium-phosphorus) are usually abundant (Burnett, 1991). Gunshot residue particles may also be associated with BSR.

The SEM equipped with EDS has the capability for elemental identification of particles, can detect and analyze both GSR and BSR debris and is an appropriate instrument for the analysis of some of the evidence in this case.

Evidence submitted. The following evidence was submitted (via FedEx and USPS Express mail) to Meixa Tech:

1) January 12, 2005. The shotgun associated with the death of Colonel Sabow: Ithaca Model 200E, 12 gauge, double barrel shotgun, serial number, 137911 (Figs. 3A and 3B). The shotgun was received wrapped in brown paper with remnants of security tape and an evidence number, 91-11-0062. (Images available upon request). The identification information concerning this shotgun is provided in Fig. 3C.

Figure 3. *The shotgun. A: Full view of the Ithaca shotgun with the Winchester "Game Load" box and cartridges used in the test of the shotgun. B: The serial number of the shotgun. C: Identification information on the barrels of the shotgun. D: The trigger area of the shotgun. The trigger housing gap is indicated. E: The opened breech of the shotgun. F: The closed breech area of the shotgun.*

Figure 4. *Reenactment of the suicide scenario with a mannequin wearing the victim's clothes. A: Pink area: region where the backspatter in this scenario will hit the bathrobe. B: Close up of the mannequin's right leg area at a different angle C: As in B, but the bathrobe is off the right leg. In this scenario, the pajama right leg in the calf area would receive the breech and trigger-housing GSR. However, the body at the crime scene indicated that the bathrobe fully covered the leg. D: Another variation of the suicide scenario with the shotgun between the legs. This scenario is unlikely for the reason described in C and the crime scene photographs indicate the shotgun was positioned outside the right leg.*

2) January 12, 2005. Light blue pajama bottoms in a paper bag along with some reports. The bag had a label from the Naval Investigative Service (Log Number 017-91, signed by C. Baldwin). The description of the bag contents: "men's white boxer shorts and blue pajama bottoms." The white boxer shorts were not in the bag. (Images available upon request.)

3) February 8, 2005. The bathrobe, undershirt, slippers, socks and underwear were received in two unmarked, unsealed plastic bags from Dr. Sabow. The bathrobe was in one of these plastic bags and the other items (slippers, t-shirt, underwear, and 1 pair socks) in the second bag. These items were, after examination, documented and secured in separate paper bags.

4) February 18, 2005. Crime scene and autopsy photographs (8X10-inch gloss) were received in a large binder.

The focus of this analysis. Meixa Tech was asked to answer, if possible, the following questions:

1) Does the shotgun produce any (gunshot residue-laden) gas leakage at the breech and from the trigger housing when fired? That is, when the shotgun is fired, does it "leak" GSR-laden gases from the trigger housing (Fig. 3D)? The breech (Fig. 3E) when closed (Fig. 3F), forms a very narrow gap with the breech-face of the shotgun. Is there GSR-laden gas leaking from this area or from the break lever when the shotgun is fired?

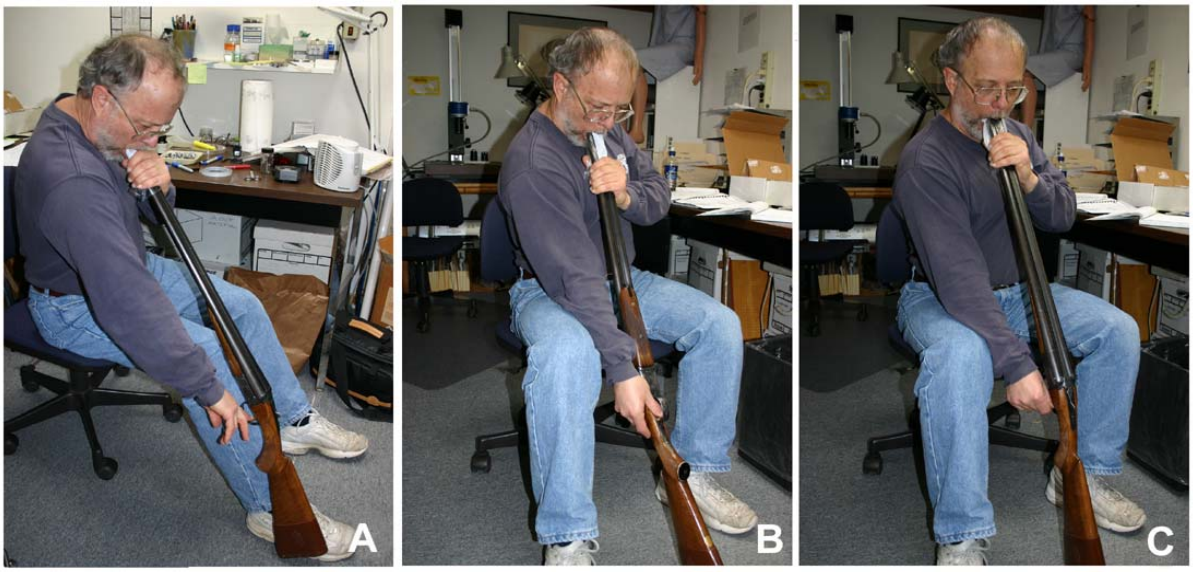

Figure 5. *Various positions of the shotgun in the suicide scenario. Only the position in A is consistent with the crime scene.*

2) If the shotgun does have breech/trigger housing leakage, a suicide scenario for the death of Colonel Sabow (Fig. 2B) would be supported by the detection of gunshot residue on one of the outside calf regions of the bathrobe (Figs 4A and 4B) or the pajamas (Fig. 4C), Do any of the calf regions of the bathrobe or pajamas have gunshot residue associated? The position of the bathrobe on the body of Colonel Sabow and the shotgun (Fig. 1), suggests if this was a suicide, the shotgun would be exterior to the body (Figs. 4A and 4B). Modeling of the possible positions of the shotgun in the suicide scenario are shown in Figs. 2B and 5. Again, considering the position of the body and the shotgun at the crime scene, the scenes depicted in either Fig 2B or Fig. 5A are the most likely for the suicide scenario.

3) Since the major exit for the gases delivered via the shotgun in the mouth is the sides of the mouth around the barrel of the shotgun (see previous reports on this case), in suicide exiting gases (red arrows, Fig. 2B) would be directed onto perhaps the front of the bathrobe and likely the thigh areas of the bathrobe (pink area of Fig. 4A) or the pajama bottoms of the victim. In a homicide scenario, the exit of the gases from the mouth would be away from the body (Red arrows, Fig 2A). Do the thigh areas of the bathrobe or the pajamas have lead, bone and lead-plus-bone particles (i.e., BSR particles) and GSR burdens?

Materials and Methods

Scanning electron microscopy. The scanning electron microscope system used in this study is an ETEC Autoscan equipped with two Kevex EDS detectors (thin window and beryllium window). The thin window detector was used in this study. A digital interface module (Kevex Model 4850S) connects to an IXRF Systems 500 Digital Processing unit. This hardware configuration and PC-based software (IXRF EDS2004) allows this system to be almost totally digital.

The ETEC scanning electron microscope used in these analyses was operated at 20 kV, work distance of 20 mm and EDS analysis time of 5 seconds with the thin-window Kevex detector (detects boron and higher atomic numbered elements).

The SEM samplers used for sampling all the items in this examination were made up of a half-inch diameter aluminum platforms upon which 1.5 mm thick graphite disks were affixed. On the graphite disk, a graphite-impregnated double-sticky tape was applied. The sticky surface of the sampler was dabbed onto the evidence item. In all the samples and evidence items unless otherwise noted, 60 dabs of the samplers were applied. The SEM stub was placed directly into the specimen chamber of the scanning electron microscope where it was viewed and analyzed.

Sampling the shotgun for breech/trigger housing leakage. The left barrel of the Ithaca 12 gauge shotgun (serial # 137911) was used in all tests (Figs. 3A and 3B). The association of the barrel with the breech is < 40 microns (measured with an automotive feeler gauge). The ammunition that was with and used in the shotgun at the time of Colonel Sabow's death was not provided for these tests. Similar ammunition was obtained for the tests: Winchester "Game Loads" 12 gauge, 2 ¾ inches, 3 ¼ Dr. Eq., 1 oz., 7 ½ lead shot. Lot Number, 47Y2UT22 (purchased January, 2005) (Fig. 3A).

Three series of tests to detect breech and trigger leakage of the Ithaca shotgun were performed. Series 1 of the breech and trigger leakage samples analysis was a preliminary study. The second series of analyses were performed as confirmation. The third series was to test if GSR deposition of the shooting hand varied with an oblique finger or thumb depression of the trigger. Analysis field size was at 300X. From four to ten fields with confirmation analyses of the particles by EDS were recorded and stored in the IXRF EDS2004 batch files. Confirmation of the particle identities by EDS was performed for each field where strong backscattering (i.e., heavy metal) particles were detected.

Figure 6. *A: The Ithaca 12 gauge shotgun, first test series, with the cloth wraps in place. B: Sample witness cloth J-1 in place after the firing of the shotgun.. C: The breech control wrap, sample I-1.*

Sampling the shotgun – test series 1. The shotgun breech and trigger areas were wrapped with strips of clean ("witness") cotton cloths (used for cleaning electron microscopes; Ted Pella, Inc. Catalogue # 812). One wrap for the detection of breech leakage and the other for trigger (Fig. 6A). Control 1 is a sample from the stock material without exposure; control 2 is a breech and trigger wrap performed after cleaning the shotgun during the testing series. One test firing of the shotgun (to check performance) was made prior to the application of the witness cotton cloth. Upon removal of the casing (approx 30 seconds after the shot), it was noted that a white cloud was released that covered the breech area of the shotgun. The shotgun breech was wiped with a clean cotton cloth and the test wraps applied. Three test shots with witness cloths were performed. Prior to the third shot, the breech area of the shotgun was cleaned with cotton cloth and the second control witness cloths (breech and trigger) applied and then removed without a shot being fired. The final shot with two witness cloths in place was the third and final shot for this series. Results of the examination of these samples (see Results and Discussion) prompted another trip to the shooting range for an additional test.

Sampling the shotgun – test series 2. The shotgun was thoroughly cleaned using three clean cotton pieces (8 X 8 inches) and Windex®. This was followed by a breech cotton wrap (Fig. 6C). The cotton breech wrap was a control and in place around the shotgun breech 12 hours prior to the second visit to the shooting range. This control wrap (sample I-1) was removed immediately prior to the applying of the test wrap (Sample J-1, Fig. 6B) at the range.

Trigger GSR collection this time was done by the wearing a polyester glove (DuraClean®) during the shot. The glove (J-2) was dabbed 60 times while on my right hand just prior to firing the shotgun (this was designated SEM sample J-3). SEM sample J-2 was created by the dabbing of the glove 60 times after the shotgun was fired. One of these DuraClean® gloves (sample I-2) was worn into the building/range and removed just prior to putting on the glove (sample J2) for the test of trigger housing GSR-gas leakage. Only one shot was fired in this sample series.

Summary of the test samples for test series 2:
J-1: The breech wrap by cotton cloth to catch GSR generated by leakage around the breech of the Ithaca shotgun (Fig. 6B). SEM sample J-1.
J-2: A DuraClean® polyester glove worn on the right hand of the shooter during the test shot. SEM Sample J-2.
I-5. A clean witness cotton cloth (2 ½ X 8 inches) placed on the shooting platform (under and to the left of the shotgun) prior to the shot. The shotgun breech was approximately 16 inches above the platform. The cloth was placed approximately 12 inches to the left so that the distance of the breech/trigger of the shotgun when fired was approximately 21 inches from the center of the cloth surface. The cloth was carefully folded and placed in a plastic bag immediately after the shot. SEM sample I-5.

Summary of controls for Series 2 breech and trigger samples:
J-3: The SEM sampler of the dabbing of the J-2 DuraClean® glove prior to the shot by the shotgun.
I-1: Control cotton wrap of the shotgun breech (Fig. 6C). The surface of the cloth that was in contact with the breech of the shotgun was dabbed 60 times. SEM sample I-1.
I-2: A polyester DuraClean® glove that I put on my right hand prior to entering the shooting range building. The glove was carefully removed (inside out) and stored just prior to putting on the test glove (J-2). In the laboratory, this glove was dabbed 60 times. SEM sample I-2.
I-3: A cotton witness cloth place exposed on the back bench of the range (approx. 5 feet from the shooting stall) when I entered the range. Approximately five minutes after the shot, this cloth was folded and placed in a sample bag. SEM sample I-3.
I-4: A cotton witness cloth (3 X 8 inches) that was taken out of its plastic bag at the range and then refolded and put back in. SEM sample I-4.

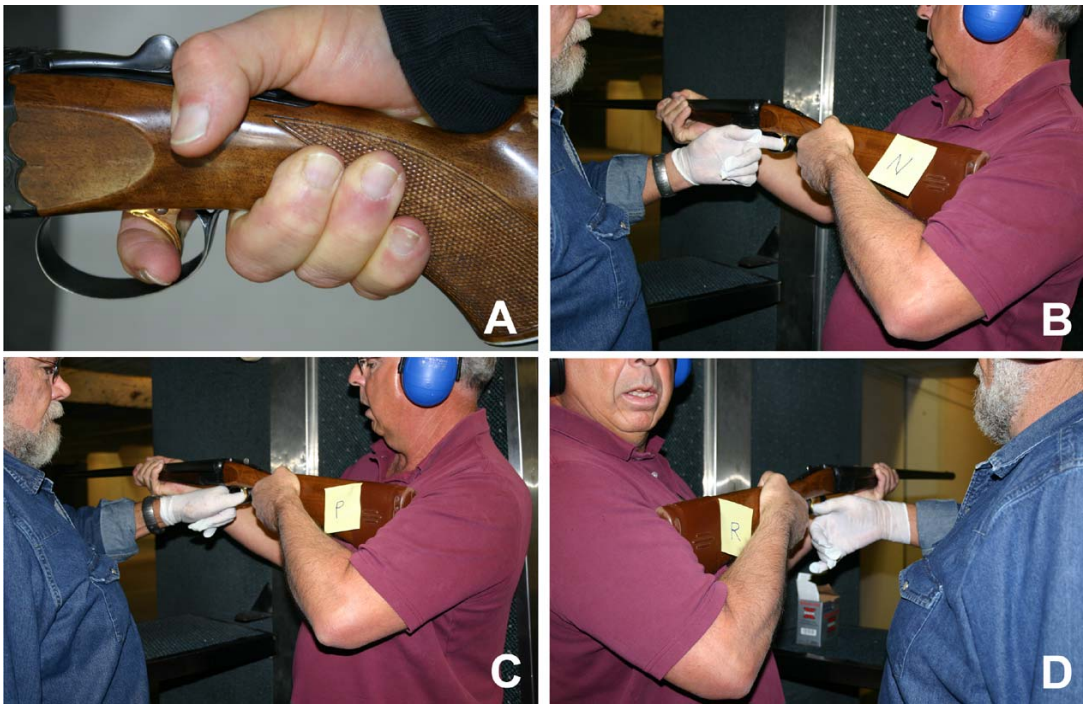

Figure 7. *Different ways of firing the Ithaca shotgun. A: the normal trigger pull. B: Oblique finger approach from the left side of the shotgun (sample N-2). C: Oblique thumb approach from the left side of the shotgun (sample P-2). D: Oblique thumb approach from the right side of the shotgun (sample R-2). Sixty dabs per sample were taken.*

Sampling the shotgun – test series 3. It was apparent from the sample series 2, that there is gas (with GSR) leakage from the trigger housing (see Results & Discussion). In normal firing of the shotgun, the forefinger would be entirely across the trigger (Fig. 7A). But in the suicide scenario, the finger or thumb would approach the trigger at an angle and would be only partially exposed to the GSR laden gases from the trigger housing gap. If the distribution of the gas emission from the trigger housing is not uniform, then the trigger may be depressed from an oblique angle without being exposed to GSR. Considering that a finger or thumb is not totally through the trigger guard in the suicide scenario (Figs. 2A, 5A, 5B and 5C), four GSR samples were taken from hands where the shooter depressed the trigger at an angle (left side of the shotgun, Figs. 7B and 7C; right side of the shotgun, Fig. 7D; one image not shown). In this test series, two assistants were required: one to hold the shotgun and the other to depress the trigger. Just after placing the DuraClean® glove on his hand (only the edges of the glove were handled), 60 dabs of the glove surface were taken with the SEM sampler. The glove was quickly collected after each shot (turned inside out during the removal) and placed in a plastic sample bag. Sampling of the glove was done in the lab with 60 dabs each. A summary of the sampling:

N-1: sixty control dabs of the glove while on the hand of the shooter.
The shooter used his forefinger from the left side of the shotgun to depress the trigger (Fig. 7B).
N-2: The glove was quickly removed from the shooter's hand and stored in a plastic bag. Sixty dabs of the SEM sample were then made on the glove.

P-1: Sixty control dabs of the glove while on the hand of the shooter.
The shooter used his thumb from the left side of the shotgun to depress the trigger (Fig. 7C)
P-2: The glove was quickly removed from the shooter's hand and stored in a plastic bag. Sixty dabs of the SEM sample was then made on the glove.

Q-1: Sixty control dabs of the glove while on the hand of the shooter.
The shooter used his forefinger from the right side of the shotgun to depress the trigger (not shown).
Q-2: The glove was quickly removed (turned inside out) from the shooter's hand and stored in a plastic bag. Sixty dabs of the SEM sample were then made on the glove.

R-1: In the lab a clean DuraClean® glove was put through the dabbing procedure for all the post shotgun firing samples (sample not analyzed at this time).
The shooter used his thumb from the right side of the shotgun to depress the trigger (Fig. 7D) Unfortunately, he selected his right glove-covered hand. This hand was not intended for the experiment; the glove was worn during the previous three tests.
R-2: Sample not analyzed at this time.

Note: the ventilation system of the range was not working. The exposed glove was removed as soon as possible from this environment after firing the shotgun. The previous test showed that GSR particle contamination from nearby shooters is possible in this environment and indeed, control samples N-1, P-1 and Q-1 were likely contaminated from this source.

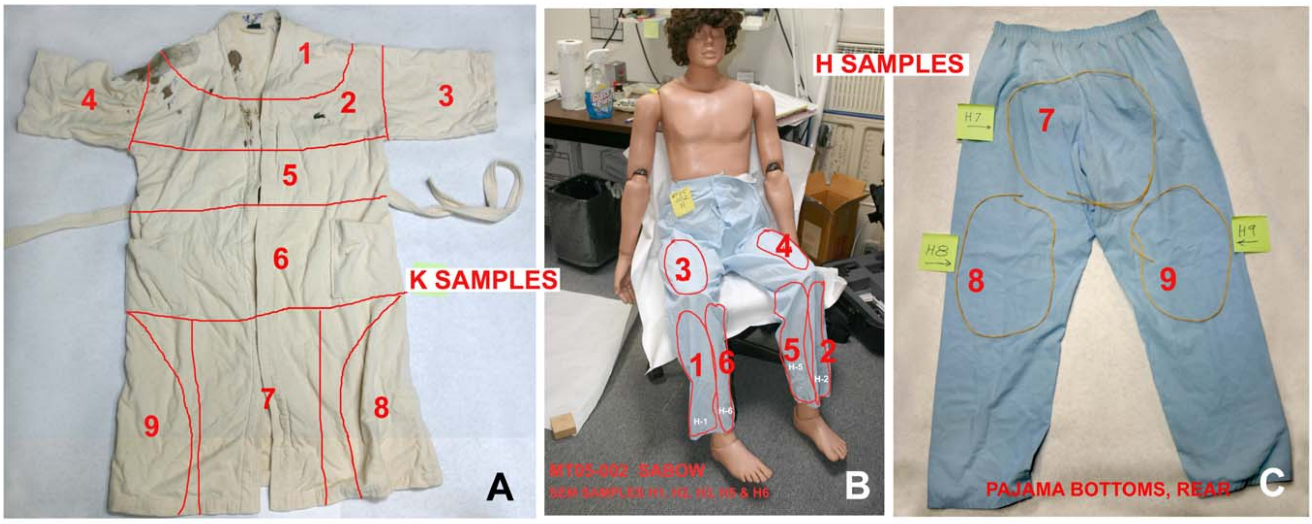

Figure 8. *A: Sample regions of the bathrobe (samples K-1 through K-9). B: The front sampling areas of the pajama bottoms (samples H1 through H-6). C: The back of the pajama bottoms showing the SEM tape lift areas H-7 (buttocks), H-8 (left rear thigh) and H-9 (right rear thigh). Sixty dabs per sample were taken.*

Sampling and testing of the bathrobe. The samplings of the bathrobe were performed by SEM double sticky samplers as noted above. The samplers were applied, 60 dabs/sampler, one SEM sampler per region of the bathrobe (Fig. 8A). There are nine SEM samplers, K-1 through K-9.

Each of the nine SEM samplers from the bathrobe was analyzed with 50 fields at 300X. Elemental analysis of particles in these fields was by EDS.

Sampling and testing of the pajama bottoms. The samplings of the pajama bottoms were done with SEM double sticky samplers. The samplers were applied, 60 dabs/sampler, one SEM stub per region of the bathrobe (Figs. 9B and 9C) so that there are nine SEM samplers, H-1 through H-9.

Each of the nine SEM samplers from the pajamas was first surveyed (10 to 15 minutes each) at low magnification using both secondary and backscatter imaging. This was followed by a quantitative analysis of 10 to 30 fields at 300X. Elemental analysis of particles in these fields was by EDS.

Results and Discussion.

Breech and trigger tests, Series 1. All the samples were analyzed in the SEM. There are three samples series (D, E, and G), each series containing two samples: the breech and the trigger cotton cloth wraps. The control series wraps (F), although containing not nearly the number of GSR particles as the test samplers that were applied to the shotgun when it was fired, still were contaminated with GSR. This was despite an attempt to thoroughly clean the shotgun, while at the range, prior to applying the control sample cotton cloth. In addition, the "breaking" of the shotgun to release the casing after the shot produced a white cloud of smoke which appeared even after waiting one minute following the shot. It appeared likely that the breech area of the shotgun was being contaminated with metaliferous GSR when it is opened to expel a shell. However, a survey of the samples by SEM/EDS suggested that the breech was indeed leaking GSR (data not shown). The trigger area appeared to be also leaking, but not to the extent of the breech. Regardless, the controls were contaminated, which resulted in a new protocol and experiment.

Breech and trigger tests, Series 2. The surface of the SEM sample J-1 is shown in Fig. 9A. This shows that many cotton fibers were picked up by the sampler. A higher magnification of 300X of this sampler is shown in Fig. 8B. Backscatter imaging (Fig. 9C) of the same area shown in the secondary image of Fig. 9B. Heavy backscattering particles (white spots in Fig. 9C) are apparent. The ETEC/ IXRF system allows for a quick assessment of the elemental composition of these particles by point analysis on images in the IXRF environment. Figure 9D shows three spectra taken of these particles – all these and the others (small numbered boxes-spectra not shown) show that the majority of these particles are GSR.

The surface of SEM sampler J-2 (glove sample of trigger leakage) is shown in Fig. 10A. There are a few fibers, but the surface appears to be largely free of large debris. A higher magnification image (at 300X – Fig. 10B) shows debris on the surface. Heavy backscattering particles (white spots in Fig. 10C) are apparent. In this image, as well as the previous backscatter image, lighter backscattering particles may be found. These particles were not counted in this analysis. Figure 10D, bottom spectra shows the composition (an aluminosilicate with iron) of one of these low backscattering particles.

The results of this series of analyses are shown in Table 1. Both the breech (sample J-1) and the trigger housing area (sample J-2) show elevated GSR particles compared to the controls (samples I-1 and J-3). It is obvious that the shotgun does leak GSR-laden gas when fired, both from the breech as well as the trigger housing. It would, therefore, be likely that a person firing this shotgun, in a normal manner (Fig. 7A), would have GSR deposited on his trigger hand.

Sample I-2 is from a glove that was worn into the gun-range facility and was sampled just prior to putting on the trigger test glove. This glove sample showed a slightly elevated GSR particle burden over the controls.

Trigger tests, Series 3. The plan was to dab the hand that depressed the trigger immediately after the shot at an angle (Figs. 7B, 7C and 7D). However, it was noted that the air conditioner was not working at the gun range and there were four other shooters, so the glove was immediately removed after the shot to minimize airborne contamination. The controls (Table 2) accumulated burdens of GSR; the origin likely the airborne particles. Control samplers P-1 and Q-1 have GSR burdens less than that of N-1. The burdens of the three gloves sampled for GSR (Table 2: N-2, P-2 and Q-2) are more than twice that of any of the controls. Thus, regardless of the position of the hand while firing the shotgun, GSR was intercepted.

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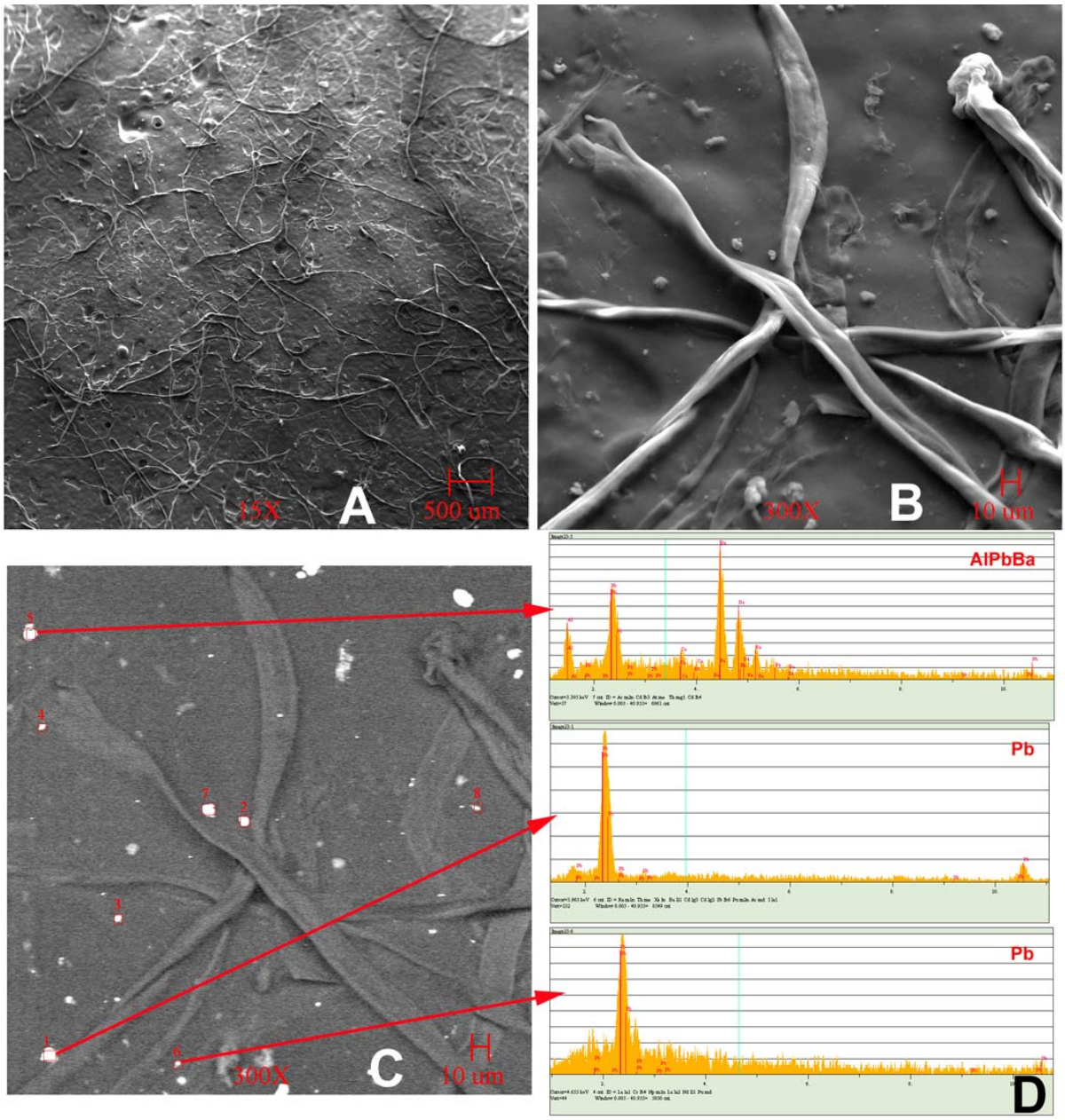

Figure 9. *Scanning electron microscope images of sample of J-1 (the cloth wrap of the breech). A: Low magnification (15X) of the sampler surface, secondary electron image. B: A 300X sample filed of J-1, secondary electron image. C: The same field as B, but a backscatter electron image. The bright spots are metaliferous GSR particles. Those particle that have had elemental analysis are indicated by red squares. D: Example spectra of some of the particles analyzed from this field. The arrows connect the spectra with the particles analyzed. The elemental identity of the particle is given in the upper right corner of each spectrum.*

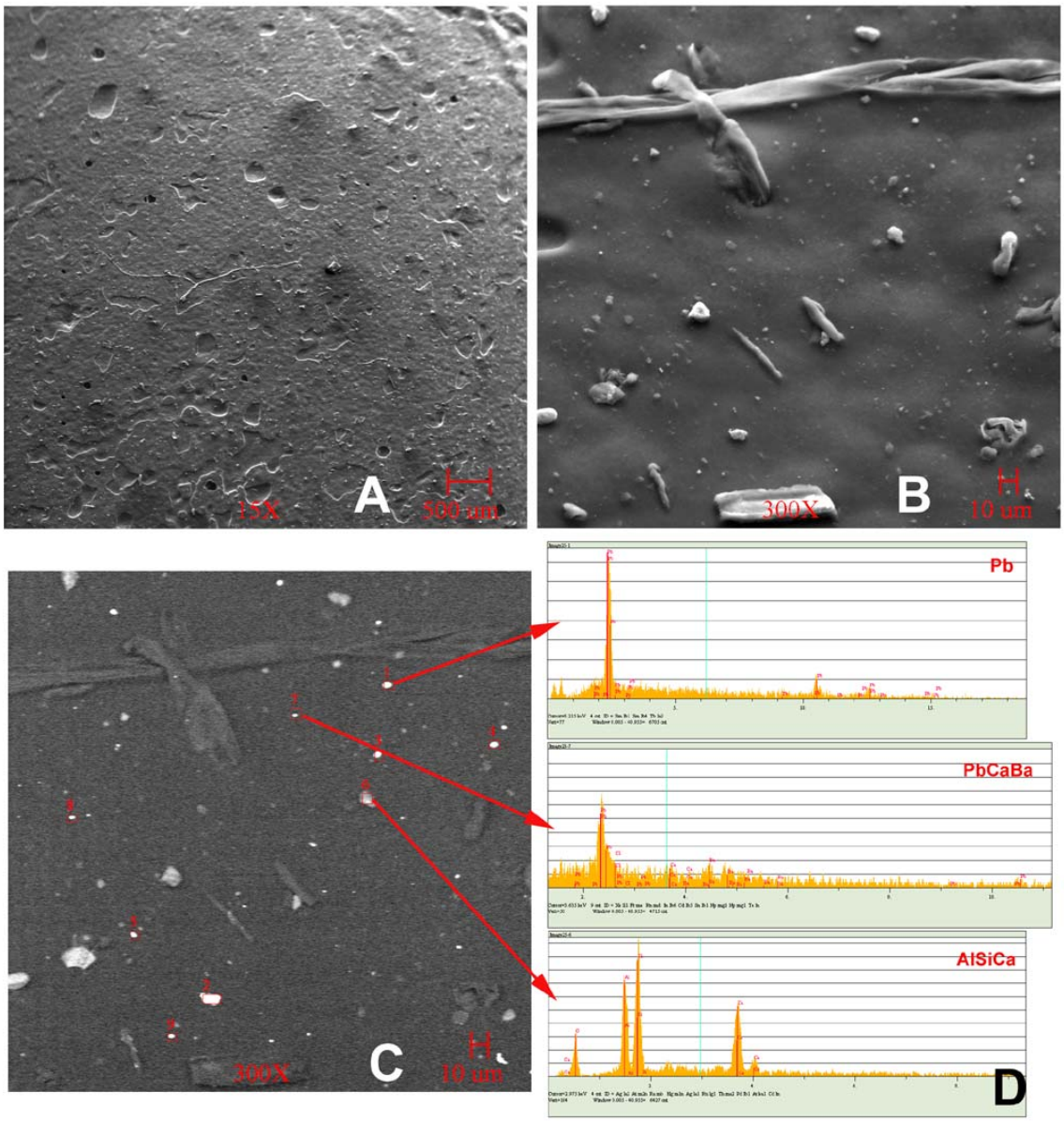

Figure 10. *Scanning electron microscope images of sample of J-2 (the polyester glove of worn by the shooter). A: low magnification (15X) of the sampler surface, secondary electron image. B: A 300X sample filed of J-1, secondary electron image. C: The same field as B in this figure, but a backscatter image. The bright spots are metaliferous GSR particles. Those particle that have had elemental analysis are indicated by red squares. D: Example spectra of some of the particles analyzed from this field. The arrows connect the spectra with the particles analyzed. The elemental identity of the particle is given in the upper right corner of each spectrum. The lowest spectrum is of a non-GSR particle whose backscatter is somewhat brighter than normal for a particle with this composition. The backscatter detector was adjusted so that such a particle would not be counted in a quantitative tally.*

Table 1. *Results of the SEM/EDS analysis of the shotgun test series 2.*

SAMPLE	DESCRIPTION	NUMBER GSR/FIELD	NUMBER FIELDS
J-1	BREECH WRAP	24.0	5
J-2	TRIGGER GLOVE	14.8	4
J-3	TRIGGER GLOVE CONTROL	0	5
I-1	BREECH WRAP CONTROL	0.5	20
I-2	FACILITY GLOVE	1.2	10
I-3	BACK BENCH CLOTH	0.5	10
I-4	CONTROL	0.1	10
I-5	SHOOTING BENCH CLOTH	0.4	10

Table 2. *Results of the SEM/EDS analysis from samples of the oblique trigger depress experiments. Time constraints prohibited quantitative analysis of those samples with missing entries.*

SAMPLE	DESCRIPTION	NUMBER GSR/FIELD	NUMBER FIELDS
N-1	CONTROL	1.10	20
N-2	TRIGGER FOREFINGER	2.55	20
P-1	CONTROL	0.55	20
P-2	TRIGGER THUMB	2.40	20
Q-1	CONTROL	0.75	20
Q-2	TRIGGER FOREFINGER	2.45	20
R-1	CONTROL	-	-
R-2	TRIGGER THUMB	-	-

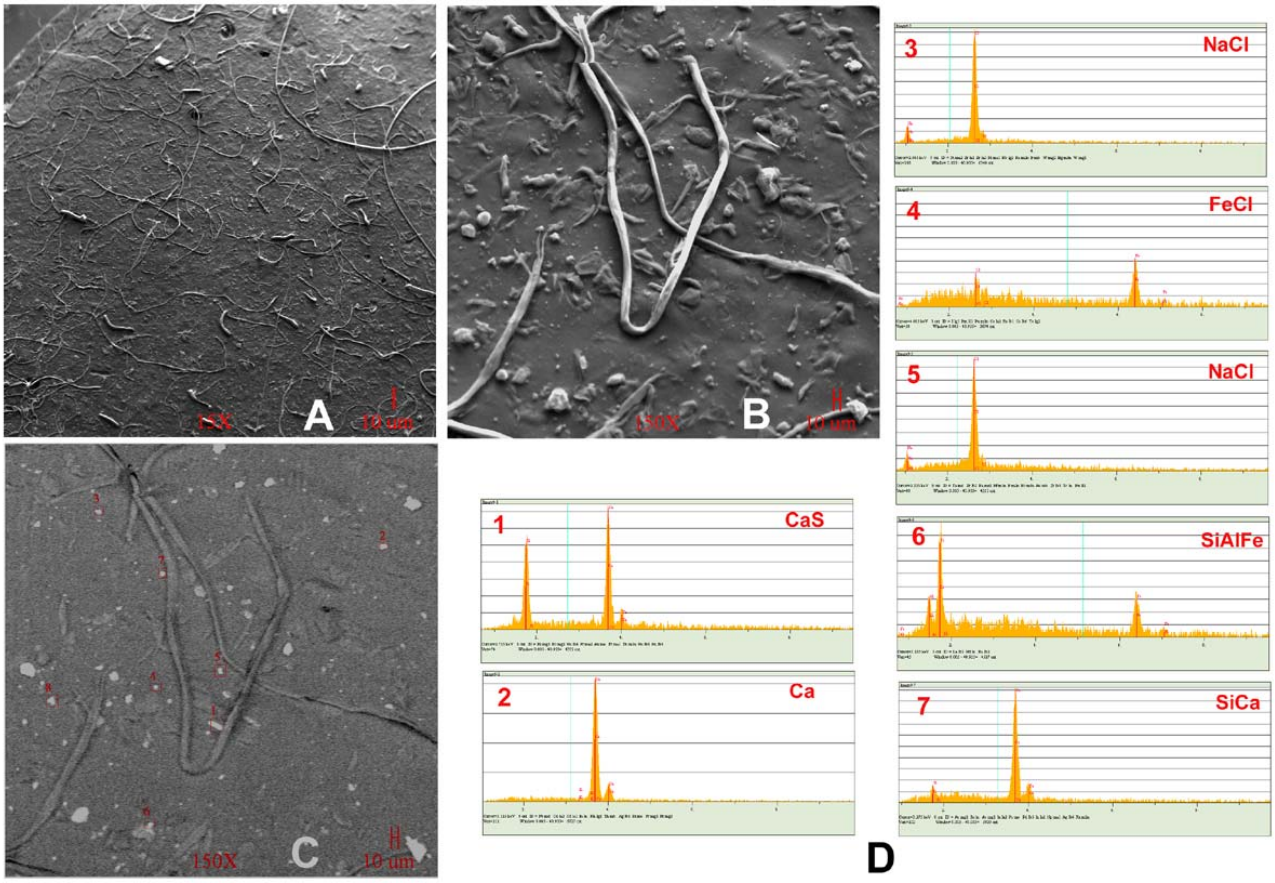

Figure 11. *Scanning electron microscope images of sampler of H-6 (sample from the inner right thigh of the pajama bottoms). A: Low magnification (15X) of the sampler surface, secondary electron image. B: A 150X sample field of H-6, secondary electron image. This sample series was abandoned for the one taken at 300X. C: The same field as B in this figure, but a backscatter image. The bright spots are low-atomic number environmental particles. Those particle that have had elemental analysis are indicated by red numbers. D: Example spectra of some of the particles analyzed from this field. The elemental identity of the particle is given in the upper right corner of each spectrum.*

Table 3. *Results of the SEM/EDS analysis of the samples from the bathrobe.*

SAMPLE	DESCRIPTION	NUMBER GSR/FIELD	NUMBER FIELDS
K-1	NECK REGION	0.02	50
K-2	CLAVICAL REGION (UPPER CHEST)	0	50
K-3	LEFT SLEEVE	0	50
K-4	RIGHT SLEEVE	0	50
K-5	ABDOMEN	0	50
K-6	LOWER ABDOMEN THIGHS	0	50
K-7	LOWER LEGS LEFT/RIGHT	0	50
K-8	LEFT CALF	0	50
K-9	RIGHT CALF	0	50

Table 4. *Results of the SEM/EDS analysis of the samples from the pajama bottoms*

SAMPLE	DESCRIPTION	NUMBER GSR/FIELD	NUMBER FIELDS
H-1	PAJAMAS, RIGHT OUTER CALF	0.05	20
H-2	PAJAMAS, LEFT OUTER CALF	0	10
H-3	PAJAMAS, RIGHT THIGH	0.1	10
H-4	PAJAMAS, LEFT THIGH	0.1	10
H-5	PAJAMAS, LEFT INNER CALF	0	10
H-6	PAJAMAS, RIGHT INNER CALF	0.1	10
H-7	PAJAMAS, BUTTOCKS	0.07	30
H-8	PAJAMAS, REAR LEFT THIGH	0	30
H-9	PAJAMAS, REAR RIGHT THIGH	0	30

(Continued from p. 10)

The bathrobe. The results of the analysis of the nine tape lifts from the bathrobe are listed in Table 3. No GSR or BSR particles were discovered.

The pajama bottoms. The survey analyses of all of these samplers revealed few heavy backscattering particles of interest for the samplers (Table 4). The particles referred to in Table 4 are all lead-only and thus likely from a source other than firearm discharge.

Samplers K-7, H-3 and H-4 (the thighs). None of these samplers revealed any particles consistent with exposure to either GSR or BSR. In the suicide scenario, the thigh areas should have BSR debris as well as some GSR particles. Example images and spectra from sampler H-6 are shown in Fig. 11.

Figure 12. *Image from crime-scene photograph 001966 showing the left hand of the victim in the process of GSR sampling. The arrow points to the GSR sampler.*

Conclusions

Gunshot residue sampling at the crime scene. The GSR sampling of the victim's hands was performed at the crime scene. It was stated to me by Dr. David Sabow and the report on this case by Jon Nordby (Nordby, 2004) that GSR was found on the left but not on the right hand of the victim. I did not receive this GSR report, so it could not be evaluated. The GSR sampler is shown in one of the crime scene photographs (Fig. 12, arrow). The sampler is of a type used for the collection of GSR for non-automated scanning electron microscopy. The sampler uses a sticky substance to pick up particles from the object being dabbed. The sticky material is dissolved in an organic solvent, centrifuged, filtered and then the surface of the filter examined in the SEM. The procedure has problems (Zeichner et al., 1989), but works quite well on clean hands. Therefore, the lack of GSR that has been reported for the right hand of Colonel Sabow is probably accurate. It is likely that the right hand of Colonel Sabow was not near the muzzle or breech of the shotgun.

Breech and trigger - housing leakage. The shotgun does have breech and trigger-housing leakage (Table 1). It is probable that objects near or in contact with the breech of the Ithaca shotgun will become contaminated with GSR. The fingers and hand of a shooter will also become contaminated with GSR upon firing the shotgun (Tables 1 and 2).

It could be argued that without the finger being directly under the trigger housing while pulling the trigger (Fig. 7A), that non-uniform leakage from the trigger housing could be an explanation for the reported lack of GSR on the right hand of Colonel Sabow. The suicide scenario has the victim obliquely pushing of the trigger with a thumb or finger of the right hand. This is simulated in the third series of GSR tests of the Ithaca shotgun. The results (Table 2) indicate GSR deposition on the hand of the shooter, regardless of either a left- or right-side approach to the shotgun trigger.

The suicide scenario shotgun position (Fig. 2B) proposes that Colonel Sabow fell out of the right side of the lawn chair following the intraoral shotgun blast. During the fall from the lawn chair, the shotgun pulled from his mouth and ended up beneath his lower legs and feet. The position of the shotgun in relation to the body suggests it was against the right leg as shown in Fig. 2B prior to its firing. The crime scene photographs also show the victim's bathrobe tucked between his legs (Fig. 1A). Thus, for the suicide scenario, the bathrobe would likely intercept the GSR from both the breech and the trigger at region K-9 (Fig. 8A). No GSR was found on this area

nor on the calf area of the pajama bottoms that would have been exposed to breech and trigger housing leakage from the shotgun if the bathrobe were not present. The other areas of the bathrobe (Table 3) and pajama bottoms were also checked (Table 4). None of the results of the sampler analyses from either the bathrobe or the pajama bottoms supports a nearby discharge of the shotgun.

The SEM samplers from area K-7 (Fig. 8A) from the thighs of the bathrobe as well as the pajamas (H-3 and H-4, Fig. 8B) were negative for either GSR or BSR (Tables 3 and 4). In the suicide scenario (Fig. 2B), backspatter via the sides of the mouth would be significant and would contaminate both the front of Colonel Sabow's bathrobe and thigh areas. Although the composition of the backspatter debris from an intraoral shotgun blast may be different from an external contact or near contact shot to a head, it is still probable that a considerable amount of BSR would have been produced. Support for Colonel Sabow's left hand gripping the barrel at the mouth is shown by blackening (Fig. 13A) and blood on the left palm (Fig. 13B). These stains should be composed of both GSR and BSR.

Figure 13. *The left hand from crime scene photographs. A: From photograph 002030. Arrow points to a small amount of soot, likely from the shotgun blast. B: From photograph 001966. Arrows point to apparent soot.*

The left hand. In both scenarios presented in this case, the left hand gripped the barrel near the muzzle of the shotgun at the victim's mouth when it fired. In the suicide scenario, Colonel Sabow gripped the shotgun himself in the manner shown in Fig. 2B. In the homicide scenario (Fig. 2A), the left hand was gripped by the alleged assailant to simulate a suicide as shown in Fig. 2B. The presence of soot on the left hand (Fig. 13B, arrows) means that apparent GSR/BSR was deposited on the left hand when the shotgun was fired. Indeed, GSR was reported present on the left hand.

The right hand. The shotgun produces breech and trigger GSR. The reported lack of GSR on the right hand is inconsistent with positioning of the this hand in either scenario of the death of Colonel Sabow. The crime scene photographs of the body (Figs. 1A and 1B) show the right hand just behind the left hand. If, assuming the homicide scenario, the right hand had the position shown in the crime scene photographs during the shotgun firing, there would also be GSR/BSR deposition; it would not be possible for the left hand to totally block GSR/BSR deposition on the right hand. Most importantly, the lack of GSR on the right hand implies that it was not involved in depressing the trigger of the shotgun, thus dispelling the suicide scenario. The homicide scenario is tenable. If Colonel Sabow did receive the shotgun blast while he was lying on the ground, his right hand was moved to the location shown in the crime scene photographs after that shotgun blast. Indeed, the blood spatter evidence suggests that not only was the right hand in a position to receive projected blood spatter (with no GSR/BSR), but it also had a secondary blood transfer (Fig. 14).

There are two events that occur with a contact or near contact shot to the head. The first is that gas is injected between the scalp and the skull causing a dissection of these tissues (see DiMaio, 1999, Figure 5.4, p. 129). The second event is an "exhalation" of gases injected into the skull itself, when there is no exit wound (Burnett, 1991). More organic debris (blood, bone fragments) is associated with the second event. Whether an intraoral 12 gauge shotgun blast without an exit wound adheres in principle to these two events is uncertain.

The thighs of the bathrobe and pajamas. For the substantial amount of gas injected into the head, a massive "exhalation" of these gases from the head occurred through the mouth. In the suicide scenario, the thighs of the bathrobe and/or the pajama bottoms would be contaminated with GSR and BSR. Yet, the samples of neither the bathrobe nor pajamas showed any evidence of involvement with either GSR or BSR. In the homicide scenario (Fig. 2A), BSR from the mouth resulting from the shotgun blast is directed away from the body.

Crime scene photographic evidence - the right hand. Image enhancements of the victim's right hand in the crime scene photographs 002033, 002032 and 002036 are shown in Fig. 14. These photographs show two types of apparent blood stains, projected and

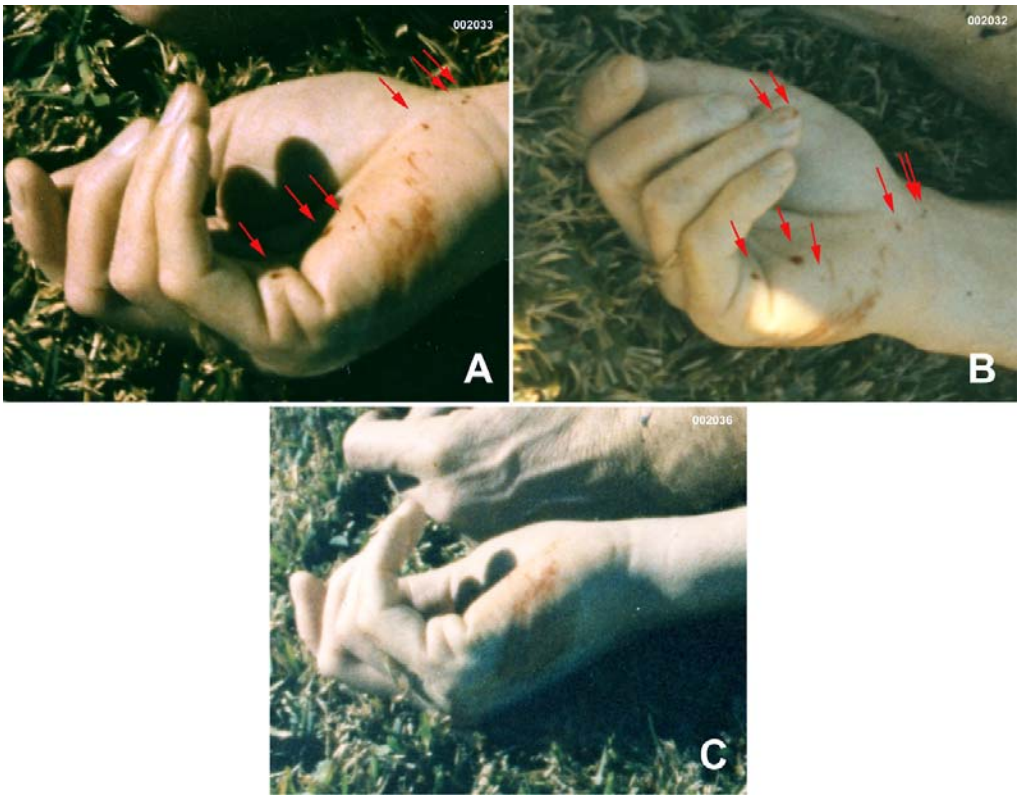

Figure 14. *The right hand of the victim from crime-scene photographs. All of the images are enhanced. A: From photograph 002033. The two types of blood stains are shown. The red arrows point to projected blood spatter. B: From photograph 002032. The two types of blood stains are shown. The red arrows point to projected blood spatter. C: From photograph 002036. The entire transfer blood stain is apparent.*

Figure 15. *The lower face from autopsy photograph 001995. Image has been slightly enhanced by a levels adjustment and sharpening.*

transferred:

1) The right palm shows small blood spatter (arrows, Figs. 14A and 14B). If the right hand depressed the trigger in the suicide scenario, its palm would be turned away from the mouth (see Figs. 2B, 5A, 5B and 5C), and not be exposed to intercept blood spatter. This is additional evidence that the right hand was not involved in the depressing of the shotgun trigger in the suicide scenario, but was in a position to intercept airborne blood spatter. Some spatter on a middle (finger 4) finger nail (Fig. 14B) indicates that the hand was partially closed when the spatter hit.

2) The ulnar aspect of the palm, extending around to the back of the hand, is a transfer stain (Figs. 14A, 14B and shown in its entirety in Fig. 14C). The streaks in this stain suggest the blood was likely transferred from the grass on which the body was lying. The solid part of the stain is at the back of the hand with the streaks directed toward the palm. This suggests that after the hand acquired the stain, it was moved.

Crime scene photographic evidence - the mouth. The autopsy photograph, 001995, shows the face and upper torso of Colonel Sabow. Figure 15 is an enlargement and enhanced image of the mouth area. The sides of the mouth show evidence of tearing which would have been caused by the "exhalation" of gases from the head after discharge of the shotgun. In addition, the lower lip shows bruising apparently from the front maxillary teeth. This trauma to the lower lip is inconsistent with the suicide scenario, and occurred prior to the shotgun blast.

The death of Colonel Sabow by suicide in the manner shown (Fig. 2B) is not supported by the GSR evidence, BSR evidence, blood spatter and transfer on the right hand, and the apparent trauma to the lower lip. The death of Colonel Sabow was by homicide.

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